MEDIAN ROUGHNESS RATINGS ASSOCIATED WITH THE MENSTRUAL CYCLE

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CHAPTER I

INTRODUCTION

"Premenstrual tension is a well recognized clinical entity, starting one to two weeks before menses and terminating with the onset of the menstrual flow" (Frable, 1962, p. 80). Frable also stated that premenstrual tension is usually characterized by a feeling of pelvic discomfort, varying degrees of edema with a temporary weight gain of four to ten pounds or more, emotional outbursts, restlessness, and irritability. The etiology of premenstrual tension is unknown; however, Frable further suggested that "excess estrogen, excess progesterone, lack of progesterone with a relative predominance of estrogen, and a disturbance of pituitary function are common hypotheses" (1962, p. 80). Kaufman (1967) stated that one of the most plausible theories of the cause of premenstrual tension is that the symptoms are due to edema.

Several authors (Brodnitz, 1971; Cooper, 1973; Delaney, Lupton, & Toth, 1976; Frable, 1962; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971) have reported perceptual changes in trained and untrained voices of women preceding or during the menstrual cycle. Each of

these authors have stated that many women exhibit hoarseness at premenstruation or during menses. Physiological changes in the vocal mechanism during premenstruation, relating to perceptual changes associated with voicing, have also been reported (Brodnitz, 1962; Frable, 1962; Graves, 1917; Greene, 1972a; Kaufman, 1967; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971).

Brodnitz (1962) stated that during premenstruation "vocal quality is deeply influenced by changes in the metabolic and hormonal balances, and by shifts between the two opposing forces of the autonomic nervous system" (p. 281). Frable (1962) noted premenstrual hoarseness, lowered pitch, and voice breaks in three case studies and proposed that this was due to edema of the vocal folds during premenstruation. Graves (1917) reported that the mucus membrane of the nose and throat, as well as, the vocal folds become swollen and there is a change in the voice quality during premenstruation. Greene (1972a) cited vocal huskiness in women during menstruation due to an endocrine imbalance. She further noted that hoarseness and pitch limitations during menstruation may be due to a mild edema. Kaufman (1967) noted that in trained voices laryngeal congestion occurred causing impairment of the voice, premenstrually. Luchsinger and Arnold (1965) reported that the menstrual changes in the female body are

shown in the vocal folds. In the days preceding or during menses, it has been noted that ". . . the vocal cords are hyperemic and possibly slightly edematous . . ." (Luchsinger & Arnold, 1965, p. 202). Meano (1967) stated that menstruation results in hoarseness in women. He reported that the hoarseness is due to congestion of endocrine glands that are associated with other glands which influence the voice by ". . . provoking transitory localized inflammation of the vocal membranes and sometimes weakening the respiratory process" (p. 154). According to Moore (1971), normal phonation is characterized by the vocal folds each vibrating with fairly regular periodicity and at the same frequency. He stated that organic changes in the vocal folds, such as edema and thickening of laryngeal epithelial, may affect the vocal folds in a manner causing dissimilar vibratory patterns or aperiodicity. Thus, Moore (1971) stated that the voice would be judged as abnormal or hoarse as evidenced by many women who develop edema of the vocal folds during premenstruation.

In describing voice quality perceptually, the term vocal roughness was introduced into the literature as an all-inclusive term of laryngeal noise, in an effort to settle the confusion of terminology for vocal quality disorders related to the sound source (Brackett, 1971).

The term vocal roughness encompasses the terms harshness, hoarseness, raspiness, huskiness, and other perceptually delineated voice abnormalities (Brackett, 1971; The National Institute of Neurological Diseases, 1967; Proceedings of the Workshop on Nomenclature, 1962). For the purpose of this paper, therefore, the term vocal roughness was selected as the perceptual feature of interest.

