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A Study of the Relationship of Certain Variables to Sex Characteristic Identification From the Speech of Heterosexual and Homosexual Individuals.

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A STUDY OF THE RELATIONSHIP OF CERTAIN VARIABLES TO SEX CHARACTERISTIC IDENTIFICATION FROM THE SPEECH OF HETEROSEXUAL AND HOMOSEXUAL INDIVIDUALS

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A STUDY OF THE RELATIONSHIP OF CERTAIN VARIABLES TO SEX CHARACTERISTIC IDENTIFICATION FROM THE SPEECH OF HETEROSEXUAL AND HOMOSEXUAL INDIVIDUALS

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ABSTRACT

This study explored relationships of speaker sex and masculinity-femininity judgments and 12 measures of rate, fundamental frequency, and intensity from taped reading and spontaneous speech samples of female and male heterosexual and homosexual individuals.

Phase One was designed to determine judgment reliability and any procedural variables that might influence judgments. Sex judgments were more accurate on the speakers' second performances. Both sex and masculine-feminine judgments were more accurate on reading than on spontaneous speech. Analysis of judgments from typescripts of spontaneous speech yielded a significant judge sex-by-training interaction.

In Phase Two, 20 listeners judged sex and masculinity-femininity from taped reading and spontaneous speech samples of female and male heterosexual and homosexual speakers. The mean fundamental frequency low of females judged male/undecided was higher than those judged correctly. The mean intensity standard deviation of females judged female was greater than that of females judged male/undecided. All male speakers were correctly identified.

Females judged masculine displayed a greater mean number of syllables per second, a lower mean fundamental frequency high, and a more restricted mean fundamental frequency range than those correctly described. Males judged feminine displayed a higher mean fundamental frequency mode and a greater mean intensity standard deviation than those correctly described.

Female speakers were judged male more often than males were judged female. Homosexuals were incorrectly described as masculine or feminine more often than heterosexuals.

Males averaged more syllables per second than females. Mean fundamental frequency low, high, and mode were higher for females than males. Mean fundamental frequency range was greater for females.

Mean intensity low and mean intensity range were significantly different for heterosexuals and homosexuals. Significant sex-by-type interaction occurred on mean intensity range and on mean syllables per second.

Mean syllables per second, words per minute, percent pause time, fundamental frequency range, and intensity standard deviation were significantly different for reading and spontaneous speech.

Suggestions for clinical application and future research were made.

Chapter 1

INTRODUCTION

An individual's voice is a highly personal instrument which conveys information about the speaker. The information it conveys should be accurate and appropriate to the speaker.

Research using the speech signal in speaker identification and the determination of various physical and psychological characteristics of the speaker is extensive (Catford, 1964; Diehl, 1960; Duncan, 1969; Hecker, 1971; Kramer, 1963; Mahl and Schulze, 1964; Moore, 1971a,b; William and Stevens, 1972). There is also a great deal of research which describes and measures the voice characteristics of males and females (Black, 1949; Curry, 1940; Duffy, 1970; Fairbanks, 1960; Fairbanks, Herbert, and Hammond, 1949; Fairbanks, Wiley, and Lassman, 1949; Fitch and Holbrook, 1970; Hollien, 1960a,b, 1962; Hollien, et al., 1971; Hollien and Jackson, 1973; Hollien and Malcik, 1962, 1967; Hollien, et al., 1965; Hollien and Michel, 1968; Hollien and Moore, 1960; Hollien and Paul, 1969; McGlone and Hollien, 1963; Michel, et al., 1965; Mysak, 1959; Peterson and Barney, 1952; Pronovost,

1942; Snidecor, 1951). Those studies which concern the judgment of a speaker's sex (male, female) and/or a speaker's sexual vocal impression (masculine, feminine) from the speech signal alone appear to assume the heterosexuality of the speakers or do not consider sexual inclination in the analysis (Beasley, Zemlin, and Silverman, 1972; Coleman, 1973; Ingemann, 1968; Marshall, 1972; Schwartz, 1968; Schwartz and Rine, 1968; Terango, 1966; Voiers, 1964; Weinberg and Bennett, 1971a,b; Wolf, 1972). An exception to that statement is Lerman and Damste's (1969) study of the voice pitch of homosexuals.

Evidence that relates certain physical characteristics of the speech signal to the subjective judgments of "male, female" and "masculine, feminine" is needed. Such evidence would be most beneficial in designing techniques to be used in voice therapy with those individuals who exhibit perceived vocal characteristics of the opposite sex. This study attempted to determine the relationship between certain physical measurements of speech and the perceived sex characteristics of speech.

Pertinent Literature

Speaker Recognition

Broadly defined, speaker recognition "refers to any decision-making process that uses the speaker-dependent

features of the speech signal" (Hecker, 1971, p.2). Two basic recognition tasks are the identification task in which the identity of the speaker is attempted and the discrimination task in which a decision as to whether two speech samples were made by the same or by different speakers is reached (Hecker, 1971). Generally, there are three methods of speaker recognition: by listening, by visual comparison of spectrograms, and by instruments, i.e., spectrum analyzer and computer (Hecker, 1971).

In his extensive survey of the literature on speaker recognition, Hecker (1971) cited studies which give experimental evidence of intra- and inter-speaker variability and research in each of the three methods of speaker recognition. He concluded that claims about the accuracy and reliability of speaker recognition by visual comparison of spectrograms are not adequately supported by experimental data. Likewise, speaker recognition by instruments is considerably less accurate than speaker recognition by listening, but Hecker (1971) predicted a closing of this performance gap as research continues and more sophisticated electronic instruments are developed.

Descriptions and Judgments from Voice of Psychological Characteristics Other than Masculinity-Femininity

The literature concerning the relationship of voice

and both normal and psychopathological personality characteristics is extensive. While there is some controversy, writers generally agree that broad correlations between characteristics of voice and personality exist (Laver, 1968). The lack of a standard labeling system of voice qualities and of a sophisticated method by which to quantify those qualities had been a major obstacle in reliable scientific experimentation (Diehl, 1960; Laver, 1968).

Diehl (1960) presented a rationale for a relationship of personality to voice. He quoted Darwin's theory regarding the development of the human voice as a means of expressing the emotion of love or as an instrument of sex attraction, and reasoned that if the theory is correct, "...it is logical to assume that the vocal mechanism, developed through and by emotional expressions, should be responsive to all affective states" (Diehl, 1960, p. 175). Furthermore, since during any emotional experience all body functions are more or less affected and since all parts of the vocal apparatus are related through the autonomic nervous system with the function of the internal organs, then "The neural effects of emotional disturbance in the internal organ are unconsciously transmitted to the various parts of the vocal mechanism" (Diehl, 1960, p. 175). Still further evi-

dence of the expression of emotion by voice is the various cries of the infant which his mother learns to recognize as comfort or discomfort (Fairbanks, 1942).

The beginning of psychological interest in personality and voice took place in the 1930's in America (Diehl, 1960). Listeners' ability to judge pleasantness, salesmanship, self-confidence, truthfulness, intelligence, dominance, introversion, emotional balance, Spranger life-value types (political, aesthetic, social, economic, theoretic, religious), and other traits from recorded voice was studied by Fay and Middleton (1939; 1940a,b, 1941a-c, 1942a-c, 1944).

Mallory and Miller (1958) and Moore (1939) attempted to match certain personality test scores and judgments of personality traits with particular voice qualities. While neither study reports the exact accoustical data necessary to make the voice quality terms used objective, Moore (1939) concluded that "breathy" voice tone is associated with lower dominance and higher introversion, and Mallory and Miller (1958) suggested that introversion is negatively related to loudness, low pitch, and resonance.

The early contributions of Fairbanks (1942), Fairbanks and Hoaglin (1941), Fairbanks and Pronovost (1939), and Skinner (1935) are considered a major breakthrough

toward formulating valid theories in the area of voice and personality since their data show how certain aspects of vocal acoustic phenomena are related to emotions (Diehl, 1960). In Skinner's (1935) study, the subjects read an emotional passage while listening to music selected to put them into a happy or sad mood and then said "ah." The results revealed that the ah's of happiness showed higher pitch and greater intensity than those of sadness (Skinner, 1935). Fairbanks and Pronovost (1939) selected as subjects six actors who read the same passage to express five emotional states (contempt, anger, fear, grief, indifference). In addition to analysis of the pitch characteristics of the samples, the samples were judged by a group of advanced speech students to insure that the intended emotion was identifiable. The results indicate that emotions expressed only by voice are easily identifiable and that there are measurable pitch characteristics which distinguish emotions. Data on pitch changes and inflections were also given (Fairbanks and Pronovost, 1939). A later study based on the same methodology found measurable differences in duration of phrases among the various emotions (Fairbanks and Hoaglin, 1941).

Pollack, Rubenstein, and Horowitz (1960) used eight neutral sentences read in 16 modes of expression (fear, boredom, anger, happiness, etc.) under increasing sig-

nal: noise ratios and judged by 18 untrained listeners. Recognition of the modes of expression was found to be better than sentence recognition in noise. Mode recognition was also possible when the sentences were whispered, thus minimizing voicing pitch.

Using speech synthesis techniques in order to separate and manipulate the acoustic parameters that exist in normal speech, Lieberman and Michaels (1962) studied the relationship of some aspects of fundamental frequency and amplitude and the emotional content of speech. Three male speakers recorded eight sentences read to reflect eight emotional modes. The unprocessed tapes and the processed tapes were judged by naive listeners as to the emotions expressed. The authors concluded

> There is no one single acoustic correlate of the emotional modes used. Phonetic content, gross changes in fundamental frequency, the fine structure of fundamental frequency, and the speech envelope amplitude, in that order, all contributed to the transmission of the emotional modes (p. 927).

The different models were not all dependent to the same degree on all the acoustic parameters investigated. It also appeared that the perturbations in fundamental frequency are an acoustic correlate of the emotional modes.

Williams and Stevens (1972) attempted to identify and measure the parameters in the speech signal which reflect the speaker's emotional state. Spectrographic

analysis was made of recordings of professional actors reading dialogue written to reflect various emotions (anger, fear, sorrow, neutral). A comparison of a recording from a real-life situation and one of an actor simulating the same situation was made also. The results indicated that while attributes for a given situation were not always consistent from one speaker to another, the aspect of the speech signal which appears to provide the clearest indication of the emotional state of a speaker is the contour of fundamental frequency versus time. The authors admitted that at present it is not possible to specify quantitative procedures which will reflect the speaker's emotional state reliably, but they maintained that if his normal (median) frequency and fundamental frequency range are known, it should be possible to classify his emotional state as one of sorrow (reduced fundamental frequency and decreased range) or of anger or fear (increased fundamental frequency and range).

Hoops (1969) opined that a person's general temperamental and personality characteristics will influence his speaking rate. If one's other motor activities are performed rapidly or slowly, then his speech will also be rapid or slow. Furthermore, Hoops (1969) believed that a speaker's attitude toward his message and his

purpose will influence speaking rate.

> ...Such states as wonder, doubt, confusion, sorrow and deep thought are more conducive to a slow tempo; whereas, states such as joy, excitement, anger, humor and a feeling of confidence and well-being are more closely connected to a rapid rate (p. 71).

In a study designed to examine the relationship between extroversion, neuroticism, and sex of subjects and speech rate changes, Steer (1974) recorded 24 males and 24 females counting to 150 in three modes: neutral, angry, and pleased. The subjects' self-ratings of their performances, their scores on a personality inventory, and their speech rate in each mode were analyzed. The results showed that there were no significant effects for extroversion and neuroticism. However, the male subjects showed a significantly slower rate of speech rate change than the females did when expressing anger.

Markel and Roblin (1965) studied the effect of sample content and the sex of the judges on judgments of personality. One male read three experimental passages in such a way that voice qualities (pitch range, tempo, etc.) and the voice set (mature male) were equivalent. The passages were classified in terms of topic and affect: vocational-neutral, recreation-pleasure, death-hostility. Twenty male and 20 female judges from each of three sections of an introductory psychology course made up the three groups who rated the reader on nine

adjective pair scales (e.g., kind-cruel, strong-weak, relaxed-tense). Results indicated that both sex-of-judge effect and content effect were significant. It was concluded that an incongruent stimulus created anxiety in the judges, causing more favorable response from the female judges; that change in content from pleasant to unpleasant led to a change in judgment from positive to negative; that content and the congruency of content with voice set determine the general attitude toward a speaker, but a speaker's voice qualities determine specific impressions of the speaker (Markel and Roblin, 1965).

In 1967, Hunt and Lin published a study which deals with personality judgment accuracy in relation to aspects of the judgment task, of the speaker, of the listener, and of the relationship between the speaker and the listener. The results of the various comparisons suggested that accurate judgment of personal attributes can be made from speech. In this study, the judgments showed "...variations and consistencies typical of psychological abilities" (p. 453). However, the variations in accuracy appear to be a function of the attribute being judged. The authors suggested that accuracy of judgment from "...voice cues seems greater for affective-conative attributes than it is for more behavioral-physical ones" (p. 453). The results further showed that accuracy of

judgment was not affected by the open-mindedness or close-mindedness of the judge or by the in-character, out-of-character role of the speaker. Hunt and Lin (1967) considered the most noteworthy findings of this study to be those which "...support the idea that stable cues to personality are carried by general voice 'qualities' independently of the lexical content of speech" (p.453), since passage content had no effect on judgment accuracy.

That voice disorders and psychological problems are sometimes related is recognized by many. Cooper (1973) noted that voice disorders may create psychological problems. On the other hand, psychological problems, emotions, and personality may be contributory to voice disorders (Berry and Eisenson, 1956; Boone, 1971; Brodnitz, 1965; Cooper, 1973; Emerick and Hatten, 1974; Johnson, et al., 1963; Murphy, 1964; Van Riper and Irwin, 1958; Wilson, 1972).

During the last two decades, some psychiatrists have become aware of the significance of their patients' vocal characteristics in diagnosis and treatment (Diehl, 1960). Moskowitz (1952) believed that speech is an important psychiatric tool, not only because of its content, but by the manner of utterance as well as what is left unsaid. Ostwald (1963) agreed and maintained that all aspects of the speaker's behavior, such as "...

squirms, grimaces, hoarseness, stammering, and other signs" (p. 50) should be scanned for clues to the problem.

Moses (1954) was more explicit in counting the dimensions and features of voice to be studied. He believed that respiration, range, registers, resonance, rhythm, melody, intensity, rate, accents, emphasis, pathos, mannerism, articulation, and pauses are all aspects of voice which can be used in the interpretation of personality.

Todt and Howell (1980) found that five trained judges could differentiate schizophrenic from non-schizophrenic patients on the basis of recorded reading samples. Results indicated not only that schizophrenic patients could be distinguished from non-schizophrenic patients on the basis of voice, but that four main types of information about psychopathology could be identified (general disintegration, dysphoria, social distance, and agitation).

Excellent reviews and discussions of the literature dealing with the relationship of vocal and non-vocal communication to personality and psychological disturbances are presented by Diehl (1960), Duncan (1969), and Mahl and Schulze (1964).

Descriptions and Judgments from Voice of Certain Physical Characteristics Other than Sex

There is some evidence suggesting that information about certain physical characteristics of a speaker may

be inferred from his speech signal.

Diehl (1960), Kramer (1963) and Licklider and Miller (1951) found conflicting evidence in the early research about the ability to judge body type, age, height, and weight of speakers from their voices. In his evaluation of the early research, Diehl (1960) concluded that while body type apparently can be judged from recorded voice with greater than chance accuracy, specific physiological characteristics (age, height, weight) cannot. He acknowledged that the measuring instruments and the methodologies of the reviewed research are antiquated, and he suggested that different results may occur with modernized instruments and more efficient methods.

A study by Ptacek and Sander (1966) investigated the ability of 10 listeners to differentiate the voices of adults under age 35 and adults over age 65. Three listening conditions of decreasing difficulty were presented on tape recordings: (1) four seconds of sustained vowel phonation, (2) a reading sample of 53 words played backward, and (3) the same reading sample played forward. The 72 recordings of the sustained vowel phonation were those used by Ptacek, Sander, Maloney, and Jackson (1966) in a different study. Thirty-six different subjects were used in the reading task and were equally divided into age and sex subgroups as were the 72 earlier sub-

jects. Mean percentages of correctly recognized age groups (under 35, over 65) were 78% on prolonged vowels, 87% on backward speech, and 99% on forward speech. After completing the judgment task, the listeners were asked to reveal the speech or voice characteristics they had used as clues in their judgments. Reading rate and phrasing were given by the majority of the listeners as the influencing clues in the reading conditions. (Mean reading rate for older subjects was 152 words per minute and for younger subjects, 200 words per minute.) Quality, pitch differences, hesitancy, voice breaks, intensity, and vitality were also given as clues which influenced judgments.

A similar study was later conducted by Shipp and Hollien (1969) using 175 adult males equally divided into seven age groups (decades) from 20 to 90 years of age. Each subject recorded the first paragraph of "The Rainbow Passage" (Fairbanks, 1960) from which the third sentence was extracted for use, a sustained vowel (/a/), and a one-minute extemporaneous talk on a neutral topic. Each speaker was presented twice randomly on the 350-item experimental tape. Thirty judges in the first listener group assigned a number indicating "young voice," "neither old nor young voice," or "old voice" to each sample. The second listener group assigned a

number to represent the age decade of each talker, and the third listener group made a direct estimate of each speaker's age. The results, according to Shipp and Hollien (1969)

> ...quantify an empirical impression that most people are able to estimate a talker's age from his voice...
> Findings from all three methods of age estimation strongly suggest that there is a perceptually identifiable parameter (or set of parameters) in speech samples that can be identified as that of age... (p. 709).

Another physical characteristic related to phonation is vital capacity. Vital capacity, which is defined by Michel and Wendahl (1971) as "...the maximum amount of volume of air which can be exhaled following maximum inhalation" (p. 468), has been related to phonation volume, that is, the total volume of air available for maximally sustaining phonation (Yanagihara and Koike, 1967; Yanagihara, et al., 1966). Yanagihara and Koike (1967) reported that as a person's pitch level decreases, both the phonation volume and the ratio of phonation volume to vital capacity decrease. Vital capacity and phonation time also appear to be related (Hirano, Koike, and von Leden, 1968). The results of their study on normal subjects indicate that higher flow rates were associated with shorter phonation times or larger vital capacities.

It is generally considered that the pitch of a person's voice should be appropriate to his sex and age (Michel and Wendahl, 1971). Peterson and Barney (1952)

generalized that the pitch of children's voices is higher than that of adult voices and that the pitch of women's voices is generally higher than that of men's voices.

In order to investigate the speaking fundamental frequency of adult males and its change as a function of age, Hollien and Shipp (1972) used 175 normal, healthy men ranging in age from 20 to 89. The subjects were grouped by decade, with 25 speakers in each. Recordings were made of each subject reading the first paragraph of Fairbanks' (1960) "The Rainbow Passage," and the mean fundamental frequency measures of each reading were obtained.

The data were compared with that of related studies and led to the conclusion that there is a "...progressive lowering of average voice in males from preadolescence until sometime in the 40 to 50 year range, and then a steadily rising trend until old age" (Hollien and Shipp, 1972, p. 158).

In a study to obtain information concerning pitch characteristics of aged women, McGlone and Hollien (1963) concluded that the speaking pitch level of women appears to vary little throughout adult life and that women's speaking pitch variability does not change appreciably with advancing age.

In order to report the mean fundamental frequency

and frequency variation of middle-aged women, Saxman and Burk (1967) divided 18 women into two groups. One group consisted of nine subjects aged 40 to 50. Each subject was recorded reading the first paragraph of "The Rainbow Passage" (Fairbanks, 1960). The results of the tape recording analysis showed the mean fundamental frequency for the 18 speakers to be 192.47 Hz and the range to be 168.48 to 221.75 Hz. The 30- to 40-year-old group showed a mean speaking frequency of 196.34 Hz with a range of 171.14 to 221.75 Hz while the 40- to 50-year-old group showed a mean of 188.58 Hz with a range of 168.48 to 208.26 Hz. These results when compared with those of previous studies of other age groups (Linke, 1973; McGlone and Hollien, 1963; Michel, et al., 1965) led the authors to suggest a trend for the speaking fundamental frequency of females to decrease during the mid-ages then rise again during old age.

Snidecor (1951) attempted to describe objectively the pitch and duration characteristics of superior female speakers and to compare the data with values established for superior male speakers (Pronovost, 1942). The results indicated that women's pitch levels were approximately two-thirds of an octave above the men's pitch levels; the median pitch levels of the subject groups were within limits of less than one and one-half tones; 50% of the

pitches used by the females were lower than the highest pitches used by the males; generally, the women's pitch was less variable than that of the men, but total pitch ranges were approximately the same for both sexes. The results also indicated that except in downward shifts between phrases, the mean extents of phonations, inflection, and shifts were slightly less for women than for men speakers. In both groups, upward shifts exceeded downward shifts in number and in mean extent. There was a less rapid mean rate of pitch change in the women's voices; women's voices had shorter mean duration of phonations than men's voices; and both groups' speaking voices encompassed pitches below the lowest tones which the singing voice can sustain (Snidecor, 1951).

Linke (1973) studied the pitch level and variability of female voices, as well as those attributes of pitch levels and variability which contribute to judgments of general effectiveness of female voices. Sixty female speech students were recorded reading an expository prose passage. Each was judged by 30 graduate students and instructors in speech on a nine-point, equal-appearing-intervals scale with a rating of one indicating superior voice usage, and a rating of nine indicating very ineffective voice usage. From this sample, 27 samples were selected for analysis of fundamental frequency, frequency

range, and variability. Average median fundamental frequency was found to be 201 Hz and range of median frequency was reported as 20.55 to 23.15 tones. A correlation analysis of these acoustic measures and judgment ratings of vocal effectiveness led the author to suggest that "...women may be tending to use median pitch levels which are lower than would seem advisable for the most effective employment of their voices in speech" (p. 185). In comparing his results with those of studies of male voices, Linke (1973) found that there is a difference of less than two-thirds of an octave in median frequency levels and that "...female voices exhibit generally less frequency variability than do male voices" (p. 184).

A comparison of the pitch and duration characteristics of oral reading and impromptu speaking performed by Snidecor (1943) showed slightly higher levels were used in reading than in impromptu speeches. Reading also exceeded impromptu speaking in pitch variability, mean rate of pitch change, and in the number of changes in the direction of pitch per second.

Fitch and Holbrook (1970) correlated both height and weight with modal vocal fundamental frequency using 100 male young adults and 100 female young adults. The results were consistently negative but not statistically significant.

In discussing pitch variability, Fairbanks (1960) contended that a good speaker will usually distribute pitches over a range of approximately two octaves while reading a short sample. He also maintained that the pitch ranges of men and women used in reading overlap substantially. Hollien and Michel (1968) agreed that overlapping of pitch ranges occur in men and women. They reported group modal frequency limits of 71 Hz to 561 Hz for the male pitch range and 122 Hz to 798 Hz for the female pitch range. The male range was just over an octave and a half while the female range was nearly two octaves. Fitch and Holbrook (1970) reported the modal fundamental frequency range to be 85 Hz to 155 Hz for males and 165 Hz to 225 Hz for females, showing only a 10 Hz difference between the highest of the male modal fundamental frequency range and the lowest of the female one. The mean of the modal fundamental frequencies of the 100 male subjects was reported to be 116.65 Hz and that of the 100 female subjects to be 217.00 Hz.

Hollien, et al., (1971) reported data on the adult phonational frequency range which is defined as

> "...that range of vocal frequencies encompassing both the modal and falsetto registers; its extent is from the lowest tone sustainable in the modal register to the highest in falsetto, inclusive; the vocal fry register is not included" (p. 755).

Data were repoted on the phonational ranges of 332 male

and 202 female adults, aged 18 to 36 years. Range was determined by having each subject match his pitch while phonating a vowel to the frequency of one of a series of discrete sinusoids. The difference between the highest and the lowest matched frequencies plus one semitone constituted the phonational range. The results indicated the mean phonational frequency range to be in excess of three octaves, 38 semitones for males and 37 semitones for females. The mean lowest frequencies of phonation were 78 and 139 Hz for males and females, respectively, and the mean highest frequencies of phonation were 698 and 1108 Hz for males and females, respectively. Mean phonational ranges were 37.9 semitones for the males and 37.0 semitones for the females. No differences in phonational frequency range were found relating to age.

More recently, Hollien and Jackson (1973) reported normative data on the speaking fundamental frequency characteristics of 157 young adult males aged 17.9 to 25.8 years. Each subject was recorded reading a prose passage and speaking extemporaneously. The recordings were then edited and processed by the Fundamental Frequency Indicator, which yielded the geometric mean frequency level and the distribution standard deviation. Phonational (term used by authors) frequency range, including both modal and falsetto registers, was obtained

on each subject by having him match recorded reference tones produced by a sine-wave generator. Height, weight, head circumference, neck circumference, chest circumference (inflated and deflated), waist circumference, arm length, and leg length were measured to investigate possible relationships between body measures and voice parameters. Lateral x-rays of each subject's larynx provided anterior-posterior distance measures. The results showed a mean oral reading fundamental frequency of 129.4 Hz with a standard deviation of 1.6 tones. Hollien and Jackson (1973) considered this value to fall "...within the ranges of similar data reported in previous research" (p. 119). A mean fundamental frequency of 123.3 Hz was found for extemporaneous speaking, a figure somewhat lower than that for oral reading. Over the modal and falsetto registers, the maximum phonational frequency range was 62.0 to 1568.0 Hz with a mean range of 79.5 to 763.6 Hz. Since no statistically significant correlations between any of the voice parameters and either laryngeal size or body dimensions were found, Hollien and Jackson (1973) concluded that "...these data do not confirm Hollien's (1962) postulation that SFF correlates positively with certain measures of physical size" (p. 120). According to Hollien and Jackson (1973), the data from this study on oral reading and extemporane-

ous speaking fundamental frequency levels and phonational frequency ranges should be considered normative for college-age U. S. males.

Speaking "...rate is influenced by the number of pauses and phonations in an utterance" (Hoops, 1969, p. 70). Traditionally, speaking rate is described as the number of spoken words per minute during a complete speaking performance (Kelly and Steer, 1949). Cotton (1936), however, used the syllable as the unit of rate. He concluded that "...from syllable to syllable speech rate varied from 50 to 450 words per minute (p. 112). Cotton (1936) was of the opinion that while speech rate determinations may be useful for some purposes, they are not particularly useful in scientific speech studies. Fairbanks and Hoaglin (1941) used the phrase as a unit of measure and found a rate range of 136 to 320 words per minute. Kelly and Steer (1949) analyzed the sentence rates of two-minute extemporaneous speech samples from 24 college speech students. The samples were also rated by judges on a one-to-five scale, with one being very slow and five being very fast. Results of the study showed extreme variability in rate in extemporaneous speech ranging from 125 to 328 words per minute. It was also found that "...in extemporaneous speaking, the mean sentence rate agrees more closely with audience

judgment than does over-all rate" (p. 225). Snidecor (1951) compared the oral reading rate of male and female speakers and found little difference between the two sexes in rate.

A study of the effect of distracting noise on speaking rate, duration, and intensity by Hanley and Steer (1949) led to the conclusion that speakers react to the presence of noise by reducing the rate of speaking, prolonging syllables, and speaking with greater intensity as the noise increases.

In a later study to show the relationships among fundamental frequency, intensity, and speaking rate, Black (1961) chose 20 male subjects who demonstrated the ability to control their vocal effort from soft to loud, spanning a 30 dB range. Each subject recorded three vowels and three phrases at each of the four intensity levels. Results of the study showed that increases in vocal sound pressure were accompanied by increases in fundamental frequency and that soft speech was characterized by a slow speaking rate.

In 1965, Markel investigated the reliability of rating paralinguistic pitch, loudness, and tempo. A group of trained judges and a group of untrained judges rated speech samples of both male and female speakers on three seven-point scales ranging from extremely low

(soft, slow) to extremely high (loud, fast). Each group judged the samples twice, the second judgment being made from seven to ten days after the first. The results clearly indicated that pitch, loudness, and tempo can be reliably rated.

Judgment of Male-Female, Masculine-Feminine From Voice

Many of the previously cited studies which deal with various descriptions and measurements of voice differentiate male and female vocal characteristics (Black, 1949; Curry, 1940; Duffy, 1970; Fairbanks, 1960; Fairbanks, Herbert and Hammond, 1949; Fairbanks, Wiley, and Lassman, 1949; Fitch and Hombrook, 1970; Hollien, 1960a,b; Hollien and Michel, 1968; Hollien and Paul, 1969; McGlone and Hollien, 1963; Michel, et al., 1965; Mysak, 1959; Peterson and Barney, 1952; Pronovost, 1942; Snidecor, 1951). However, the research dealing with the judgment of a speaker as being male or female and/or as being masculine or feminine from the voice alone is limited.

Due to the increasing interest in voice printing and speaker identification, Voiers (1964) realized the necessity of determining the number and nature of the basic ways in which a listener will perceive differences in voices. Sixteen male voices were described by 32 listeners on a 49 item semantic-differential rating

scale. To determine the dimensionality of the speaker effect, the listener effect, and the effect of the interaction of speakers and listeners, factor-analytic techniques were employed. Four factors labeled clarity, roughness, magnitude (the group which included the description "masculine-feminine"), and animation accounted for "...an average of 88% of the variance in mean ratings given speakers on each of the 49 items" (Voiers, 1964, p. 1065).

To investigate the listener's ability to identify the speaker's sex from isolated, voiceless fricatives, Schwartz (1968) recorded the production of /f/, /θ/, /s/, and /ʃ/ by nine adult males and nine adult females and presented the recordings randomly to 10 listeners. The results indicated that the listeners could identify the sex of the speakers from the production of /s/ and /ʃ/ but not from /f/ and /θ/. Spectrographic analysis of the /s/ and the /ʃ/ productions revealed that the female spectra tended to be higher in frequency than the male spectra.

A follow-up study was conducted using isolated, whispered productions of /i/ and /a/ as stimuli. The speakers were five adult males and five adult females. Eight adult listeners judged the speaker of each stimulus as male or female. The results showed that no errors

were made in the identification of speaker sex for /a/ and four errors were made for /i/. The results of the spectrographic analysis were similar to those noted for /s/ and /ʃ/ in the previous study. Schwartz and Rine (1968) concluded

> ...that listeners are able to identify speaker sex from isolated production of whispered vowels; the primary acoustic cue that underlies the distinction appears to be the upward frequency displacement of the resonance peaks of the female vowels (p. 1737).

A series of experiments modeled after that of Schwartz (1968) but which included more voiceless fricatives spoken in isolation as stimuli were conducted by Ingemann (1968). Her results support Schwartz' findings that speaker sex can be distinguished with better than chance accuracy from many voiceless fricatives. In several of the experiments, Ingemann (1968) attempted to locate cues in a portion of the fricatives by tape-cutting procedures. These attempts did not produce positive results, and the only conclusion which could be made was "...that a part is usually more difficult to identify than the whole" (p. 1144).

Beasley, Zemlin, and Silverman (1972) studied listeners' judgments of sex, intelligibility, and preference for frequency-shifted speech. Eleven vowels embedded in an /h-vowel-d/ context were the stimulus

items spoken by two normal male and two normal female adults. The stimuli were processed through five conditions (20% through 60% in 10% increments) of frequency shifted-time expanded and frequency shifted-time restored. Twenty-nine adult listeners rated the stimuli on semantic-differential type scales of masculine-feminine, like-dislike, and intelligible-unintelligible. The results showed (1) that the female speech sounded increasingly more masculine for 20% to 60% with the effect most pronounced in the frequency-shifted-time-restored conditions; (2) that the female speaker was preferred over the male speaker; and (3) that the female speaker was considered more intelligible than the male speaker.

Wolf (1972) found fundamental frequency, features of vowel and nasal spectra, estimation of glottal source spectrum slope, word duration, and voice onset time to be useful parameters in the identification of speakers. He suggested that fundamental frequency is the easiest parameter to modify in order to disguise the voice. Coleman (1973) used the electro-larynx as sound source to equalize the glottal source characteristics of his subjects, 10 normal-speaking adult males and 10 normal-speaking females. The study was designed to test the accuracy of speaker identification in the absence of inter-subject differences in glottal source characteris-

tics and to compare male and female speakers under these conditions. A listening tape was prepared which contained 40 pairings of the subjects' speech samples: 20 pairs consisting of the speaker paired with himself, 10 pairs consisting of a male paired with a female, five pairs consisting of two different males, and five pairs consisting of two different females. Twenty-eight listeners judged each pair as the same or different people. According to Coleman (1973),

> The results of the study indicate that sufficient individuality exists in speech characteristics other than those associated with glottal sound source to support speaker-pair discrimination with slightly better than 90% accuracy... The study also indicated that female speakers may be expected to be more successful in disguising their voices in this way than males. Such a finding suggests that males may differ more among themselves on the nonphonatory aspects of speech (p. 1743).