To date, there have been four systematic research studies concerning premenstrual vocal roughness in normal female voices (Herrera, 1978; Silverman & Zimmer, 1976, 1978; Whitehead, Kohler, & Schlueter, 1974). Herrera (1978) investigated the effects of the menstrual cycle on vowel spectral noise levels (SNLs). Findings indicated slightly greater overall SNL means for eight subjects during the menses than nonmenstrual days, but this difference was not statistically significant. Silverman and Zimmer (1976) examined acoustic properties and fundamental frequency of normal female voices during ovulation and premenstruation. They reported that hoarseness was not a feature of the premenstrual syndrome, stating ". . . the typical subject in this study was no more hoarse at premenstruation than at ovulation" (p. 6). Silverman and Zimmer (1976) also reported that there were not statistically significant differences in the fundamental frequencies of the

subjects at ovulation and at premenstruation. Additionally, Silverman and Zimmer (1978), in a replication of their 1976 study, found that ". . . the average subject demonstrated no tendency to become hoarse at premenstruation" (p. 9). The fundamental frequency analysis was not undertaken due to the assumption that it would be essentially the same at premenstruation as at ovulation.

Whitehead et al. (1974), however, investigated vowel spectral harmonic and inharmonic changes of the female voice during one complete menstrual cycle. They reported statistically significant increases in vowel spectral noise levels and corresponding decreases in vowel spectral harmonic levels beginning, on the average of, three days before menses and concluding on the fourth day into the menstrual cycle. High positive correlations between perceived vocal roughness and acoustic spectral noise levels have been reported elsewhere (Isshiki, Yanagihara, & Morimoto, 1966; Lively & Emanuel, 1970; Sansone & Emanuel, 1970; Whitehead & Emanuel, 1974).

In summary, many authors have cited perceptual, as well as physiological changes in female voices prior to or during menses (Brodnitz, 1962, 1971; Cooper, 1973; Delaney et al., 1976; Frable, 1962; Graves, 1917; Greene, 1972a; Kaufman, 1967; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971). Whitehead et al. (1974) found an

increase in spectral noise levels in a group of 12 women with normal voices approximately three days prior to and four days into menses. Herrera (1978) found slightly greater overall SNL means for eight subjects during menstruation than nonmenstruation; however, the difference was not statistically significant. Silverman and Zimmer (1976, 1978) have suggested that the mean hoarseness ratings for each vowel and the average of those ratings at ovulation and at premenstruation indicated that female subjects do not become hoarse at premenstruation.

Research is needed to determine possible differences in vocal roughness associated with menstruation and non-menstrual days as perceived acoustically by trained listeners. Such data would be useful regarding the perceptual evaluation of voice quality disorders in female patients. Moreover, such data might be considered in counseling aimed at preventing vocal misuse in these patients. For example, Boone (1971) stated that a voice disorder often commences as a natural sequela of a true organic problem. It was noted that endocrine imbalances related to menstruation might cause the occurrence of vocal symptoms initially. This problem ". . . may force the individual to produce his voice with unusual effort, resulting in a hyperfunctional voice behavior which may well persist after the acute infection is over" (Boone,

1971, p. 10). Moore (1971) noted that the voice is often affected by edema from glandular imbalance. Moore further stated that the change of voice quality noticed by many women in relation to their menstrual cycles is the most frequent evidence of fluid imbalance caused by variations in gonadal function. "Usually, the vocal problem lasts for only a few days, but in some women it is persistent" (Moore, 1971, p. 104). Finally, such data should add information delineating the psychoacoustic effects of assumed vocal fold changes. The present study, therefore, was designed with these aims in mind.

CHAPTER II

REVIEW OF THE LITERATURE

The perceptual assessment of female vocal quality, premenstrually and during the onset of menstruation, is of interest to speech pathologists because of their responsibility in the evaluation of normal voice quality and their responsibility in the prevention of rehabilitation of vocal misuse. "The voice is indirectly influenced by several body symptoms including the respiratory, phonatory, resonatory, endocrine, and neural. With so many systems functioning, it is often difficult to determine just which potential etiological factor is responsible for any given symptom" (Emerick & Hatten, 1974, p. 262). They further stated that "our concern is with what the ear hears but that is the end product of several inter-related systems, each having a specific influence" (Emerick & Hatten, 1974, p. 262). West and Ansberry (1968) suggested that many vocal abnormalities are symptoms of underlying pathologies. Bauer (1968) reported that voice changes resulting from endocrine disturbances have long been regarded as unimportant side effects. Van Gelder (1974) suggested that endocrine disorders of the voice can occur in relation to menstruation.