Coleman (1976), in two experiments, compared the contributions of fundamental frequency and vocal tract resonance to the perception of maleness and femaleness in the voices of adults. Twenty normal adult males and 20 normal adult females were recorded. Each repeated a standard six-word sentence twice, read a section of "The Rainbow Passage" (Fairbanks, 1960) twice, and produced each of the vowels /i/, /u/, /ɛ/, and /a/ three times. While the sample sentences and one version of "The Rainbow Passage" were produced normally, the vowels

and two versions of "The Rainbow Passage" were produced with a laryngeal vibrator, 120 Hz and 240 Hz being representative of the typical male and female fundamental frequency, respectively. To compute vocal tract resonances (VTR), values for Formants 1, 2, and 3 were averaged for each vowel /i/, /ɛ/, and /u/. The two repetitions of the sentence were used to determine the fundamental frequency of each speaker. In Experiment I, 17 judges listened to five-second samples of the normal voice productions of "The Rainbow Passage" presented backwards and were asked to determine each speaker's sex and to estimate on a seven point scale "how much of the quality they associate with that particular sex was present in each voice" (p. 172). Results indicate that fundamental frequency of natural voice correlated highly with degree of maleness and femaleness while vocal tract resonances correlated less highly. In Experiment II, the five female speakers with the highest vocal tract resonances and the males with the lowest vocal tract resonances were selected from the first experiment's speakers. Each speaker articulated the tone of the 120 Hz and 240 Hz laryngeal vibrators. Therefore, the listening tape consisted of combinations of low vocal tract resonance with both low and high fundamental frequency. Listeners were asked only to identify the sex of the speaker. Results

indicate that sex identification is easy to make when both vocal characteristics are consistent with one sex, that is, high vocal tract resonance with high fundamental frequency and low vocal tract resonance with low fundamental frequency. However, when the two characteristics were contrasted in the same voice, "...both male characteristics were found to be perceptually more prominent than their female counterparts" (p. 178).

There is a scarcity of experimental research which would relate certain acoustic parameters with the perception of femininity and masculinity in voice. Suggestions that high pitch in the voices of males is associated with effeminacy are made, however, in the literature (Brodnitz, 1965; Moore, 1971b; Van Riper and Irwin, 1958). According to Moore (1971b),

> A consistently high-pitched voice in the late adolescent and adult male is one of the most distressing of voice defects. The resemblance to the female voice suggests a lack of masculinity. It is this implication, with its psychosocial sequelae, which creates the seriousness of the disorder, since the voice proper does not interfere with communication; nor would it be unpleasant if it were produced by a female (p. 539).

Terango (1966) investigated the fundamental frequency and duration of male voices which were judged to be effeminate and masculine. To obtain his subjects, Terango (1966) asked the faculty of the Speech Depart-

ment, Kent State University, to refer male students who they thought exhibited masculine speech and those who they thought exhibited effeminate speech. The 40 referred males were recorded reading "The Rainbow Passage" (Fairbanks, 1960), and the recordings were randomly presented to 27 male and 117 female judges to rate on a nine-point masculinity-femininity continuum. From this analysis, seven voices at each extreme were used for the acoustical analysis. The results yielded a 127 Hz median frequency for the masculine voices. Mean rate of pitch change during inflections (tones per second) was 23.35 tones for the effeminate voices and 17.51 tones for the masculine voices. A measurement of downward inflections showed 20.61 tones for the effeminate voices and 18.00 tones for the masculine voices. Mean reading rates were 185 and 194 words per minute for the effeminate and masculine groups, respectively. Terango (1966) concluded that the only measure "...which indicates rather positive trends toward differentiating the effeminate voices from the masculine voices is the mean rate of pitch change during inflections" (p. 594).

Descriptions and Judgments of Male-Female, Masculine-Feminine From Language

Research dealing with sex differences in the development of expressive language in children is abundant

(Cowan, et al., 1967; Fisher, 1934; McCarthy, 1930, 1954; Templin, 1957; Winitz, 1959). However, information which pertains to sex differences in the language of adults is scarce, and that which does exist only implies in a general manner that there are content differences in the language usage of the two sexes.

In a pamphlet published by the Erickson Educational Foundation (1974a), the statement is made that speech therapists who work with male-to-female transsexuals point out that "...the use of a more feminine vocabulary" (p. 26) contributes to a more feminine impression. What constitutes a "feminine vocabulary" is not explained. Likewise, Money and Primrose (1969) suggest that male transsexuals may increase a feminine effect through the use of "...feminine idioms and emotional vocalizations" (p. 118fn) in their speech. Those terms, "feminine idioms" and "emotional vocalizations," are not defined and no examples are given.

In a discussion of intelligence tests, Anastasi (1958) and Tyler (1965) stated that there is a consistent difference between the sexes in verbal ability and that females express themselves in words more readily and more skillfully than males from infancy to adulthood. Tyler (1965) reviewed several studies on comparisons of vocabularies, concluding that the sex groups do not differ

significantly in that regard.

While Yorberg (1974) agreed that "...more females have better verbal skills--they learn to speak sooner, articulate more clearly, and use longer sentences, better grammar, and more correct spelling" (p. 158), she found no significant differences in the performance of males and females on adult intelligence tests. Yorberg (1974) did not find this fact surprising since she maintained that "...items on intelligence tests are standardized to eliminate sex differences" (p. 159).

In a study designed to examine the relationship of verbal aptitude to psychosocial development in cases of gender identity disorder (eonism and juvenile effeminacy), Money and Epstein (1967) reviewed the results of the Wechsler Intelligence Scale--the Wechsler Intelligence Scale for Children administered to subjects under age 16, the Wechsler Adult Intelligence Scale and the Wechsler-Bellevue Form 1 administered to adults. The results, according to Money and Epstein (1967), "...agree with published social psychological surveys that imply a relationship between verbal aptitude and feminine interests" (p. 453).

Three early studies (Carlson, et al., 1936; Landis and Burtt, 1924; Moore, 1922) categorized by topic fragments of overheard conversations and concluded that

there are marked sex differences in conversational topics. The most controlled study (Carlson, et al., 1936) reported that men talk more about money and business and sports while women talk more about other women and clothes.

The masculinity-femininity (hereafter called M-F) scales developed by psychologists deserve mention. According to Tyler (1965), the most thorough and comprehensive investigation of tests for measuring masculinity-femininity was that of Terman and Miles (1936). According to Terman and Miles (1936), the purpose of the M-F test is to quantitatively estimate the amount and direction of deviation from the mean of one's sex, and to make quantitative comparisons of groups which differ in such traits as age, intelligence, education, culture, occupation, and interests.

Other M-F scales have been developed since that of Terman and Miles (1936), and the accompanying research has shown "...that masculinity-femininity is not a unidimensional trait" (Tyler, 1965, p. 263). Tyler (1965) concluded her discussion of M-F scales by stating that while they may be useful for classifying subjects in some kinds of research, the scales are "...no longer an important focus of research interest" (p. 264).

In regard to sex differences in language content--vocabulary, sentence structure (length, complexity)--

there appears to be no available definitive information (Tavris and Offir, 1977). Furthermore, a search of the literature has yielded no evidence that reliable judgment of sex and/or masculinity-femininity of a person can be made from a transcribed (written) spontaneous speech sample about a neutral subject.

Voice Characteristics of Homosexuals

According to Laver (1968), "We all act, as listeners, as if we were experts in using information in voice quality to reach conclusions about biological, psychological and social characteristics of speakers" (p. 50). There is a tendency to make stereotyped judgments of an individual based on his speech or vocal characteristics (Kramer, 1963; Laver, 1968; Ostwald, 1963). For example, a person speaking in a "tremulous" voice might be considered anxious or tense (Ostwald, 1963). A "weak" voice might be associated with a weak, submissive, shy, or repressed person; a "loud" voice, with a self-assured, aggressive, arrogant, dominant, or brutal person (Murphy, 1964).

An individual's vocal image--the voice he either likes or dislikes or either identifies with or declines to identify with--is an important influence on his vocal characteristics (Berry and Eisenson, 1956; Cooper, 1973). This vocal image is formed by the cultures

surrounding the individual, his peer group, his family, and the communication media (Berry and Eisenson, 1956; Cooper, 1973). Early in childhood, one learns to imitate or identify with those individuals important in his environment (Cappell, 1978; LaTorre, 1979; Lips, 1978; Murphy, 1964; Tavris and Offir, 1977). If, as some of the literature suggests, the male homosexual identified more strongly with his mother than with his father and the female homosexual identified more strongly with her father than with her mother, and each adopted the mannerisms of that parent, then perhaps the vocal characteristics of that parent would also be emulated (Gagnon and Simon, 1973; Moses, 1954).

The stereotypical view of the homosexual male is usually one of effeminate body manner, affected speech, and a high-pitched voice (Lerman and Damste, 1969). If stereotyped judgments are based on some aspects of reality, then the assumption could be made that the male homosexual's vocal output is of a higher perceived pitch than that of the male heterosexual, and it would appear to follow that the fundamental frequency of the male homosexual would be higher than that of the male heterosexual (Lerman and Damste, 1969). To test this hypothesis, Lerman and Damste (1969) designed a study in which the mean fundamental frequencies of a group of

male homosexual adults and a group of male heterosexual adults were measured and compared. Each subject produced six speech samples; a read passage, spontaneous speech of five or more sentences, sustained phonation for two seconds of /i/ in saying the word "Marie," and sustained phonation for two seconds of /a/ in saying the syllable "lah." According to Lerman and Damste (1969), there were no statistically significant differences in fundamental frequency between the homosexual and heterosexual groups on any of the sample types. The authors concluded that when only voice pitch characteristics are considered, the voices of male homosexuals and male heterosexuals cannot be differentiated. Lerman and Damste (1969) suggest

> That no differences were present may be due to: 1. the fact that no real differences exist; 2. the fact that because homosexuality is considered abnormal behavior and not totally acceptable to society, the homosexual tends to use his 'higher' voice only in his own social milieu; or 3. the possibility that the role of the homosexual in his relationships (masculine or feminine) helps determine his vocal quality and our sample consisted mainly of those homosexuals adopting a masculine role in the relationship (p. 344).

From an anatomical viewpoint, the results of Lerman and Damste's study (1969) might be expected. The male subjects, both homosexual and heterosexual, were adults and therefore presumably had experienced pubertal voice mutation resulting from an increase in androgens and

consisting of laryngeal growth, vocal fold thickening, and a drop in the lower range of the voice (Brodnitz, 1971; Zemlin, 1968). This assumption would appear valid in view of Money's (1970) conclusion after reviewing the research regarding hormonal factors that may be related to behavioral homosexuality. Money (1970) stated that "One may fairly safely interpret today's clinical evidence to mean that the sex-hormone levels of adulthood have very little to do with the etiology of homosexuality" (p. 434).

Scientific research on the voice characteristics of homosexuals, both male and female, appears to be limited to the Lerman and Damste (1969) study. Weinberg and Bell (1972) annotated 1263 items--books and articles written in or translated into English from 1940 to 1968--related to male and female homosexuality. None of the items presented research data on the voice characteristics of homosexuals. When voice characteristics are mentioned in the literature dealing with homosexuals, as well as with transsexuals and presumed heterosexuals, they are nearly always done so subjectively by equating high-pitched voice in males with femininity and low-pitched, "hoarse" voice in females with masculinity (Cooper, 1973; Moses, 1954). More frequently mentioned and of apparently more concern are descriptions of

homosexuals and transsexuals in terms of their attitudes, dress, values, behavior, and sexual object choice (Baker, 1969; Barlow, et al., 1973; Benjamin and Ihlenfeld, 1973; Forester and Swiller, 1972; Gagnon and Simon, 1973; Green, 1970; Newman and Stoller, 1974; Socarides, 1969; Stoller, 1973).

Other Related Studies

According to Benjamin and Ihlenfeld (1973), "Transsexualism is a disorder of gender identity" (p. 457). The etiology of transsexualism is unknown and it is the subject of much discussion and controversy (Money, 1968; Pauly, 1969). The homosexual, the transvestite, and the hermaphrodite may also experience "...gender identity disturbances which are sometimes confused with transexualism [sic], but which are distinct from it" (Erickson Foundation, 1974b, p. 2). Eonistic transsexualism is the syndrome commonly referred to in the literature as the phonomenon "transsexualism." Money (1969) describes eonistic transsexualism in this way:

> In eonistic transsexualism, there is no known discrepancy between the sex assigned at birth, and the appearance of the external genitals. Typically, also, there is no discrepancy between assigned sex and the other measurable somatic criteria of sex. This is not to say that transsexuals are physiologically and morphologically all identical, but simply that the vast majority fall within the limits of normal variation...(p. 111).

Because differential diagnosis is difficult, special care is given and considerable time is spent in selecting the individuals who would undergo sex reassignment surgery (Baker, 1969; Benjamin and Ihlenfeld, 1973; Cappon, 1970a, b; Green, 1970; Newman and Stoller, 1974; Socarides, 1969). Green (1970) summarized the psychiatric management of persons who seek sex reassignment in this way:

> Management of persons seeking sex reassignment includes exploring their motivation for sex change, facilitating a realistic appreciation of the limits of medical and surgical procedures, encouraging them to undergo reversible somatic changes with hormones during a trial period of living in the desired gender role prior to undertaking irreversible surgical steps, promoting a realistic anticipation of the future after sex reassignment, and, for those who undergo sex change, assisting in the postoperative adjustment (p. 1596).

In view of Money's (1969) description of the eonistic transsexual as falling within the limits of normal variation physiologically and morphologically, it is not surprising that voice characteristics of the transsexual before hormone treatment are given little, if any, attention . Green (1970) did, however, make the observation that many males requesting consultation over the telephone display a voice with "...an unusual hoarse, slow, studied quality to it--the result of an attempt to sound more feminine" (p. 1597).

An integral element in the sex reassignment procedure is hormonal therapy. The role of hormones in male

pubertal voice mutation is well-known (Brodnitz, 1971; Duffy, 1970; Zemlin, 1968). Several studies have reported the virilizing effects of certain hormones on the voice of females (Brodnitz, 1971; Damste, 1964, 1967; Dordain, 1972; Goldman and Salmon, 1942; Pruszewicz, et al., 1973; Wendler, 1972).

The effects of androgens (male hormones) on female vocal anatomy is dramatic. The change which occurs is the same as that which occurs in the pubertal male, namely, increased laryngeal and vocal fold size resulting in a deepening of the voice and prominent Adam's apple (Benjamin and Ihlenfeld, 1973; Green, 1970; Hamburger, 1969; Money and Primrose, 1969). The new status of the androgenized female's vocal anatomy is irreversible, and the female transsexual is advised during the pre-operative management period of these results of hormonal therapy should the decision be made not to proceed with sex reassignment surgery (Green, 1970). Her advantage over the male transsexual is that, as a result of the androgen therapy, the change to a true masculine voice will greatly facilitate her acceptance as a male (Money and Primrose, 1969).

The adult male transsexual, having already undergone vocal mutation at puberty, is at a disadvantage since that effect of his naturally produced testosterone

is irreversible by any amount of estrogen (female hormone) administration (Green, 1970; Hamburger, 1969; Money and Primrose, 1969). For cosmetic reasons, he may choose to have the Adam's apple reduced in size by a plastic surgeon (Money and Primrose, 1969).

Some transsexuals seek professional assistance in voice training. The Erickson Foundation (1974a) reported that

> ...Speech therapists who work with male-to-female transexuals [sic] concentrate not only on raising the pitch and reasonance and softening the quality of the voice; they point out that the use of a more feminine vocabulary, more careful articulation, and a greater range of inflection (rise and fall) of the voice all contribute to a more feminine impression (p. 26).

It should be noted that there is a lack of research which would justify such therapeutic techniques.