> The dysfunctions of all the numerous glands and their internal secretions which enrich our body also notably influences the general condition of the body which, in turn, reacts upon the voice. The menstrual period is frequently characterized by a congestion of specific endocrine glands related to other glands which influence the activity of the voice, provoking transitory localized inflammation of the vocal membranes and sometimes weakening the respiratory process (Meano, 1967, p. 154).

Brodnitz (1971) reported that transitory voice changes are common during menstruation. Wyatt (1941) described vocal problems originating in physical alterations of the vocal mechanism and listed certain endocrine imbalances, including menstruation, as a condition that might cause initial vocal symptoms. Cooper (cited in Travis, 1971) and Moore (1971) warned that temporary voice changes which occur premenstrually and during menstruation may become permanent.

The aim of the present investigation was (1) to determine what differences can be demonstrated between median vocal roughness ratings associated with and without menstrual flow during a complete menstrual cycle of 30 consecutive days; and (2) to determine the interjudge and intrajudge reliability associated with normal female production of the vowel /a/ during a complete menstrual cycle of 30 consecutive days. Literature

reviewed as background to this study is reported under three major headings: a) Perceptual assessment of laryngeal voice quality; b) Nature of menstruation; and c) Effect of menstruation on the voice.

Perceptual Assessment of Laryngeal Voice Quality

Vocal quality assessment has primarily been based upon the subjective perception of the clinician. Kanter (1948) stated that the final detector and arbiter in the assessment of vocal quality is the human ear. Laguaite (1972) also reported that the human ear is the principal instrument for judging voice quality. She noted that "critical listening ability is the skill most otolaryngologists and speech pathologists rely on for relating vocal production to medical history and physical examination data" (Laguaite, 1972, p. 147). Moll (1964) recognized the importance of listener judgments in the perceptual assessment of vocal quality by stating that "the ultimate test of the acceptability of speech involves its perceptual acceptability to listeners" (p. 371).

Michel and Wendahl (cited in Travis, 1971) reported that no stable definition of the term voice exists in speech pathology. "The imprecision of labels, which is the bane of voice study, begins with the term 'voice' itself" (Emerick & Hatten, 1974; p. 262). "Much of the

current literature on voice is liberally sprinkled with fiction, mythology, physiological and acoustical misconceptions, and problems of perceptual communication" (Michel & Wendahl, cited in Travis, 1971, p. 465). Furthermore, they stated that "the terminology consists of an interweaving of fact and fancy within a traditional conceptual framework drawing from the fields of medicine, anatomy, elocution, singing, or any other area that may provide just the 'right' words to describe an individual's auditory perception" (Michel & Wendahl, cited in Travis, 1971, p. 465).

Vocal quality perceptions are linked both to the phonatory and resonatory characteristics of the speaker (Emerick & Hatten, 1974). The phonatory and resonatory characteristics of voice quality are reported in common descriptions of vocal quality. Some of these descriptions of vocal quality restrict the term to the generation of sound at the level of the larynx, while others include the influence of the vocal tract upon the generated tone, and still others broaden the definition to include aspects of tonal generation, resonation, articulation, and prosody (Emerick & Hatten, 1974).

Descriptive Terminology

Voice quality descriptions associated with the phonatory characteristics of the speaker are restricted to the generation of sound at the level of the larynx.

> Voice quality disorders have been descriptively labeled in the literature as breathy, husky, hoarse, harsh, throaty, metallic, thin, hypernasal, denasal, and so on through a great number of terms. Unfortunately, these labels do not denote the same meanings universally, and their diversity reflects both the complexity of voice problems and the current lack of basic information about voice production (Moore, 1971, p. 6).

The perceptual assessment of laryngeal voice quality is in a state of confusion with regards to classification and terminology. Emerick and Hatten (1974) stated that the terminology in describing the vocal qualities heard are confusing and oftentimes inappropriate. Morris and Spriestersbach (cited in Darley & Spriestersbach, 1978) stated that "there is indeed some confusion in the labels used to describe voice quality" (p. 200). Additionally, Bowler (1964) reported that proper identification and adequate descriptions of voice qualities presents a problem to clinicians. Boone (1971) noted that the clinician is in immediate difficulty when attempting to describe the voice heard.

It appears that there is a lack of training of clinicians in the perceptual assessment of laryngeal voice

quality. Michel and Wendahl (cited in Travis, 1971) stated that the tradition of labeling has persisted in spite of the increase of information currently available on the mechanics of voice. They further noted that descriptive terminology is used when it is not related to what is actually occurring in the vocal mechanism, but rather to the auditory impression of the listener (Michel & Wendahl, cited in Travis, 1971). Boone (1971) reported that descriptive terminology of voice quality has one meaning to the clinician writing it, but has a variety of meanings to all those who read it. Michel and Wendahl (cited in Travis, 1971) stated that while there is some overlap occurring in terminology used by some authors, this overlap should not be construed as agreement, since the explanation of identical terms by differing authors is seldom the same.

There appears to be little, if any, unified agreement on the terms used to describe laryngeal phonatory voice quality. Perkins (1977) studied classifications of vocal qualities from nine speech pathology texts and found 27 terms. Of the 27, only 12 terms were used in more than one text. Only two terms, hoarseness and nasality, were used by all texts. Murphy (1964) collected over 60 descriptive terms used for normal and abnormal voice quality. "Obviously this gordian knot of intertwined

terminology hardly provides a lucid description of defective vocal behavior" (Perkins, 1977, p. 279).

Emerick and Hatten (1974) found some agreement on the meanings of five descriptive terms and felt confident in using them. They were hoarseness, harshness, breathiness, hypernasality, and denasality. Morris and Spriestersbach (cited in Darley & Spriestersbach, 1978) recognized the controversy on the labeling of voice qualities, however, used the four categories of breathiness, harshness, hoarseness, and nasality in describing disorders of voice quality. Moore (1971) described the terms hoarseness, breathiness, harshness, spastic dysphonia, aphonia, hypernasality, hyponasality, and muffled voice. He described these terms for a twofold purpose consisting of tradition, in part, and because these descriptive terms are associated with specific phonatory or resonatory phenomena that are in turn associated with the auditory factors that are voice disorders.

However, many researchers have found difficulty in such terminology related to laryngeal function. Jensen (1965) found poor agreement among trained listeners when distinguishing between the terms hoarseness, breathiness, and harshness. Thurman (1954) found that trained

listeners were able to reliably differentiate between an abnormal voice quality associated with a resonance or phonatory disorder, however, were not reliable in determining qualities associated with phonatory disorders. He further reported that the most confusion was associated with the terms hoarse and harsh, but there was also confusion between the terms hoarse, breathy, harsh, and strident (Thurman, 1954). Kreul and Hecker (cited in Wayte, 1971) found judges had difficulty differentiating between the terms hoarseness, harshness, and breathiness in rating connected speech samples produced by normal-speaking adult males and adult males presenting quality disturbances secondary to laryngeal malignancies. On the basis of their findings, Kreul and Hecker concluded ". . . that either the concepts of nominally different voice qualities overlap in the minds of naive listeners or at least for the laryngeal disease under consideration, well defined voice qualities coexist perceptually" (p. 7).