In regard to voice use, Money and Primrose (1969) observed that

> The majority of male transsexuals are able to effect a transformation of their voices so that they neglect the lower registers in favor of the higher. They may gain further feminine effect by means of a whispery huskiness or by means of a slight lisp. They may also increase the effect still further by the subtle use of feminine cadences and modulations of vocal speed, to which are added feminine idioms and emotional vocalizations. When to all of this is added the effect of feminine facial postures and speaking gestures, including gestures of the arms, it is possible to create so complete a feminine effect that the listener does not question the sex of the speaker. It is accepted that she is vocally a woman (p. 118fn).

Purposes of the Study

Definition of Terms

Certain variables refers to the measure of modal fundamental frequency, intensity, pause time, and rate (words per minute and syllables per second).

Sex characteristics refers to the speaker's anatomical gender (male, female) and to the auditor's impression of the speaker's masculinity or femininity as judged from his speech.

Speech refers to tape recorded samples of spontaneous speech and those of a read passage.

Heterosexual refers to individuals who admit to preference for sexual relationships with members of the opposite sex.

Homosexual refers to individuals who admit to preference for sexual relationships with members of their own sex.

Specific Questions

The primary purpose of this study was to investigate the relationship of listener judgments of speaker sex and speaker masculinity-femininity and the physical measurements of modal fundamental frequency, intensity, pause time, and rate.

Specifically, this study attempted to answer the

following questions:

A. Can reliable judgments of speaker sex and speaker masculinity-femininity be made from tape recorded samples of spontaneous speech and read speech? (See Chapter 3).

B. Regarding the four sex-by-speaker type groups (female heterosexual, homosexual; male heterosexual, homosexual), the two speech modes (spontaneous speech, reading), do speech mode, speaker sex, and/or speaker type significantly affect
   1. Judgments of sex?
   2. Judgments of masculinity-femininity?

C. Are there significant differences between those speakers whose sex was incorrectly identified and those whose sex was correctly identified in terms of rate, fundamental frequency, and intensity measures?

D. Are there significant differences between those speakers who were described incorrectly as masculine or feminine and those who were described correctly in terms of rate, fundamental frequency, and intensity measures?

E. Regarding the four sex-by-speaker type groups (female heterosexual, homosexual; male hetero-

sexual, homosexual) and two speech modes (spontaneous speech, reading),

1. Are there significant differences between spontaneous speech and reading in terms of rate, fundamental frequency, and intensity measures?
2. Are there significant differences between female and male speakers in terms of rate, fundamental frequency, and intensity measures?
3. Are there significant differences btween heterosexual and homosexual females in terms of rate, fundamental frequency, and intensity measures?
4. Are there significant differences between heterosexual and homosexual males in terms of rate, fundamental frequency, and intensity measures?

Chapter 2

PROCEDURES AND RESEARCH DESIGN

Phase One

In order to determine if reliable judgments of speaker sex and speaker masculinity-femininity can be made from tape recorded samples of spontaneous speech and read speech, a preliminary study, Phase One, was designed and run. The data obtained from Phase One were analyzed by means of two multivariate analyses of variance. Phase One is reported in detail in Chapter 3.

Phase Two

Judges

Five male and 15 female adults served as judges. The chronological age range of the group was 21 to 49 years. Six of the judges held masters degrees, four held bachelors degrees, nine completed at least one year of college, and one completed high school. The judges were "untrained" in the sense that none had experience in the diagnosis and treatment of speech and voice disorders.

Speakers

Two types of speaker provided the speech stimuli for judgment: heterosexual and homosexual. There were

23 speakers: five heterosexual males, six heterosexual females, eight homosexual males, and four homosexual females. The chronological age range of the group was 21 to 40 years.

Individuals who demonstrated speech and/or hearing disorders extraneous to the present study, such as, stuttering, foreign dialect, articulation (with the possible exception of "sibilant affectation"), excessive nasality, language problems, etc., were excluded from the study. The absence of these disorders was verified by three certified speech pathologists who listened to the taped speech samples.

Pertinent biographical information was obtained through the use of a questionnaire completed by each volunteer speaker (Appendix A). Each volunteer speaker was asked to sign Participation Agreement (Appendix B).

Speech Samples

Spontaneous Speech: Each speaker was shown the same Currier and Ives print and instructed to "tell a story about this picture." The resulting speech samples of approximately 30 seconds in length were tape recorded.

Read Speech: Each speaker was recorded reading the first paragraph of "The Rainbow Passage" (Fairbanks, 1960).

Measurements

Judgmental: Each of the 46 speech samples (23 speakers, two samples -- spontaneous and read -- each) was judged using the instructions and check lists shown in Appendices C and D. For each sample, judges were asked to determine the anatomical sex of the speaker and to describe the speech of the speaker as being masculine or feminine. "Undecided" was an option for both judgments.

Physical: The following measurements were made on each of the 46 recorded speech samples: (1) syllables per second, (2) words per minute, (3) percent pause time, (4) fundamental frequency low, (5) fundamental frequency high, (6) fundamental frequency mode, (7) fundamental frequency range, (8) intensity mean, (9) intensity low, (10) intensity high, (11) intensity standard deviation, and (12) intensity range.

The fundamental frequency measurements were made at Florida State University using the Florida I, a frequency-to-voltage converter. By suppressing the harmonic partials in a complex wave form, the Florida I tracks the fundamental frequency and registers the duration of the fundamental vocal frequency energy falling within a preset band-pass (20 Hz for males, 30 Hz for females). The modal fundamental frequency is the center frequency of the band-pass which registers the greatest duration.

Florida I is described in more detail by Holbrook and Meador (1969).

For each speech sample, scanning was begun at the band-pass where, according to normative data, one would expect to find the mean fundamental frequency for the speaker's age and sex. Band-passes above and below the starting point were then analyzed until the highest and the lowest band-passes at which energy registered were found. These band-passes constituted the upper and lower limits of the speaker's fundamental frequency range.

To measure relative intensity, a Bruel and Kjaer Graphic Level Recorder (GLR), type 2305, with a 0-50 dB potentiometer was used. A graphic ink recording was made on paper divided into dB units. The peak values of the wave forms were identified to the nearest dB and recorded. An Ampex AG 440-B tape recorder provided the input source to the GLR.

Total speaking time and articulation time, the difference between which is pause time, were measured through the use of the Duration Encoder, an instrument developed in the Speech Research Laboratory at Florida State University. The Duration Encoder is an electronic switch device capable of determining the duration of each signal to within a 0.5 millisecond. The amplified speech signal from an Ampex AG 440-B dual channel tape recorder

opened the switch causing the signal from a 1000 Hz electronic tuning fork (American Time Products, Type 2001-PE) to be gated, thus activating the timing device, a Fluke frequency counter Model 1953-A, operating in the summing mode.

Recording Presentations

The 46 speech samples were randomized for the listening/judging session in such a way that two speech samples from the same individual were not presented adjacent to each other.

Recording Equipment

All recordings were made in a sound-treated room using a Sony Model TC-570 tape recorder and a Teledyne electret condenser lapel microphone, Model EO-300.

The tape randomization and copying processes were performed using a Sony Model TC-270 tape recorder and the Sony Model TC-570 tape recorder as the slave recorder.

Statistical Analysis

The method of analysis involved the following:

A. Fourteen 2 x 2 x 2 least squares analyses of variance (two speaker sexes: female, male; two speaker types: heterosexual, homosexual; two speech modes: spontaneous speech, reading) utilizing 14 criterion measures:

1. Mean syllables per second
2. Mean words per minute
3. Mean percent pause time
4. Mean fundamental frequency low
5. Mean fundamental frequency high
6. Mean fundamental frequency mode
7. Mean fundamental frequency range
8. Mean intensity mean
9. Mean intensity low
10. Mean intensity high
11. Mean intensity range
12. Mean intensity standard deviation
13. Percent of incorrect sex judgments
14. Percent of incorrect masculine-feminine judgments

B. Twelve one-way analyses of variance (female speakers incorrectly judged male/undecided) utilizing 12 criterion measures (See A, 1 - 12).

C. Twelve one-way analyses of variance (females incorrectly described as masculine/undecided) utilizing 12 criterion measures (See A, 1 - 12).

D. Twelve one-way analyses of variance (males incorrectly judged female/undecided) utilizing 12 criterion measures (See A, 1 - 12).

E. Twelve one-way analyses of variance (males incorrectly described as feminine/undecided) utilizing 12 criterion measures (See A, 1 - 12).

F. Discriminant function analysis of female speakers by speaker type (heterosexual, homosexual) utilizing 12 criterion measures (See A, 1 - 12).

G. Discriminant function analysis of male speakers by speaker type (heterosexual, homosexual) utilizing 12 criterion measures (See A, 1 - 12).

H. Discriminant function analysis of female speakers by sex judgments utilizing 12 criterion measures (See A, 1 - 12).

I. Discriminant function analysis of female speakers by masculine-feminine judgments utilizing 12 criterion measures (See A, 1 - 12).

J. Discriminant function analysis of male speakers by sex judgments utilizing 12 criterion measures (See A, 1 - 12).

K. Discriminant function analysis of male speakers by masculine-feminine judgments utilizing 12 criterion measures (See A, 1 - 12).

Chapter 3

PHASE ONE

Purpose of the Study

The purpose of Phase One was to develop a tool for obtaining reliable judgments of speaker sex and masculinity-femininity. Procedural variables that might influence judgment of speaker sex and masculinity-femininity were explored.

Specifically, this first phase attempted to answer the following questions:

A. Regarding the speakers,
   1. Is there a difference in the accuracy of sex judgments as a function of speaker sex?
   2. Is there a difference in the accuracy of masculinity-femininity judgments as a function of speaker sex?
   3. Are the six speakers different (individual variability)?
   4. Are the speakers stable across time (temporal variability)?

B. What effect, if any, does speech mode (reading, spontaneous speech, typescript) have on

judgments?

C. Regarding the judges,
   1. Do male and female judges differ significantly in the accuracy of judgment of speaker sex and masculinity-femininity?
   2. Do trained speech pathologists differ significantly from untrained listeners in judgments of sex and of masculinity-femininity?
   3. Are the 32 judges different (individual variability)?
   4. Are the judges stable across time (temporal variability)?

D. Does order of judgmental tasks significantly affect performance?

Procedures and Research Design

Judges

Sixteen male and sixteen female adults served as judges. Eight males and eight females were individuals who had been trained in the diagnosis and treatment of speech and voice disorders and who held the Certificate of Clinical Competence in Speech Pathology from the American Speech-Language-Hearing Association. The remaining eight males and eight females were over 21 years

of age but had had no experience in or exposure to the diagnosis and treatment of speech and voice disorders.

These 32 individuals were randomly divided into four groups, each representing one of the four orders of judgmental tasks. Each group consisted of two trained males, two trained females, two untrained males, and two untrained females.

Speakers

Six adult speakers, each demonstrating one of the following speech characteristics as judged by the experimenter and two other speech pathologists, provided speech samples.

1. An "average sounding" female
2. An "average sounding" male
3. A female with low-pitched voice
4. A male with high-pitched voice
5. A "masculine sounding" female
6. A "feminine sounding" male.

Speech Samples

Because in spontaneous speech no constraints are placed on speakers, allowing each speaker to perform in his customary manner, each speaker was recorded telling a story of approximately 30 seconds in length about a given picture.

The oral reading of an identical passage places similar constraints on the speakers, eliminating vocabulary and language differences. Therefore, each speaker was recorded reading the first paragraph of "The Rainbow Passage" (Fairbanks, 1960).

In order to establish if "language" (non-audible aspects of the message) influenced listeners' judgment, typescripts of the spontaneous speech samples were prepared for judgment.

Reliability

Each speaker was recorded in two sessions, the second not less than 24 hours nor more than 72 hours after the first. Each session consisted of recording a spontaneous speech sample and a read speech sample.

Each judge performed the judgmental task twice. The second listening/judgment session took place not less than seven days nor more than ten days after the first.

Judgmental Measurements

Part A of the judgmental task concerned the judgment of speaker sex and consisted of the following instructions:

> "Determine the anatomical sex of this speaker. (Check only one.)

_____Male

_____Female

_____Undecided"

Part B of the judgmental task concerned the judgment of speaker masculinity-femininity and consisted of the following instructions:

"Describe the speech of this person by checking only one of the following blanks:

_____Masculine

_____Feminine

_____Undecided"

Recording Presentations

The 24 speech samples (initial and second reading and initial and second spontaneously spoken for each speaker) were randomized for the first listening/judgment session and then re-randomized for the second session. The randomizations were made in such a way that two speech samples from the same individual never occurred adjacent to each other.

There were four presentation orders, one for each Judge Group.

Judge Group I listened to the 24 speech samples and after each sample completed Parts A and B of the judgmental task, in that order.

Judge Group II listened to the 24 speech samples and

after each sample completed Parts B and A of the judgmental task, in that order.

Judge Group III listened to the 24 speech samples and after each sample completed Part A. The 24 speech samples were presented in the same order a second time, and after each sample, Part B was completed.

Judge Group IV listened to the 24 speech samples and after each sample completed Part B. The 24 speech samples were presented in the same order a second time, and after each sample, Part A was completed.

Typescript Presentations

Prior to the listening/judgment task, during the first listening/judgment session only, randomized typescripts of the 12 spontaneous speech samples (two from each speaker) were presented and judged in the same four orders as the recording presentations.

Equipment

All recordings were made in a sound-controlled room using a Sony Model TC-570 tape recorder and a Teledyne electret condenser lapel microphone, Model EO-300. The tape randomizations and copying processes were performed using a Sony Model TC-270 tape recorder and the Sony Model TC-570 tape recorder as the slave recorder.

Statistical Analysis for Judgments from Recorded Samples

A 2 x 2 x 6 x 2 x 32 x 4 x 2 x 2 x 2 analysis of variance was used to analyze the effects of the following:

1. Speech Mode (spontaneous vs. read speech)
2. Time of speaker (first vs. second performance)
3. Different speaker (six speakers)
4. Time of judgment (first vs. second performance)
5. Different judge (32 judges)
6. Order of judgmental tasks (four orders)
7. Training of judges (trained vs. untrained)
8. Sex of judge (male vs. female)
9. Sex of speaker (male vs. female)

Statistical Analysis for Judgments from Typescripts

A 2 x 6 x 32 x 4 x 2 x 2 x 2 analysis of variance was used to analyze the effects of the following:

1. Time of speaker (first vs. second performance)
2. Different speaker (six speakers)
3. Different judge (32 judges)
4. Order of judgmental tasks (four orders)
5. Training of judges (trained vs. untrained)
6. Sex of judge (male vs. female)
7. Sex of speaker (male vs. female)

Results

Phase One of this study was designed to explore the several procedural variables that might influence judgments of speaker sex and of speaker masculinity-femininity. Specifically, the effects of the following variables on such judgments were assessed: speaker sex, inter-speaker variability, intra-speaker variability, judge sex, judge training, inter-judge variability, intra-judge variability, speech sample type, and order of judgmental

tasks.

Judgments of Sex and Masculinity-Femininity from Recordings

Table 1 presents the analyses of variance based on judgments of sex and judgments of masculinity-femininity made from recorded spontaneous and read speech samples.

There was a significant difference in the accuracy of sex judgments in regard to time of speaker (F = 23.51; df = 1, 528; $p<0.01$). The sex of the speakers was more accurately determined on the speakers' second performance (Mean = 0.85) than on their first performance (Mean = 0.81). The difference of only 4%, which in reality is very small, reaches statistical significance because of the large number of degrees of freedom in the error term (528). Although statistically significant, it is too small to warrant the complex arrangements and the inconvenience to the volunteer speakers and judges.