The finding of Kreul and Hecker (cited in Wayte, 1971), Thurman (1954), and Jensen (1965) appear to support the need of a single descriptive term to refer to phonatory voice quality disorders. Thus, the term vocal roughness was introduced into the literature as a perceptually delineated continuum of phonatory quality

disorders (Brackett, 1971). Morris and Spriestersbach (cited in Darley & Spriestersbach, 1978), in defining the descriptive label hoarseness, stated "some specialists, objecting to the label of hoarseness on the grounds that it is somewhat vague, prefer a label such as roughness" (p. 201).

Severity Judgments of Voice Quality

The need for measures of degree of severity of quality disorders which are reliable and valid was reported by Sherman (1954). Morris and Spriestersbach (cited in Darley & Spriestersbach, 1978) stated that estimating the relative severity of voice disorders is troublesome because clinical judgments are not optimally reliable. They further stated that "there is a procedure by which reliable values for relative severity of a voice disorder can be obtained: psychological scaling" (p. 204). This is a procedure that many have used to assess the relative severity of a variety of voice disorders (Morris & Spriestersbach, cited in Darley & Spriestersbach, 1978).

Equal-appearing interval scales have been used to rate voice disorders in recent literature. Shipp and Huntington (1965) had four experienced judges rate connected speech samples produced by 15 subjects who presented hoarseness secondary to acute laryngitis on an

eight-point scale of hoarseness. Two months later, the judges rated the samples on an eight-point scale of breathiness. The conclusions obtained were that perceptions of breathiness and hoarseness were related to some degree. Each judge's rating for each sample was correlated with the ratings of the other judges to obtain interjudge reliability. They found that the judges were moderately reliable in judging breathiness and hoarseness on an eight-point equal-appearing interval scale.

Sherman (1954) reported that extraneous factors, such as articulation proficiency, language usage, and phonemic context may influence voice quality judgments of connected speech samples. To study the effects of meaningfulness related to perceptual judgments of quality, samples of 15 clinically diagnosed harsh voices and 15 clinically diagnosed nasal voices were played forwards and backwards to determine whether backward play reduced judgment contamination. Seven-point scales were used to rate harshness and nasality by 35 trained judges. Results indicated that backward play seemed to eliminate the influence of irrelevant factors on the perception of voice disorders.

It has generally been found that tongue height in vowel production tends to influence the degree of roughness, perceptually. Sherman and Linke (1952) used a seven-point equal-appearing interval scale to rate connected speech samples containing front, back, high, low, tense, and lax vowels produced by 15 males presenting clinically diagnosed harsh voices. Each of the samples was rated four times by 35 trained judges. They found that passages containing high vowels, which are relatively short in duration, were judged to be less harsh than passages containing low vowels, which are longer in duration. Tense vowels were also judged to be more harsh than lax vowels. A high degree of positive correlation between judge's ratings for the first and second sessions and the ratings obtained for the third and fourth sessions was found.

Rees (1958) also found that high vowels tended to be judged less harsh than low vowels when the test vowels were produced either in isolation or in CV and CVC syllables by adult males. A group of 32 judges, using a seven-point scaling technique rated CVC and CV syllables, and isolated, sustained vowels produced by 12 males presenting clinically harsh vocal quality. She found that vowels in voiced consonant environments

tended to be rated more harsh than those in voiceless consonant environments, and that regardless of consonant voicing, vowels in fricative environments tended to be rated more harsh than those in plosive environments. Furthermore, she found that vowels produced in isolation did not significantly differ in harshness from those combined with voiced fricative consonants in CV and CVC syllables. These findings seem to indicate that vowels in isolation tend to be perceived at least as harsh as vowels in CV and CVC syllables. Additionally, Rees (1958) observed that vowels initiated with the voiceless glottal fricative /h/ were judged to be less harsh than isolated vowels, but more harsh than vowels in CV or CVC syllables. The order of vowels for all environments, with respect to increasing severity of harshness, was /i/, /u/, /ɪ/, /ʊ/, /ʌ/, /ɛ/, /æ/, /ɑ/, and /ɔ/.

Studies using five-point equal-appearing interval scales of roughness to rate isolated sustained vowels have reported high percentages of interjudge and intra-judge reliability. Morris and Spriestersbach (cited in Darley & Spriestersbach, 1978) noted that the smaller the number of points on the scale, the more reliability the scale has for clinical judgments of voice. They further stated that "typically, a 5-point scale proves

to be adequately discriminating yet fairly reliable" (Morris & Spriestersbach, cited in Darley & Spriestersbach, 1978, p. 205).

Sansone and Emanuel (1970) studied roughness ratings of normal and simulated abnormally rough samples of the vowels /u/, /i/, /ʌ/, /ɑ/, and /æ/ produced by 20 normally speaking adult males. A group of eleven graduate students rated each production using a five-point equal-appearing interval scale. Results revealed an approximately linear relationship (Pearson r = .97) when the medians of the judge's first and second ratings of a 50 vowel reliability sample were correlated. When each judge's ratings of roughness was compared to the ratings of other judges, high percentages (≥92%) of interjudge reliability ±1 scale value, were reported. They also reported that high vowels were judged to be less rough than low vowels.

Lively and Emanuel (1970) duplicated the Sansone and Emanuel (1970) study using females. Twenty normal-speaking adult females produced the vowels /i/, /u/, /ʌ/, /ɑ/, and /æ/ normally and with simulated abnormal vocal roughness. Using a five-point equal-appearing interval scale, judges consisting of 11 graduate students, obtained a high degree of intrajudge (Pearson r = .98)

and interjudge (≥92%) roughness rating agreement. They also found high vowels to be judged less rough than low vowels.

Emanuel, Lively, and McCoy (1973), using the vowel samples obtained by Sansone and Emanuel (1970) and Lively and Emanuel (1970), had 11 graduate students rate these productions using a five-point equal-appearing interval scale. They found that male productions, generally, were judged more rough than female productions. A high degree of intrajudge (Pearson $\underline{r}$ = .98) and interjudge (≥92%) reliability was obtained in the roughness ratings. Furthermore, high vowels were judged to be less rough than low vowels.

Whitehead and Emanuel (1974) had eleven graduate students use a five-point scaling technique to rate the vowels /i/, /u/, /ʌ/, /ɑ/, and /æ/ produced normally and with simulated abnormal vocal roughness and in the vocal fry register. The roughness ratings of the vocal fry productions were similar to those obtained for the rough productions. The vocal fry ratings and the abnormal vocal roughness ratings each exceeded those obtained for the normal productions. They obtained a high degree of intrajudge reliability (Pearson $\underline{r}$ = .98) and a high percentage (≥90%) interjudge reliability, ±1 scale value. It was again found that low vowels were judged to be more

rough than high vowels.

Direct Magnitude Estimation

Another method used in delineating vocal quality is direct magnitude estimation. Small (1973) described direct magnitude estimation as being designed so

> that the listener would make ratio judgments with respect to a standard stimulus and provide numbers consistent with his judgments. For example, a stimulus is presented to a listener and he is told that it has a quality that corresponds to the number 100 (or any other arbitrary number). Any time during the course of the experiment he hears a stimulus that sounds identical to the standard, he is asked to assign the number 100 to the stimulus. He is further instructed that should he hear a stimulus whose quality seems to be one-half that of the standard, he is to assign it the number 50. Correspondingly, should he hear a stimulus whose quality was twice that of a standard, he should assign it the number 200 (p. 364).

Further research is needed regarding the results and reliability of direct magnitude estimation as a method used to perceptually rate voice quality. To date, very little has been reported in the literature on direct magnitude estimation.