Judgments of speaker sex were significantly more accurate on reading samples (Mean = 0.84) than on the spontaneous speech samples (Mean = 0.82; F = 5.51; df = 1, 528; $p<0.05$). Also, more appropriate judgments of masculinity-femininity were made on the reading samples (Mean = 0.61) than on the spontaneous speech samples (Mean = 0.57; F = 5.21; df = 1, 528; $p<0.05$). The small differences between judgments made on reading and on spontaneous speech (2% on judgments of sex; 4% on judgments

Table 1. Analyses of variance utilizing as criterion judgments of sex and masculinity-femininity from recorded spontaneous and read speech samples

Source	df	Sum of Squares: Sex	Sum of Squares: M-F
Judge Sex	1	0.11	0.00
Order	3	0.43	3.63
Judge Sex x Order	3	1.21	0.35
Training	1	0.11	0.55
Judge Sex x Training	1	0.05	0.11
Order x Training	3	0.84	4.06
Judge Sex x Order x Training	3	3.11*	1.27
Error (a)	16	5.09	13.91
Speaker Sex	1	39.08	8.02
Error (b)	4	94.24	128.22
Judge Sex x Speaker Sex	1	0.34	1.32
Order x Speaker Sex	3	0.50	6.16
Judge Sex x Order x Speaker Sex	3	0.44	0.35
Training x Speaker Sex	1	0.24	0.05
Judge Sex x Training x Speaker Sex	1	0.34	0.01
Order x Training x Speaker Sex	3	0.81	1.50
Judge Sex x Order x Training x Speaker Sex	3	3.93*	1.21
Error (c)	16	4.47	22.82
Error (d)	60	17.01	21.90
Error (e)	64	12.00	32.74
Speaker Time	1	0.63**	0.00
Speech Mode	1	0.15*	0.47*
Speaker Time x Speech Mode	1	0.15*	0.34
Judge Sex x Speaker Time	1	0.08	0.11
Order x Speaker Time	3	0.09	0.33
Judge Sex x Order x Speaker Time	3	0.13	0.03
Training x Speaker Time	1	0.02	0.01
Judge Sex x Training x Speaker Time	1	0.03	0.03
Order x Training x Speaker Time	3	0.04	0.29
Judge Sex x Order x Training x Speaker Time	3	0.04	0.23
Judge Sex x Speech Mode	1	0.05	0.15
Order x Speech Mode	3	0.05	0.69
Judge Sex x Order x Speech Mode	3	0.00	0.08
Training x Speech Mode	1	0.11*	0.24
Judge Sex x Training x Speech Mode	1	0.02	0.00
Order x Training x Speech Mode	3	0.08	0.48
Judge Sex x Order x Training x Speech Mode	3	0.05	0.09
Judge Sex x Speaker Time x Speech Mode	1	0.00	0.05
Order x Speaker Time x Speech Mode	3	0.05	0.11
Judge Sex x Order x Speaker Time x Speech Mode	3	0.12	0.24
Training x Speaker Time x Speech Mode	1	0.01	0.05
Judge Sex x Training x Speaker Time x Speech Mode	1	0.08	0.03
Order x Training x Speaker Time x Speech Mode	3	0.04	0.66
Judge Sex x Order x Training x Speaker Time x Speech Mode	3	0.07	0.29
Error (f)	528	14.05	48.11
Error (g)	768	17.50	70.50
Total	1535	217.98	371.78

*$p<0.05$
**$p<0.01$

of masculinity-femininity) reach statistical significance because of the large number of degrees of freedom in the error term (528).

A partial table of means for judgments of sex and masculinity-femininity from recorded spontaneous and read speech samples is presented in Table 2.

Table 2. Partial summary table of means for judgments of sex and masculinity-femininity from recorded spontaneous and read speech samples

Variable	Sex	M-F
Time of Speaker		
First Performance	0.81	0.59
Second Performance	0.85	0.59
Speech Mode		
Spontaneous Speech	0.82	0.57
Read Speech	0.84	0.61
Training of Judge		
Untrained	0.84	0.57
Trained	0.82	0.61
Sex of Judge		
Female	0.82	0.59
Male	0.84	0.59
Sex of Speaker		
Female	0.67	0.52
Male	0.99	0.66

The interaction of speaker time (first, second performances) and speech mode (spontaneous speech, reading) was found to be significant ($F = 5.51$; $df = 1, 528$; $p<0.05$).

Table 3. Mean of percent correct sex judgments on spontaneous speech and reading samples of two speaker performances

Speaker Time	Spontaneous Speech	Reading
First Performance	0.79	0.83
Second Performance	0.85	0.85

Sex of the speakers was more accurately determined on both the spontaneous speech samples and the reading samples recorded during the second taping session (second performance). Sex judgments on spontaneous speech samples were 6% more accurate on the second performance, and those on reading samples were 2% more accurate on the second performance.

While training of the judges as a main effect was not significant, the interaction of training with speech mode was significant ($F = 4.13$; $df = 1, 528$; $p<0.05$).

Table 4. Mean of percent correct sex judgments on spontaneous speech and reading samples by untrained and trained judges

Judges	Spontaneous Speech	Reading
Untrained	0.84	0.84
Trained	0.80	0.84

On spontaneous speech samples, the untrained judges (Mean = 0.84) more accurately judged the sex of the

speakers than the trained judges (Mean = 0.80). Untrained and trained judges performed equally well on determining speaker sex from reading samples (Means = 0.84).

Significant differences in sex judgments were found when the sex of the judges, the order of judgmental tasks, and the training of the judges interacted (F = 3.25; df = 3, 16; $p<0.05$). Judge accuracy in sex judgment shifted as a function of the combination of judge sex, judge training, and judgmental task order.

A third-order interaction of sex of judge, order of judgmental tasks, judge training, and speaker sex was found to be significant (F = 4.64; df = 3, 16; $p<0.05$). All judges were more accurate in determining the sex of the male speakers than they were in determining the sex of the female speakers.

Judgments of Sex and Masculinity-Femininity from Typescripts of Spontaneous Speech Samples

Table 5 presents analyses of variance for judgments of sex and masculinity-femininity from typescripts of spontaneous speech samples.

As main effects, neither the sex nor the training of judges was significant in determining speaker sex from typescripts of spontaneous speech. However, the interaction of those variables was significant (F = 4.88; df = 1, 16; $p<0.05$). Untrained female judges and trained

Table 5: Analyses of variance utilizing as criterion judgments of sex and masculinity-femininity from typescripts of spontaneous speech samples

Source	df	Sum of Squares Sex	Sum of Squares M-F
Judge Sex	1	0.00	0.04
Order	3	0.55	1.44
Judge Sex x Order	3	1.40	0.15
Training	1	0.07	0.17
Judge Sex x Training	1	3.19*	1.04
Order x Training	3	2.38	1.44
Judge Sex x Order x Training	3	4.13	0.73
Error (a)	16	10.46	5.67
Speaker Sex	1	0.59	0.26
Error (b)	4	4.61	10.61
Judge Sex x Speaker Sex	1	0.21	0.26
Order x Speaker Sex	3	0.53	0.09
Judge Sex x Order x Speaker Sex	3	0.20	0.09
Training x Speaker Sex	1	0.00	0.01
Judge Sex x Training x Speaker Sex	1	0.07	0.51
Order x Training x Speaker Sex	3	0.36	0.43
Judge Sex x Order x Training x Speaker Sex	3	0.34	0.18
Error (c)	140	28.34	32.89
Speaker Time	1	0.07	0.26
Judge Sex x Speaker Time	1	0.44	0.09
Order x Speaker Time	3	0.05	0.03
Judge Sex x Order x Speaker Time	3	0.80	1.05
Training x Speaker Time	1	0.21	0.09
Judge Sex x Training x Speaker Time	1	0.02	0.26
Order x Training x Speaker Time	3	0.65	0.30
Judge Sex x Order x Training x Speaker Time	3	0.22	0.30
Error (d)	176	36.04	37.33
Total	383	95.93	96.00

*$p<0.05$

male judges were more accurate than trained female judges and untrained male judges in determining speaker sex from typescripts.

Discussion and Summary

Speech mode, speaker time, speaker sex, order of presentation, judges' sex and judges' training were explored as procedural variables that could influence the determination of speaker sex and speaker masculinity-femininity.

In general, judgments of speaker sex were more often made correctly than those of masculinity-femininity. Male speakers tended to be correctly judged with regard to sex and masculinity-femininity more frequently than female speakers.

Of the six variables explored, only speech mode showed significant differences in judgments of both sex and masculinity-femininity, judgments from the reading samples being more accurate than judgments from the spontaneous speech samples in both instances.

While time of speaker proved to be a highly significant variable, it should be noted that judgments of sex were only 4% more accurate on the speakers' second performance than on their first performance. The error term based on 528 degrees of freedom made the test

highly sensitive and showed very small differences to be statistically significant. It was felt that the small increase in sex judgment accuracy on the speakers' second performance would not compensate for the difficulty in arranging a second taping session, the inconvenience to the volunteer speakers, and the doubling of the listening time and tasks of the judges. Therefore, for Phase Two, only one taping session was conducted.

Time of speaker and speech mode interacted significantly, again small differences surfacing due to the error term's large number of degrees of freedom (528).

As main effects, sex of the judges, order of judgmental tasks, judges' training, and sex of the speakers were not significant in either the judgment of sex or masculinity-femininity. However, when training interacted with speech mode, with judges' sex and order of judgmental tasks, and with judges' sex, order of judgmental tasks, and speaker sex, the several interactions were significant for judgments of sex but not for judgments of masculinity-femininity.

There were no significant main effects regarding judgments of sex or judgments of masculinity-femininity from typescripts of the spontaneous speech samples. The variables of sex of judges and training of judges interacted significantly only for judgments of sex, not for

judgments of masculinity-femininity. Because there were no significant main effects regarding judgments from typescript presentations, typescript judgments and analysis were eliminated from Phase Two.

Also, because the training of the judges, the sex of the judges, and the order of judgmental tasks were significant factors only when they interacted with one or more of the other variables, those conditions were not considered for control in Phase Two.

Chapter 4

RESULTS AND DISCUSSION

This study was designed to investigate the relationship of listener judgments of speaker sex and of speaker masculinity-femininity and the physical measures of fundamental frequency, intensity, and rate. Specifically, the relationships among speaker sex, speaker type, speech mode, judgments of sex (female, male), and judgments of masculinity-femininity were investigated. Judgments of sex and of masculinity-femininity were then related to the fundamental frequency, intensity, and rate measures.

Also, the differences between female and male speakers, between heterosexual and homosexual speakers, and between spontaneous speech and reading were explored in terms of 12 physical characteristics (four fundamental frequency measures, five intensity measures, and three rate measures).

Chapter 4 is divided into five major sections:

A. Sex Judgments: Differences Between the Incorrectly and the Correctly Identified Speakers on Measures of Rate, Fundamental Frequency, and Intensity;

B. Masculine-Feminine Judgments: Differences

Between the Incorrectly and the Correctly Described Speakers on Measures of Rate, Fundamental Frequency, and Intensity;

C. Relationships Among Speaker Sex, Speaker Type, and Speech Mode and Judgments of Sex and Judgments of Masculinity-Femininity;

D. Relationships Among Speaker Sex, Speaker Type, and Speech Mode and Measures of Rate, Fundamental Frequency, and Intensity; and

E. Differentiation of Heterosexual From Homosexual Speakers Within Sexes Using Measures of Rate, Fundamental Frequency, and Intensity.

Sex Judgments: Differences Between the Incorrectly and the Correctly Identified Speakers on Measures of Rate, Fundamental Frequency, and Intensity

Each speech sample was judged for sex of the speaker by 20 judges. If four or more judges misclassified a speaker, that speaker was arbitrarily considered to be incorrectly judged. For example, if a male speaker was judged to be a female or if his sex could not be determined (i.e., judged "undecided") by four or more judges, that male speaker was considered to be incorrectly judged. If a speaker received three or fewer incorrect judgments, the speaker was considered to be correctly judged. Using this criterion for sex judgments, 16 of the 20 females were judged correctly and all 26 males were judged cor-

rectly.

Discriminant function analyses using 11 or more misjudgments and 18 or more misjudgments to denote the speaker as being incorrectly judged for sex and for masculinity-femininity were also done. However, the analyses using those criteria failed to produce groupings that would make discrimination possible.

Table 6 is a summary of means of rate, fundamental frequency, and intensity measures for speakers incorrectly and correctly judged as male or female. It is presented first to clarify the following analysis of variance tables.

Females Judged as Males/Undecided

One-way analyses of variance showed two of the 12 measures explored to be significantly different for those females correctly judged and those incorrectly judged: mean fundamental frequency low and mean intensity standard deviation.

Table 7 indicates a highly significant difference ($F = 14.20$; $df = 1, 18$; $p<0.01$) between mean fundamental frequency low of the correctly judged females and that of the incorrectly judged females. Females judged as male/undecided had a higher mean low fundamental frequency (Mean = 150.00 Hz) than females correctly judged as female (Mean = 128.44 Hz).

Table 6: Summary table of means of rate, fundamental frequency and intensity measures for incorrectly and correctly judged speakers: sex

	FEMALES		MALES	
	Judged Incorrectly As Male N = 4	Judged Correctly As Female N = 16	Judged Incorrectly As Female N = 0	Judged Correctly As Male N = 26
Mean Syllables Per Second	3.90	3.78	----	4.29
Mean Words Per Minute	181.55	176.62	----	195.10
Mean Percent Pause Time	32.59	31.12	----	32.09
Mean Fundamental Frequency Low (Hz)	150.00	128.44	----	80.00
Mean Fundamental Frequency High (Hz)	276.25	288.13	----	212.88
Mean Fundamental Frequency Mode (Hz)	195.00	179.69	----	117.31
Mean Fundamental Frequency Range (Hz)	126.25	159.69	----	132.88
Mean Intensity Mean (dB)	33.81	34.78	----	31.09
Mean Intensity Low (dB)	2.00	5.38	----	4.77
Mean Intensity High (dB)	50.50	51.56	----	50.88
Mean Intensity Range (dB)	48.50	46.19	----	46.12
Mean Intensity Standard Deviation (dB)	8.18	9.87	----	9.90

Table 7: Analysis of variance for sex judgments of female speakers; dependent variable = mean fundamental frequency low

Source	df	Sum of Squares	F Value	P > F
Sex	1	1487.81	14.20	0.00**
Error	18	1885.94		
Corrected Total	19	3373.75		

**$p<0.01$

There was a highly significant difference (F = 23.41; df = 1, 18; $p<0.01$) between the mean intensity standard deviation of the correctly judged and that of the incorrectly judged females, as shown in Table 8. The mean intensity standard deviation of correctly judged females (Mean = 9.87 dB) was greater than that of incorrectly judged females (Mean = 8.18 dB).

Table 8: Analysis of variance for sex judgments of female speakers; dependent variable = mean intensity standard deviation

Source	df	Sum of Squares	F Value	P > F
Sex Judgment	1	9.18	23.41	0.00**
Error	18	7.06		
Corrected Total	19	16.24		

**$p<0.01$

A discriminant function analysis was done. The resultant function was found to be highly significant ($p<0.01$) in differentiating those females correctly judged as female and those incorrectly judged as male/undecided.

Table 9 indicates that without benefit of discriminant function analysis, one could classify all the female speakers as female and be in agreement with the judges 80% of the time. If all female speakers were classified as male/undecided, probability for agreement with the judges would be 20%.

Table 9: Prior probabilities for the classification of females as incorrectly or correctly judged for sex

Group	Number	Prior Probability
Females Judged Male/Undecided	4	0.20
Females Judged Female	16	0.80

The discriminant function analysis yielded the three measures and their weightings, shown in Table 10, which, when combined to form one derived variable, allowed 100% accuracy in classifying the female speakers into the correctly or incorrectly judged groups.

Table 10: Standardized canonical discriminant function coefficients

Variables	Weightings
Mean Intensity Standard Deviation	-1.22
Mean Words Per Minute	0.92
Mean Fundamental Frequency Low	0.46

As Table 11 shows, the derived variable (mean intensity standard deviation, mean words per minute, mean fundamental frequency low) was 100% successful in classifying those female speakers judged as male/undecided and those females judged as female.

Table 11: Classification results: females judged incorrectly or correctly for sex

Actual Group	Number of Cases	Predicted Group Membership	
		Male/Undecided	Female
Females Judged Male/Undecided	4	4 (100%)	0 (0.0%)
Females Judged Female	16	0 (0.0%)	16 (100%)

Males Judged as Females/Undecided

According to established criterion (four or more incorrect judgments classified the speaker as incorrectly identified; three or fewer incorrect judgments clas-

sified the speaker as correctly identified), all of the 26 male speech samples were identified correctly as being from male speakers and therefore constituted only one group. This finding precluded further statistical analysis of variance or discriminant function analysis.

Discussion

According to the criterion established for classifying a speaker as incorrectly or correctly judged, four female speakers were judged to be male/undecided and 16 were correctly judged to be female. Those female speakers incorrectly judged had a significantly higher mean low fundamental frequency than those correctly judged. This finding is inconsistent with what one would expect and may be due to the small number misjudged (four).