Semantic Differential Technique

Still, another method used to describe voice quality is the semantic differential technique. The purpose of the semantic differential technique is to reduce the many judgment scales used to a limited but distinctive quantity (Osgood, Suci, & Tannebaum, 1967). Isshiki,

Okamura, Tanabe, and Morimoto (1969) performed a factor analysis of hoarseness using the semantic differential technique. Analysis of 16 sets of adjectives, i.e., dark-bright, sharp-dull, calm-excited, etc., indicated that four factors were indicative of hoarse voice quality. Arbitrary terms were given to these factors which were: "B" (breathy), "A" (astenic), "D" (degree of hoarseness), and "R" (rough, rumbling, or rattling). Isshiki et al. (1969) attempted to differentiate among clinically hoarse voices using these factors. Five Japanese vowels were produced by 150 subjects, presenting both laryngeal pathology and functional voice disorders. Five otolaryngologists used four-point scales to rate each vowel production using the four factors, B, A, D, and R. Results revealed that different factors, or combinations of factors were suggestive of certain pathology types. For example, a voice associated with vocal cord nodules or polyps was most frequently of the R type, while a voice associated with laryngeal cancer was most frequently of the RB type.

Nature of Menstruation

The Endocrine System

Wyatt (1941) reported endocrine changes, such as puberty, pregnancy, and menstruation as one of the reasons

that clinical voice pathology gives for functional voice disturbances. He further stated that "these voice inefficiencies apparently have their primary source in a disturbance of the physiological mechanism of the vocal organs and may therefore be called genuine functional voice disturbances" (Wyatt, 1941, p. 237). It is necessary to briefly review the function of the endocrine system and how it affects the functioning of the speech mechanism.

The major endocrine glands include the thyroid, parathyroid, pituitary, suprarenals, and pineal glands, and the gonads, which control certain functions of the whole body or of specific remote target organs by secreting hormones into the blood stream (Gray, 1973; Luchsinger & Arnold, 1965). West (1947) stated that the operation of the endocrine system depends upon the secretory nature of all the living tissues in the body. He went on to report that every tissue, as it metabolizes in the process of functioning, produces some secretion which is carried into the blood stream by the serum that permeates the functioning tissue. Those products act as chemical messengers of intercommunication among the various organs of the body, and are called hormones (Gray, 1973; West, 1947). These hormones pass to all parts of the body and may either produce or inhibit

activity in areas that are far removed from the site of origin (Diehl, 1968). Diehl (1968) stated that hormones do not initiate action themselves, but energize the reactions catalyzed by specific enzymes and that the action of certain glands may be independent or inter-dependent involving a complex series of events. The endocrine system involves "1) glands that produce special drug-like products, 2) a blood system to transport these products, and 3) tissues whose natural properties make them responsible to these products" (West, 1947, p. 20). Since the endocrine glands are ductless, their products or hormones transfuse directly from the secreting cell of the gland through the capillaries which interlace the gland tissue, and on through the entire vascular system (Gray, 1973; West, 1947). Although the hormones are carried by the blood stream to all parts of the body, only certain types of cells or organs are able to respond to their stimulation (Gray, 1973). He also stated that the specific organ which does respond to the stimulation of the hormone is the target organ.

> The endocrine products affect the functioning of the speech mechanism in two ways: 1) they permeate the muscle tissue itself, affecting its irritability; 2) they similarly permeate and affect the tissues of the nerves that control the muscles. In the main, only general responses and changes in the degree of activity are brought about by endocrine activity (West, 1947, p. 20).

Furthermore, he stated that the various functions of the system are kept in balance by the opposition of one gland or group of glands to another and that normalcy is maintained by a state of balance between opposing tendencies (West, 1947).

The Menstrual Cycle

The purpose of this paper is to focus on the vocal changes affected by ovarian function, which is endocrinologically related to the gonads and the pituitary gland. In particular, this paper will deal with only one aspect of vocal change dependent on ovarian function which is menstrual dysodia, a term used by Luchsinger and Arnold (1965) to describe vocal disorders occurring prior to or during menstruation. To obtain a better understanding of menstrual dysodia, occurring in a woman prior to or during menstruation, it is necessary to briefly examine the complete menstrual cycle and the hormonal changes occurring which are affected by the endocrine system.