Mean intensity standard deviation was also significantly different for the incorrectly and correctly judged groups, that of the incorrectly judged group being less than that of the correctly judged group. It would appear that greater variability of intensity provided clues for making correct judgments of sex on female speakers.

Both mean fundamental frequency low and mean intensity standard deviation were included, along with words per minute, in the discriminant function which significantly differentiated the incorrectly from the correctly judged females.

Masculine-Feminine Judgments: Differences Between the Incorrectly and the Correctly Described Speakers on Measures of Rate, Fundamental Frequency, and Intensity

After listening to each of the 46 samples, the 20 judges described the speaker's speech as masculine or feminine or indicated "undecided" if the judge was unable to commit to a masculine or feminine classification. If four or more judges described a speaker inappropriately or indicated "undecided," that speaker was arbitrarily considered to be incorrectly judged. For example, a male speaker was considered to be incorrectly judged if he received four or more judgments of "feminine" or "undecided." If a speaker received three or fewer incorrect classifications, he was considered to be correctly judged. Using this criterion, six of the 20 females were judged correctly as feminine and seven of the 26 males were judged correctly as masculine.

A summary of means of rate, fundamental frequency, and intensity measures for speakers incorrectly and correctly judged as masculine-feminine is presented first in Table 12 to clarify the following analysis of variance tables.

Females Judged as Masculine/Undecided

One-way analyses of variance yielded three measures which were significantly different for those female speakers judged correctly and those judged incorrectly: mean

Table 12: Summary table of means of rate, fundamental frequency, and intensity measures for incorrectly and correctly judged speakers: masculine-feminine

	FEMALES		MALES	
	Judged Incorrectly As Masculine N = 14	Judged Correctly As Feminine N = 6	Judged Incorrectly As Feminine N = 19	Judged Correctly As Masculine N = 7
Mean Syllables Per Second	4.01	3.32	4.42	3.96
Mean Words Per Minute	185.96	158.10	202.81	174.17
Mean Percent Pause Time	31.53	31.14	30.74	35.76
Mean Fundamental Frequency Low (Hz)	133.57	130.83	79.74	80.71
Mean Fundamental Frequency High (Hz)	276.07	308.33	214.47	208.57
Mean Fundamental Frequency Mode (Hz)	177.86	194.17	120.79	107.86
Mean Fundamental Frequency Range (Hz)	142.50	177.50	134.74	127.86
Mean Intensity Mean (dB)	34.71	34.28	31.12	31.00
Mean Intensity Low (dB)	5.71	2.33	4.53	5.43
Mean Intensity High (dB)	50.93	52.33	51.00	50.57
Mean Intensity Range (dB)	45.21	50.00	46.47	45.14
Mean Intensity Standard Deviation (dB)	9.44	9.74	10.08	9.41

syllables per second, mean fundamental frequency high, and mean fundamental frequency range.

Table 13 indicates a significant difference (F = 4.68; df = 1, 18; $p<0.05$) between mean number of syllables per second used by the incorrectly described females and that used by the correctly described females. The incorrectly described females used more syllables per second (Mean = 4.01) than the correctly described females (Mean = 3.32).

Table 13.: Analysis of variance for masculine-feminine judgments of female speakers; dependent variable = mean syllables per second

Source	df	Sum of Squares	F value	P > F
Masculine-Feminine Judgment	1	2.04	4.68	0.04*
Error	18	7.87		
Corrected Total	19	9.91		

*$p<0.05$

There was a significant difference (F = 5.13; df = 1, 18; $p<0.05$) between the mean high fundamental frequency of the correctly described group of females and that of the incorrectly described group of females as shown in Table 14. The female speakers described as masculine/undecided had a lower mean high fundamental frequency (Mean = 276.07 Hz) than the female speakers judged as

feminine (Mean = 308.33 Hz).

Table 14: Analysis of variance for masculine-feminine judgments of female speakers; dependent variable = mean fundamental frequency high

Source	df	Sum of Squares	F value	P > F
Masculine-Feminine Judgment	1	4371.49	5.13	0.04*
Error	18	15342.26		
Corrected Total	19	19713.75		

*$p<0.05$

Table 15 shows that the correctly described female speakers were significantly different ($F = 6.00$; $df = 1, 18$; $p<0.05$) from the incorrectly described female speakers in terms of mean fundamental frequency range. The group of females described as masculine/undecided used a more restricted fundamental frequency range (Mean = 142.50 Hz) than the group of females described as feminine (Mean = 177.50 Hz).

A discriminant function analysis was done. The resultant function was found to be highly significant ($p<0.01$) in differentiating those female speakers incorrectly described as masculine/undecided from those described correctly as feminine.

Table 16 indicates that prior to the use of dis-

criminant function, the probability for correct classification if all the females were described as masculine/undecided would be 70%. If all the females were classified as feminine, the probability for accuracy would be 30%.

Table 15: Analysis of variance for masculine-feminine judgments of female speakers; dependent variable = mean fundamental frequency range

Source	df	Sum of Squares	F value	P > F
Masculine-Feminine Judgments	1	5145.00	6.00	0.02*
Error	18	15425.00		
Corrected Total	19	20570.00		

*$p<0.05$

Table 16: Prior probabilities for classification of females incorrectly and correctly described for masculinity-femininity

Group	Number	Prior Probability
Females Described Masculine/ Undecided	14	0.70
Females Described Feminine	6	0.30

The six measures shown in Table 17 with their weightings comprise one derived variable which discriminated

between the females incorrectly described and those correctly described.

Table 17: Standardized canonical discrimination function coefficients

Variables	Weightings
Mean Fundamental Frequency Mode	-1.27
Mean Syllable Per Second	1.25
Mean Percent Pause Time	1.13
Mean Words Per Minute	0.87
Mean Fundamental Frequency Low	0.82
Mean Fundamental Frequency Range	0.76

As Table 18 indicates, the derived variable (the discriminant function) composed of mean fundamental frequency mode, low and range, mean syllables per second, mean words per minute, and mean percent pause time was 100% successful in classifying the female speakers described as masculine/undecided and those classified as feminine.

Males Judged as Feminine/Undecided

One-way analyses of variance yielded two measures which were significantly different for those male speakers judged correctly (masculine) and those judged incorrectly (feminine/undecided): Mean fundamental frequency mode and mean intensity standard deviation.

Table 18: Classification results: females judged incorrectly or correctly for masculinity-femininity

Actual Group	Number of Cases	Predicted Group Membership Masculine/Undecided	Feminine
Females Described Masculine/Undecided	14	14 (100%)	0 (0.0%)
Females Described Feminine	6	0 (0.0%)	6 (100%)

Table 19 shows that there was a significant difference ($F = 4.71$; $df = 1, 24$; $p<0.05$) between the mean fundamental frequency mode of the correctly described male speakers and that of the incorrectly described speakers. The male speakers described as feminine/undecided had a higher mean fundamental frequency mode (Mean = 120.79 Hz) than the male speakers described as masculine (Mean = 107.86 Hz).

Table 19: Analysis of variance for masculine-feminine judgments of male speakers; dependent variable = mean fundamental frequency mode

Source	df	Sum of Squares	F value	P > F
Masculine-Feminine Judgments	1	855.52	4.71	0.05*
Error	24	4356.02		
Corrected Total	25	5211.54		

*$p<0.05$

Table 20 indicates a significant difference (F = 5.93; df = 1, 24; $p<0.05$) in mean intensity standard deviation of the correctly and the incorrectly described male speakers. The mean intensity standard deviation of the group of male speakers described as feminine/undecided was greater (Mean = 10.08 dB) than that of the group described as masculine (Mean = 9.41 dB).

Table 20: Analysis of variance for masculine-feminine judgments of male speakers; dependent variable = mean intensity standard deviation

Source	df	Sum of Squares	F value	P > F
Masculine-Feminine Judgments	1	2.32	5.93	0.02*
Error	24	9.37		
Corrected Total	25	11.69		

*$p<0.05$

The derived variable consisting of mean fundamental frequency mode, mean fundamental frequency low, mean intensity standard deviation, mean intensity high, which resulted from discriminant function analysis was significantly able to differentiate those male speakers incorrectly described from those correctly described ($p<0.05$).

Table 21 indicates the probabilities for successful classification without use of the discriminant function. If all the male speakers were described as feminine/undecided, there would be a 73% chance of accuracy. There would be a 27% chance of accuracy if all male speakers were described as masculine.

Table 21: Prior probabilities for classification of males incorrectly and correctly described for masculinity-femininity

Group	Number	Prior Probability
Males Described Feminine/Undecided	19	0.73
Males Described Masculine	7	0.27

The result of discriminant function analysis yielded a derived variable consisting of the measures shown in Table 22 which allowed for correct classification of the male speakers into the correctly and incorrectly described groups 92.31% of the time.

Table 23 shows that, using the derived discriminant function (mean fundamental frequency mode, mean fundamental frequency low, mean intensity high, mean intensity standard deviation), there was 100% agreement with the judges' classification of those males described as feminine/undecided and 71.4% agreement with the judges' classification of those males described as masculine.

Table 22: Standardized canonical discriminant function coefficients

Variables	Weightings
Mean Fundamental Frequency Mode	0.98
Mean Fundamental Frequency Low	-0.74
Mean Intensity High	0.53
Mean Intensity Standard Deviation	0.50

Table 23: Classification results: males judged incorrectly or correctly for masculinity-femininity

Actual Group	Number of Cases	Predicted Group Membership	
		Feminine/Undecided	Masculine
Males described Feminine/Undecided	19	19 (100%)	0 (0.0%)
Males Described Masculine	7	2 (28.6%)	5 (71.4%)

Discussion

According to the criterion established, 14 female speakers were incorrectly described as masculine/undecided and six were correctly described as feminine. Those females described as masculine/undecided had a lower mean fundamental frequency high and a more restricted mean fundamental frequency range than those described correctly

as feminine. The incorrectly described females used more syllables per second than the correctly described females.

Both mean syllables per second and mean fundamental frequency range were included in the derived discriminant function, along with mean fundamental frequency mode, mean fundamental frequency low, mean percent pause time and mean words per minute, to differentiate the correctly from the incorrectly described groups with 100% accuracy.

According to the criterion set, 19 male speakers were incorrectly described as feminine/undecided and seven were correctly described as masculine. Those male speakers incorrectly described displayed a higher mean modal fundamental frequency and a greater mean intensity standard deviation than the male speakers correctly described.

Two variables, mean modal fundamental frequency and mean intensity standard deviation, along with mean fundamental frequency high and mean intensity high, comprised the derived discriminant function which differentiated the correctly from the incorrectly described groups with 92.31% accuracy.

Relationships Among Speaker Sex, Speaker Type, and Speech Mode and Judgments of Sex and Judgments of Masculinity-Femininity

Listeners were asked to classify the speaker of each speech sample as either a male or a female. They were also asked to judge whether the speaker sounded

masculine or feminine.

Table 24 presents the least squares means of percent incorrect male-female judgments and percent incorrect masculine-feminine judgments for the two sex groups (females, males), the two type groups (heterosexual, homosexual), and the two speech modes (spontaneous speech, reading). Because of unequal cell sizes, least squares analyses of variance were used, and therefore least squares means are presented throughout when appropriate to least squares analyses of variance. Table 24 is presented first to clarify the following analysis of variance tables.

Table 24: Summary table of least squares means of percent incorrect sex judgments and percent incorrect masculine-feminine judgments by sex, type, and mode

			Percent Incorrect Male-Female Judgments	Percent Incorrect Masculine-Feminine Judgments
SEX	Females	N=20	9.06	43.33
	Males	N=26	0.56	32.19
TYPE	Heterosexuals	N=22	3.38	25.21
	Homosexuals	N=24	6.25	50.31
MODE	Spontaneous Speech	N=23	3.80	32.42
	Reading	N=23	5.82	43.10

Judgments of Sex

Table 25 shows a highly significant difference (F = 9.37; df = 1, 38; $p<0.01$) in percent of incorrect sex judgments dependent upon the sex of the speakers. That is, whether the speaker was a male or a female was a significant factor in making an incorrect judgment of speaker sex. Females were judged to be males more often (Mean = 9.06%) than males were judged to be female (Mean = 0.56%).

Table 25: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = sex judgment

Source	df	Sum of Squares	F value	P > F
Sex	1	779.33	9.37	0.00**
Type	1	89.16	1.07	0.31
Sex x Type	1	81.57	0.98	0.33
Mode	1	44.05	0.53	0.47
Sex x Mode	1	24.95	0.30	0.59
Type x Mode	1	21.02	0.25	0.62
Sex x Type x Mode	1	8.66	0.10	0.75
Error	38	3161.67		
Corrected Total	45	4210.41		

** $p<0.01$

Judgments of Masculinity-Femininity

As Table 26 indicates, speaker type had a highly significant effect (F = 10.36; df = 1, 38; $p<0.01$) on percent of incorrect judgments of speaker masculinity-femininity. Homosexual speakers were incorrectly judged as masculine or feminine more often (Mean = 50.31%) than heterosexual speakers (Mean = 25.21%).

Table 26: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = masculine-feminine judgment

Source	df	Sum of Squares	F value	P > F
Sex	1	1340.00	2.04	0.16
Type	1	6797.87	10.36	0.00**
Sex x Type	1	196.75	0.30	0.59
Mode	1	1232.06	1.88	0.18
Sex x Mode	1	701.17	1.07	0.31
Type x Mode	1	64.09	0.10	0.76
Sex x Type x Mode	1	15.21	0.02	0.88
Error	38	24939.17		
Corrected Total	45	35286.32		

** $p<0.01$

Discussion

In exploring the effects of speaker sex, speaker type, and speech mode on percent incorrect judgments of speaker sex and of speaker masculinity-femininity, it was found that the sex of the speaker had a significant effect on sex judgments but not on judgments of masculinity-femininity. Female speakers were misclassified as male more often than males were misclassified as female. Making an incorrect judgment of sex was not influenced by whether the speaker was heterosexual or homosexual or by whether the presentation was spontaneous speech or reading. Although not statistically significant, there was a tendency for homosexual speakers to be misclassified by sex more often than the heterosexual speakers and for misclassification of sex to occur more often on reading than on spontaneous speech. Since speaker type, mode, and the interactions among the three variables were not significant, the implication is that percent of incorrect sex classifications was unaffected by them.

In the classification of a speaker as being masculine or feminine, speaker type had a significant effect. The homosexual speakers were inappropriately described as masculine (females) or feminine (males) more often than the heterosexual speakers. While neither sex nor speech mode was significant in determining percent of incorrect

masculine-feminine classifications, there was a tendency for female speakers to be described as masculine more often than male speakers were described as feminine and for inappropriate masculine-feminine judgments to be made on the reading mode more often than on the spontaneous speech mode.

Relationships Among Speaker Sex, Speaker Type, and Speech Mode and Measures of Rate, Fundamental Frequency, and Intensity

The least squares means of the 12 physical measures for the speaker sexes (female, male), the speaker types (heterosexual, homosexual), and the speech modes (spontaneous speech, reading) are presented in Table 27. Table 28 presents the least squares means of the 12 physical measures for the two types of female speakers and the two types of male speakers. Both tables are presented first to clarify the following analysis of variance tables.

Mean Syllables Per Second

As indicated by Table 29, the effect of speaker sex on syllables per second was significant ($F = 5.20$; $df = 1, 38$; $p<0.05$). Male speakers used more syllables per second than female speakers (Means = 4.32 and 3.87, respectively).

Table 27. Summary table of least squares means of 12 physical measures for speaker sex, speaker type, and speech mode

	Females N=20	Males N=26	Hetero-sexuals N=22	Homo-sexuals N=24	Spontaneous Speech N=23	Reading N=23
Mean Syllables Per Second	3.87	4.32	3.98	4.21	3.59	4.60
Mean Words per Minute	180.12	195.56	182.55	193.13	160.85	214.84
Mean Percent Pause Time	31.08	31.63	31.18	31.53	35.88	26.83
Mean Fundamental Frequency Low (Hz)	132.60	80.28	107.42	105.47	107.60	105.28
Mean Fundamental Frequency High (Hz)	284.48	213.56	253.67	244.38	242.30	255.74
Mean Fundamental Frequency Mode (Hz)	181.56	116.88	151.25	147.19	148.09	150.34
Mean Fundamental Frequency Range (Hz)	151.88	133.28	146.25	138.91	134.70	150.46
Mean Intensity Mean (dB)	34.69	31.10	32.65	33.14	32.81	32.98
Mean Intensity Low (dB)	5.15	4.79	3.91	6.03	4.93	5.01
Mean Intensity High (dB)	51.27	50.91	51.33	50.84	50.97	51.21
Mean Intensity Range (dB)	46.13	46.11	47.43	44.81	46.04	46.20
Mean Intensity Standard Deviation (dB)	9.55	9.89	9.62	9.81	9.46	9.97

Table 28. Summary table of least squares means of rate, fundamental frequency, and intensity measures for female types and male types

	FEMALES		MALES	
	Hetero-sexual N = 12	Homo-sexual N = 8	Hetero-sexual N = 10	Homo-sexual N = 16
Mean Syllables Per Second	3.54	4.20	4.42	4.21
Mean Words Per Minute	167.53	192.71	197.57	193.56
Mean Percent Pause Time	32.75	29.42	29.62	33.64
Mean Fundamental Frequency Low (Hz)	133.33	131.88	81.50	79.06
Mean Fundamental Frequency High (Hz)	290.83	278.13	216.50	210.63
Mean Fundamental Frequency Mode (Hz	187.50	175.63	115.00	118.75
Mean Fundamental Frequency Range (Hz)	157.50	146.25	135.00	131.56
Mean Intensity Mean (dB)	34.16	35.22	31.15	31.05
Mean Intensity Low (dB)	2.92	7.38	4.90	4.69
Mean Intensity High (dB)	51.67	50.88	51.00	50.81
Mean Intensity Range (dB)	48.75	43.50	46.10	46.13
Mean Intensity Standard Deviation (dB)	9.47	9.63	9.77	9.98

Table 29: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean syllables per second

Source	df	Sum of Squares	F value	P > F
Sex	1	2.14	5.20	0.03*
Type	1	0.55	1.33	0.26
Sex x Type	1	2.02	4.91	0.03*
Mode	1	11.12	27.02	0.00**
Sex x Mode	1	0.27	0.65	0.43
Type x Mode	1	0.10	0.25	0.62
Sex x Type x Mode	1	0.02	0.05	0.82
Error	38	15.64		
Corrected Total	45	31.86		

*$p<0.05$
**$p<0.01$

A significant sex-by-type interaction, however, indicates that female heterosexuals were significantly reduced in rate (Mean = 3.54), compared to the other three groups, which had similar means (4.20, 4.21, 4.42). Refer to Table 28 for summary of means.

There was a highly significant difference in mean syllables per second as a function of speech modes (F = 27.02; df = 1, 38; $p<0.01$). Rate measured in syllables per second was greater on reading (Mean = 4.60) than on

spontaneous speech (Mean = 3.59), regardless of speaker sex or type.

Mean Words Per Minute

Table 30 indicates a highly significant difference between speech modes on mean words per minute (F = 46.15; df = 1, 38; $p<0.01$). Rate measured in words per minute was greater on reading (Mean = 214.84) than on spontaneous speech (Mean = 160.85).

Table 30: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean words per minute

Source	df	Sum of Squares	F value	P > F
Sex	1	2571.51	3.77	0.06
Type	1	1208.02	1.77	0.19
Sex x Type	1	2298.14	3.37	0.07
Mode	1	31446.45	46.15	0.00**
Sex x Mode	1	906.00	1.33	0.26
Type x Mode	1	0.29	0.00	0.98
Sex x Type x Mode	1	65.20	0.10	0.76
Error	38	25891.43		
Corrected Total	45	64387.04		

** $p<0.01$

Mean Percent Pause Time

Table 31 reveals a highly significant difference between speech modes on mean percent pause time (F = 17.36; df = 1, 38; $p<0.01$). Mean percent pause time was greater in the spontaneous speech mode (Mean = 35.88%) than in the reading mode (Mean = 26.83%).

Table 31. Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean percent pause time

Source	df	Sum of Squares	F value	P > F
Sex	1	3.20	0.06	0.80
Type	1	1.30	0.03	0.87
Sex x Type	1	145.49	2.86	0.10
Mode	1	884.81	17.36	0.00**
Sex x Mode	1	1.25	0.02	0.88
Type x Mode	1	0.36	0.01	0.93
Sex x Type x Mode	1	0.07	0.00	0.97
Error	38	1936.26		
Corrected Total	45	2972.74		

**$p<0.01$

Mean Fundamental Frequency Low

There was a highly significant difference between

the mean low fundamental frequency of female speakers and that of male speakers (F = 231.78; df = 1, 38; $p<0.01$) as indicated in Table 32. Mean low fundamental frequency was significantly higher for female speakers (Mean = 132.60 Hz) than for male speakers (Mean = 80.28 Hz). That differences between speaker types or between speech modes did not exist as a function of fundamental frequency low may be because both type and mode effects involved both male and female speakers.

Table 32: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean fundamental frequency low

Source	df	Sum of Squares	F value	P > F
Sex	1	29530.11	231.78	0.00**
Type	1	40.93	0.32	0.57
Sex x Type	1	2.59	0.02	0.89
Mode	1	58.20	0.46	0.50
Sex x Mode	1	8.06	0.06	0.80
Type x Mode	1	43.60	0.34	0.56
Sex x Type x Mode	1	35.03	0.27	0.60
Error	38	4841.46		
Corrected Total	45	34559.98		

**$p<0.01$

Mean Fundamental Frequency High

As indicated by Table 33, there is a highly significant difference between female speakers and male speakers in terms of mean high fundamental frequency (F = 95.57; df = 1, 38; $p<0.01$). Mean high fundamental frequency of females was higher (Mean = 284.48 Hz) than that of males (Mean = 213.56 Hz). Since both sexes were in the type and the mode effects, no differences as a function of mean high fundamental frequency were found.

Table 33: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean fundamental frequency high

Source	df	Sum of Squares	F value	P > F
Sex	1	54247.27	95.57	0.00**
Type	1	931.25	1.64	0.21
Sex x Type	1	125.92	0.22	0.64
Mode	1	1947.68	3.43	0.07
Sex x Mode	1	9.48	0.02	0.90
Type x Mode	1	26.33	0.05	0.83
Sex x Type x Mode	1	9.48	0.02	0.90
Error	38	21569.17		
Corrected Total	45	78866.58		

** $p<0.01$

Mean Fundamental Frequency Mode

A highly significant difference between the mean modal fundamental frequency of female speakers and that of male speakers is indicated in Table 34 (F = 145.69; df = 1, 38; $p<0.01$). The mean modal fundamental frequency of females (Mean = 181.56 Hz) was higher than that of male speakers (Mean = 116.88 Hz).

Table 34: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean modal fundamental frequency

Source	df	Sum of Squares	F value	P > F
Sex	1	45135.88	145.69	0.00**
Type	1	178.02	0.57	0.45
Sex x Type	1	658.36	2.13	0.15
Mode	1	54.61	0.18	0.68
Sex x Mode	1	28.48	0.09	0.76
Type x Mode	1	0.67	0.00	0.96
Sex x Type x Mode	1	1.52	0.00	0.94
Error	38	11772.50		
Corrected Total	45	57830.04		

** $p<0.01$

Mean Fundamental Frequency Range

Table 35 indicates a significant difference (F = 6.11;

df = 1, 38; p<0.05) between the mean fundamental frequency ranges of females and males. Female speakers displayed a greater range as expressed in Hertz (Mean = 151.88 Hz) than male speakers (Mean = 133.28 Hz).

Table 35: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean fundamental frequency range

Source	df	Sum of Squares	F value	P > F
Sex	1	3729.20	6.11	0.02*
Type	1	581.72	0.95	0.34
Sex x Type	1	164.59	0.27	0.61
Mode	1	2679.27	4.39	0.04*
Sex x Mode	1	0.06	0.00	0.99
Type x Mode	1	137.70	0.23	0.64
Sex x Type x Mode	1	80.96	0.13	0.72
Error	38	23203.54		
Corrected Total	45	30577.04		

*p<0.05

Table 35 also shows the effect of mode on fundamental frequency range to be significant (F = 4.39; df = 1, 38; p<0.05). Mean fundamental frequency range was greater on reading (Mean = 150.46 Hz) than on spontaneous

speech (Mean = 134.70 Hz).

Mean Intensity

A highly significant difference (F = 91.31; df = 1, 38; $p<0.01$) between the mean intensity of females' recorded speech samples and that of males' recorded speech samples is shown in Table 36. Females' mean intensity (Mean = 34.69 dB) was greater than males' mean intensity (Mean = 31.10 dB).

Table 36: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean intensity

Source	df	Sum of Squares	F value	P > F
Sex	1	139.06	91.31	0.00**
Type	1	2.50	1.64	0.21
Sex x Type	1	3.62	2.38	0.13
Mode	1	0.28	0.18	0.67
Sex x Mode	1	0.12	0.08	0.78
Type x Mode	1	0.00	0.00	1.00
Sex x Type x Mode	1	0.62	0.41	0.53
Error	38	57.87		
Corrected Total	45	204.07		

**$p<0.01$

Mean Intensity Low

Table 37 indicates a significant difference (F = 4.93; df = 1, 38; $p<0.05$) between the mean intensity low of heterosexual speakers and that of homosexual speakers when the two sexes were combined. The mean intensity low of the heterosexual speakers was lower (Mean = 3.91 dB) than that of the homosexual speakers (Mean = 6.03 dB).

Table 37: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean intensity low

Source	df	Sum of Squares	F value	P > F
Sex	1	1.34	0.14	0.71
Type	1	48.61	4.93	0.03*
Sex x Type	1	58.83	5.97	0.02*
Mode	1	0.09	0.01	0.93
Sex x Mode	1	0.96	0.10	0.76
Type x Mode	1	3.00	0.30	0.58
Sex x Type x Mode	1	2.54	0.26	0.61
Error	38	374.46		
Corrected Total	45	489.83		

*$p<0.05$

A significant sex-by-type interaction (F = 5.97; df = 1, 38; $p<0.05$) on mean intensity low is also shown

in Table 37. The mean intensity low of female heterosexual speakers (Mean = 2.92 dB) was significantly lower than that of female homosexual speakers (Mean = 7.38 dB). Refer to Table 28 for summary of means.

Mean Intensity High

As Table 38 shows, there were no significant main effects or interactions dependent upon mean intensity high.

Table 38: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean intensity high

Source	df	Sum of Squares	F value	P > F
Sex	1	1.43	0.73	0.40
Type	1	2.58	1.32	0.26
Sex x Type	1	0.98	0.50	0.48
Mode	1	0.64	0.33	0.57
Sex x Mode	1	1.57	0.80	0.38
Type x Mode	1	2.12	1.08	0.30
Sex x Type x Mode	1	0.35	0.18	0.67
Error	38	74.39		
Corrected Total	45	84.06		

Mean Intensity Range

Table 39 shows a significant difference (F = 5.28;

df = 1, 38; p<0.05) between the mean intensity range of heterosexual speakers and the intensity range of homosexual speakers. Heterosexual speakers displayed a greater intensity range (Mean = 47.43 dB) than homosexual speakers (Mean = 44.81 dB).

Table 39: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean intensity range

Source	df	Sum of Squares	F value	P > F
Sex	1	0.00	0.00	0.99
Type	1	73.62	5.28	0.03*
Sex x Type	1	75.04	5.38	0.03*
Mode	1	0.26	0.02	0.89
Sex x Mode	1	4.98	0.36	0.55
Type x Mode	1	10.17	0.73	0.40
Sex x Type x Mode	1	1.00	0.07	0.79
Error	38	529.97		
Corrected Total	45	695.04		

*p<0.05

A significant sex-by-type interaction (F = 5.38; df = 1, 38; p<0.05) is also shown in Table 39. Female heterosexual speakers displayed a greater intensity

range (Mean = 48.75 dB) than female homosexual speakers (Mean = 43.50 dB). Refer to Table 28 for summary of means.

Mean Intensity Standard Deviation

There is a significant difference ($F = 4.46$; $df = 1, 38$; $p<0.05$) between speech modes in terms of mean intensity standard deviation, as shown in Table 40. Mean intensity standard deviation on the reading mode (Mean = 9.97 dB) was greater than that on the spontaneous speech mode (Mean = 9.46 dB).

Table 40: Least squares analysis of variance for speaker sex, speaker type, and speech mode; dependent variable = mean intensity standard deviation

Source	df	Sum of Squares	F value	P > F
Sex	1	1.19	1.89	0.18
Type	1	0.37	0.59	0.45
Sex x Type	1	0.01	0.01	0.92
Mode	1	2.81	4.46	0.04*
Sex x Mode	1	0.14	0.22	0.65
Type x Mode	1	0.05	0.08	0.79
Sex x Type x Mode	1	0.21	0.33	0.57
Error	38	23.97		
Corrected Total	45	28.75		

*$p<0.05$

Discussion

The frequency measures (mean fundamental frequency low, high, mode, and range) were significantly different for male and female speakers. This finding was to be expected and supports previous research which describes modal fundamental frequency of the two sexes. The rate measure, syllables per second, was also significantly different for males and females, indicating a tendency for male speakers to use more syllables per second than female speakers. Mean intensity was significantly different for the two sexes, the female speakers having a greater intensity mean than the male speakers.

Both mean low intensity and mean intensity range were significantly different for the two speaker types (heterosexual, homosexual). Heterosexual speakers used a lower mean low intensity and a greater intensity range than homosexual speakers.

There were significant sex-by-type interactions for mean syllables per second, mean intensity low, and mean intensity range. Female homosexual speakers used more syllables per second than female heterosexual speakers, and male heterosexual speakers used more syllables per second than female heterosexual speakers. The heterosexual females' mean intensity low was significantly lower than that of the homosexual females. Heterosexual females

also used a greater intensity range than the homosexual females.

The three rate measures (mean syllables per second, mean words per minute, and mean percent pause time), as well as intensity standard deviation and fundamental frequency range, were significantly different for spontaneous speech and reading. Both syllables per second and words per minute were greater on reading than on spontaneous speech. These results support past findings that rate is faster when reading than when speaking spontaneously. It should be noted that, since there were no significant interactions with speech mode, whatever differences found in sex and in type were the same for both spontaneous speech and reading. Mean percent pause time was significantly greater in spontaneous speech than in reading. Since percent pause time is a component of rate, as are syllables per second and words per minute, both of which were found to significantly differentiate the speech modes, significance of percent pause time would be expected. Significant differences in fundamental frequency range and in intensity standard deviation were also found as an effect of speech mode. Both fundamental frequency range and intensity standard deviation were greater on the reading mode than on the spontaneous speech mode.

Differentiation of Heterosexual from Homosexual Speakers Within Sexes Using Measures of Rate, Fundamental Frequency, and Intensity

In order to determine which measures were most effective in distinguishing between the two groups of female speakers (heterosexual females and homosexual females) and between the two groups of male speakers (heterosexual males and homosexual males), how best to combine the measurements, and how successfully the distinction between the groups could be made, discriminant function analyses were done. The discriminant function is a multivariate technique used to determine the extent to which two different groups overlap or diverge from one another (Snedecor and Cochran, 1967).

Heterosexual Female-Homosexual Female Differentiation

Table 41 presents the probabilities for successful type classification of female speakers without consideration of the results of the discriminant function.

Table 41: Prior probabilities for the classification of females as heterosexual or homosexual

Group	Number	Prior Probability
Heterosexual	12	0.60
Homosexual	8	0.40

Without the benefit of discriminant function analysis, one could classify all of the female speakers as heterosexual and be correct 60% of the time. Classification of all the female speakers as homosexual would have a 40% chance of accuracy.

Table 42 indicates the result of the discriminant function analysis. The function yielded four physical measures and their weightings that, when combined to form one derived variable, allowed correct heterosexual-homosexual classification of female speakers 85% of the time.

Table 42: Standardized canonical discriminant function coefficients

Variables	Weightings
Mean Intensity Low	1.42
Mean Fundamental Frequency Low	1.33
Mean Syllables Per Second	0.52
Mean Intensity Mean	0.43

Table 43 shows that, using the derived discriminant function (mean intensity low, mean fundamental frequency low, mean syllables per second, mean intensity mean), 11 of the 12 heterosexual females (91.7%) were correctly

classified and six of the eight homosexual females (75%) were correctly classified. The result is 85% overall correct classification, an improvement over the prior probabilities for successful classification. A test of significance showed that the discriminant function was significantly able to discriminate between heterosexual and homosexual females ($p<0.01$).

Table 43: Classification results: females as heterosexual or homosexual

Actual Group	Number of Cases	Predicted Group Membership	
		Heterosexual	Homosexual
Heterosexual	12	11 (91.7%)	1 (8.3%)
Homosexual	8	2 (25%)	6 (75%)

Heterosexual Male-Homosexual Male Differentiation

The discriminant function analysis yielded a derived variable composed of five measures (mean fundamental frequency low, mean percent pause time, mean fundamental frequency mode, mean intensity standard deviation, and mean fundamental frequency high) and their weightings that correctly classify the male speakers as heterosexual or homosexual 81% of the time. While 81% accuracy appears to be an improvement over the prior probabilities for correct classification (male heterosexual = 38%; male

homosexual = 62%), a test of significance failed to show that the discriminant function could significantly differentiate the two male types ($p>0.05$).

Discussion

The previously discussed sex-by-type-by-mode analysis of variance yielded three variables (mean syllables per second, mean intensity low, mean intensity range) which significantly distinguished between female heterosexual speakers and female homosexual speakers. Homosexual females used more syllables per second than heterosexual females; homosexual females displayed a greater mean intensity low than heterosexual females; heterosexual females used a greater intensity range than homosexual females. The discriminant function which differentiated the two female types was based on a derived variable that included those two variables (mean syllables per second, mean intensity low) as well as mean fundamental frequency low and intensity mean.

None of the rate, frequency, and intensity measures were found significant in differentiating male heterosexual speakers from male homosexual speakers. Although not significant, the discriminant function analysis yielded a derived variable consisting of five measures (mean fundamental frequency low, mean percent pause time,

mean fundamental frequency mode, mean intensity standard deviation, and mean fundamental frequency high), which tended to be the most discriminating of the 12 measures studied.

Chapter 5

SUMMARY AND CONCLUSIONS

The present study explored the relationships among several variables and listener judgments of speaker sex and speaker masculinity-femininity. Specifically, the differences between the incorrectly and the correctly judged groups of speakers were investigated in relation to the several measures of rate, fundamental frequency, and intensity. Also, the relationships among speaker sex, speaker type (heterosexual, homosexual), speech mode (spontaneous speech, reading), measures of rate, fundamental frequency, and intensity, judgments of sex and judgments of masculinity-femininity were studied.

Twenty listeners judged 46 speech samples (23 spontaneous speech, 23 reading) for speaker sex and speaker masculinity-femininity. The adult speakers were six heterosexual and four homosexual females and five heterosexual and eight homosexual males.

Phase One

In order to identify any procedural variables that might influence judgment of speaker sex and masculinity-

femininity, a preliminary study, Phase One, was conducted. (See Chapter 3.) The six variables explored were speech mode (spontaneous speech, reading), speaker time (first recording session, second recording session), speaker sex, order of presentation, the sex of the judges, and the training of the judges. Speech mode had a significant effect on judgments of both sex and masculinity-femininity. While speaker time was shown to have a significant effect on judgments of speaker sex, the difference in judgments on the first and the second recorded performances was only 4%. Neither the sex of the speaker, the order of judgmental tasks, the sex of the judges, nor the judges' training were significant as main effects in either judgment of sex or judgment of masculinity-femininity. Therefore, order of judgmental tasks, judges' sex, and judges' training were not controlled variables in Phase Two of this study.

Phase Two

Sex Judgments: Differences Between the Incorrectly and the Correctly Identified Speakers on Measures of Rate, Fundamental Frequency, and Intensity

Female Speakers

Of the four fundamental frequency measures, only mean fundamental frequency low was significantly different for those female speakers incorrectly identified as

male/undecided and those correctly identified as female. The incorrectly identified group had a higher mean fundamental frequency low than the correctly identified group. This finding, along with the non-significant tendency for incorrectly identified females to have a higher mean fundamental frequency mode than the correctly identified females, is probably due to the small number (4) in the incorrectly identified group.

Mean intensity standard deviation was the only other measure significantly different for the incorrectly and correctly identified groups, with that of the correctly identified group being greater than that of the incorrectly identified group.

Both of those measures (mean fundamental frequency low and mean intensity standard deviation), along with mean words per minute, constituted the derived discriminant variable which significantly differentiated incorrectly from correctly judged female speakers.

Male Speakers

Since none of the male speakers received more than three judgments of female/undecided, all were classified as being correctly identified and further analyses were considered to be unwarranted.

Masculine-Feminine Judgments: Differences Between the Incorrectly and the Correctly Described Speakers on Measures of Rate, Fundamental Frequency, and Intensity

Female Speakers

Incorrectly and correctly described female speakers differed significantly on three measures. Those female speakers incorrectly described as masculine/undecided displayed a greater mean number of syllables per second, a lower mean fundamental frequency high, and a more restricted mean fundamental frequency range than those females correctly described as feminine. Two of those measures (mean syllables per second and mean fundamental frequency range) were components of a subsequently derived discriminant variable. The rate measures (mean words per minute and mean percent pause time), along with mean fundamental frequency mode and mean fundamental frequency low, were the other components of the derived variable which significantly differentiated the incorrectly and the correctly described female groups.

Male Speakers

The male speakers incorrectly described as feminine/undecided displayed a higher mean fundamental frequency mode and a greater mean intensity standard deviation than the male speakers correctly described as masculine. Both of those measures, along with mean fundamental frequency

low and mean intensity high, constituted the derived discriminant variable which significantly differentiated the two groups.

Relationships Between Speaker Sex, Speaker Type, and Speech Mode and Incorrect Judgments of Sex

The sex of the speaker significantly affected judgments of speaker sex. Female speakers were incorrectly identified as male/undecided more often than male speakers were incorrectly identified as female/undecided. Incorrect judgments of speaker sex were not affected by the speakers' type (heterosexual, homosexual) or the speech mode (spontaneous speech, reading).

Relationships Between Speaker Sex, Speaker Type, and Speech Mode and Incorrect Judgments of Masculinity/Femininity

Whether the speaker was heterosexual or homosexual (speaker type) significantly affected judgments of masculinity/femininity. Homosexual speakers were incorrectly described more often than heterosexual speakers. Neither the sex of the speaker nor the speech mode significantly influenced judgments of speaker masculinity-femininity.

Differences Between Spontaneous Speech and Reading on Measures of Rate, Fundamental Frequency, and Intensity

All three of the rate measures were significantly

different for spontaneous speech and reading. Both mean syllables per second and mean words per minute were greater on reading than on spontaneous speech, indicating that, on the average, a faster rate is used when reading than when speaking spontaneously. Mean percent pause time was greater during spontaneous speech than during reading. One would expect this finding in view of the results on syllables per second and words per minute. The greater the pause time, the fewer syllables per second and words per minute would be used. Therefore, since rate was faster on reading than on spontaneous speech, it follows that percent pause time was greater on spontaneous speech than on reading.

Of the fundamental frequency measures, only mean fundamental frequency range was significantly different for the two speech modes. A greater mean fundamental frequency range was shown for reading than for spontaneous speech.

Mean intensity standard deviation was significantly greater on reading than on spontaneous speech. Since intensity fluctuates with fundamental frequency and since the mean fundamental frequency range was greater for reading than for spontaneous speech, then it might logically follow that the intensity variation would also be greater during reading than during spontaneous speech.

Differences Between Female Speakers and Male Speakers on Measures of Rate, Fundamental Frequency, and Intensity

Of the three measures of rate (mean syllables per second, mean words per minute, mean percent pause time), only mean syllables per second was significantly different for female and male speakers. Male speakers averaged more syllables per second than female speakers.

All of the fundamental frequency measures (mean fundamental frequency low, mean fundamental frequency high, mean fundamental frequency mode, mean fundamental frequency range) were significantly different for female and male speakers. Means of fundamental frequency low, high, and mode were higher for female speakers than for male speakers. This finding was to be expected, and it supports findings of other research on fundamental frequency characteristics of females and males. Mean Fundamental frequency range was greater for female speakers than for male speakers. Since the ranges were expressed in Hertz, this finding would also be expected, Hertz being a linear measure. However, if the same ranges were calculated in octaves, the females' range would be similar to that of the males' since the octave is a non-linear unit and reflects the non-linear processing of the auditory mechanism.

Of the five intensity measures (mean intensity low,

high, mean, range, standard deviation), only the mean of the intensity means was significantly different for female and male speakers. Female speakers had a greater mean intensity than male speakers.

Differences Between Heterosexual Speakers and Homosexual Speakers on Measures of Rate, Fundamental Frequency, and Intensity

Two of the intensity measures, mean intensity low and mean intensity range, were significantly different for heterosexual and homosexual speakers. Mean intensity low of the heterosexual speakers was softer than that of the homosexual speakers. The mean intensity range, however, was greater for the heterosexual speakers than for the homosexual speakers.

Heterosexual speakers and homosexual speakers did not differ significantly on any of the rate measures or on any of the fundamental frequency measures. Since both the heterosexual and the homosexual groups were comprised of both females and males, appreciable fundamental frequency differences would not be expected.

However, there were three significant speaker sex-by-speaker type interactions. On the rate measure, syllables per second, the homosexual females averaged more syllables per second than the heterosexual females while the heterosexual males averaged more than the hetero-

sexual females. Two interactions occurred on intensity measures. Heterosexual females had a softer mean intensity low and a greater mean intensity range than the homosexual females.

Discriminant function analysis yielded a derived variable, consisting of mean syllables per second, mean fundamental frequency low, mean intensity mean, and mean intensity low, which significantly differentiated the heterosexual female speakers from the homosexual female speakers.

Discriminant function analysis failed to yield a derived variable that significantly differentiated heterosexual male speakers from homosexual male speakers.

Conclusions

The results of this study show that reliable judgments of speaker sex and speaker masculinity-femininity can be made from recorded speech samples. The results also support the findings of previous studies of rate and fundamental frequency characteristics of females and males and of speech modes (spontaneous speech, reading).

Based on this study's results, the profile of the typical female speaker would include slower rate, higher fundamental vocal frequency, and slightly louder intensity than those of the typical male.

The female speakers correctly judged as being female demonstrated the above profile of characteristics when compared to those incorrectly judged as male/undecided except on mean fundamental frequency low, mean fundamental frequency mode, and mean intensity range. It is felt, however, that those deviations from the typical profile reflected the small number of incorrectly identified female speakers.

A general comparison of the female speakers correctly described as feminine to those incorrectly described as masculine/undecided showed the correctly described females to have a slower rate, a higher fundamental vocal frequency, and a slightly louder intensity than the incorrectly described females. Those characteristics are the same profile characteristics of the typical female.

The profile of the typical male speaker, based on the results of this study, would include faster rate, lower fundamental vocal frequency, and slightly softer intensity than the typical female speaker. The male speakers correctly described as masculine followed this profile in terms of the fundamental vocal frequency and intensity characteristics but not the rate characteristic. Although not significant, there was a tendency for rate to be slower for the correctly described males than for the incorrectly described males.

Implications

It would appear that two of the physical characteristics (rate, fundamental vocal frequency) investigated in this study influence listeners' perceptions of speaker sex and masculinity-femininity. The manipulation of a speaker's modal fundamental frequency could be hazardous to the speaker's laryngeal structure by imposing an internal state of hypertension and therefore would not be recommended as a clinical procedure for making females sound more feminine or males sound more masculine. An acceptable clinical procedure would be to confirm that the speaker is using his appropriate fundamental frequency mode. Adjustment of speaking rate, slower for females and faster for males, would be a safe clinical procedure.

The effectiveness of rate manipulation to improve femininity in females' speech and masculinity in males' speech needs further investigation. Future research should also investigate the pitch shifts (changes in fundamental vocal frequency during cessation of phonation) and inflectional patterns (changes in fundamental vocal frequency during phonation) of female and male speakers who are inappropriately described as masculine or feminine. If pitch shifts and/or inflectional pat-

terns were found to be significant in differentiating feminine-sounding females from masculine-sounding females and masculine-sounding males from feminine-sounding males, a potentially valuable clinical procedure would be realized.

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APPENDIX A

ALL INFORMATION IS STRICTLY CONFIDENTIAL.
NO IDENTIFYING INFORMATION WILL BE USED IN THIS STUDY.

QUESTIONNAIRE FOR VOLUNTEER SPEAKERS

Name_____

Address_____ OPTIONAL

Phone_____

1. Anatomical Sex: Male____ Female____

2. Sexual inclination: Heterosexual____ Homosexual____

3. Age____ Height____ Weight____

4. Have you ever had a voice, speech or hearing problem?

   Yes____ No____. If "Yes," please explain.

5. Have you ever had speech therapy? Yes____ No____
   If "yes," please state the nature of the problem and treatment and the age and length of time you received therapy.

6. Grade completed in school_____

7. Have you had any experience in formal speaking activities? If "yes," please specify type and your approximate age at that time.

Return to: Norma C. Travis, M.A.

APPENDIX B

CONSENT FOR RESEARCH PARTICIPATION

I, _____, being of full age of majority, hereby consent to engage in the research project conducted by Norma Travis subject to the following conditions:

1. I agree to permit Norma Travis to record my voice for research purposes;

2. I agree to permit Norma Travis to use the results of this research in any form or manner with the understanding that my name will not be divulged unless my permission is given in writing;

3. My participation in this research project is strictly voluntary. Should this research, in whole or in part, be published, I understand that I do not receive any compensation whatever;

4. I agree that all tapes and questionnaires are the property of Norma Travis, and I hereby waive all rights to originals and copies of tapes and questionnaires either on a voluntary or subpoenaed basis; and

5. I have agreed to participate in this research based on the fact that I am assured that all personal information is strictly confidential and that my name will not be released by Norma Travis to any third party.

_____
Signature

_____
Date

Accepted by:_____

APPENDIX C

INSTRUCTIONS

Your participation in this research project is divided into two phases, each phase consisting of two judgmental tasks:

PHASE ONE

You will be given paragraphs which are typescripts of spontaneous speech samples.

Task 1: After reading each paragraph, decide if the person who said that passage is a Male or a Female. If you cannot make such a decision, check "Undecided" on your score sheet.

Task 2: After making the first judgment, next decide if you think the speech of that person shows masculine traits or feminine traits. If you cannot make such a decision, check "Undecided" on your score sheet.

PHASE TWO:

You will listen to 46 speech samples, some reading and some spontaneous speech.

Tasks: After, or during, each sample, make the same judgments as Tasks 1 & 2 of Phase One; that is, (1) decide if the speaker is a Male or a Female, or indicate your being unable to decide, and (2) decide if the speech sounds Masculine or Feminine, or indicate your being unable to decide.

APPENDIX D

PART A

Speaker #_____

Determine the anatomical sex of this speaker. (Check only one.)

_____MALE

_____FEMALE

_____UNDECIDED

PART B

Speaker #_____

Describe the speech of this person by checking only one of the following.

_____MASCULINE

_____FEMININE

_____UNDECIDED

VITA

Norma Cospelich Travis was born November 16, 1937, in New Orleans, Louisiana. She graduated from F. T. Nicholls High School in 1955. In 1959 she received her Bachelor of Science degree from Louisiana State University. She entered Graduate School in June 1970, and served as an Office of Education trainee in the LSU Speech and Hearing Clinic until August 1972. In December 1972, she received her Master of Arts degree in Speech. From September 1972, until August 1976, Ms. Travis was employed part-time as a speech pathologist at Earl K. Long Memorial Hospital. From 1977 to present, she has been employed full-time as instructor/clinic supervisor at the LSU Speech and Hearing Clinic. She is now a candidate for the Doctor of Philosophy degree in Speech.

EXAMINATION AND THESIS REPORT

Candidate: Norma Jean Cospelich Travis

Major Field: Speech Pathology

Title of Thesis: A Study of the Relationship of Certain Variables to Sex Characteristic Identification from the Speech of Heterosexual and Homosexual Individuals.

Approved:

Major Professor and Chairman
Stuart I. Gilmore, Ph.D.

Dean of the Graduate School

EXAMINING COMMITTEE:

Albert J. Jetty, Ph.D.

Amelia I. Hudson, Ph.D.

J. Donald Ragsdale, Ph.D.

Ralph Dreger, Ph.D.

Date of Examination:

July 14, 1981