"The uterus is an organ which is under the influence of hormones and which is constantly undergoing changes throughout the monthly cycle" (Lauersen & Whitney, 1977, p. 71). Gray (1973) reported that the changes in the uterus and the cyclic changes in the ovary are highly related, and both organs must be considered together.

Furthermore, he stated that menses is the process of periodic or cyclic changes occurring in the endometrium or lining of the uterus after puberty and throughout the childbearing years. The result of menses is bleeding from the uterus and the point of time from which the cycle is measured occurs with the beginning of the bleeding (Gray, 1973). Gray (1973) and Wilson and Wilson (1978) stated that the menstrual cycle usually ranges from 20 to 35 days with 28 days being average, but can vary markedly from individual to individual and between cycles of the same individual. "Although the changes are a continuous process, the cycle is usually divided into four phases, viz: a) proliferative, b) secretory or progravid, c) premenstrual, and d) menstrual" (Gray, 1973, p. 1329).

The proliferative phase commences immediately after menstruation. Gray (1973) cited that the basalis, which is the portion of the endometrium adjacent to the myometrium, remains after the cessation of the menstrual flow allowing the glands and lining epithelium to be restored to an inactive condition. At this time, the hypothalamus produces a releasing factor that causes the anterior lobe of the pituitary gland to release follicle stimulating hormone (FSH) (Luchsinger & Arnold, 1965; Wilson & Wilson, 1978). FSH stimulates the

growth of the follicles in the ovary. As these follicles start to increase in size, they produce estrogen, an ovarian hormone, from the theca internal cells surrounding the follicles (Gray, 1973; Lauersen & Whitney, 1977; Wilson & Wilson, 1978). The increased amount of estrogen produced by the follicles stimulates the proliferation of the endometrium of the uterus, greatly enlarging the uterine glands (Gray, 1973; Wilson & Wilson, 1978).

The secretory phase occurs when one ovarian follicle has ripened into a mature Graafian follicle and ruptures at the middle of the cycle, or about the fourteenth day of the cycle, thus freeing the ovum and resulting in ovulation (Gray, 1973). This occurs when the rising estrogen level in the blood acts on the hypothalamus, which in turn acts upon the anterior pituitary to release luteinizing hormone (LH) (Wilson & Wilson, 1978). Additionally, they reported that a brief increase in the release of LH, and to a lesser degree of FSH, causes the weakening of the wall of the Graafian follicle in the ovary and enables the mature egg to be released at ovulation and pass into the fallopian tube. Under the influence of LH and the further decrease of FSH, the ruptured follicle develops into a corpus luteum (Gray, 1973; Wilson & Wilson, 1978). The proliferating cells

of the corpus luteum produce the ovarian hormone, progesterone; and this increased amount of progesterone, as well as, estrogen prepares the uterus for implantation through an increase in the vascularity and thickness of the endometrium and in stimulating growth of the uterine glands (Gray, 1973; Wilson & Wilson, 1978).

The premenstrual phase of the menstrual cycle occurs when the corpus luteum begins to regress about 10 days after ovulation, if ferilization of the ovum does not occur (Gray, 1973; Wilson & Wilson, 1978). These authors further stated that there is a sudden withdrawal of progesterone and estrogen when the corpus luteum begins to degenerate. Thus, the endometrium reciprocates by blood supply changes, tissue deterioration, and fragmentation of the glands and epithelium (Gray, 1973). Wilson and Wilson (1978) stated that prior to menstruation, the arterioles in the endometrium contract and cease the blood flow to the cells in the superficial layers of the endometrium.

The menstrual phase occurs when the functionalis, which is the upper layers of the endometrium containing abundant capillaries and the enlarged glands, is sloughed away and the ruptured vessels produce the bleeding of the menstrual flow (Gray, 1973). Wilson and Wilson (1978) reported that an average of 300 ml of menstrual

fluid is released consisting of epithelial and stromal cells, blood, and secretions of the uterine glands. Gray (1973) stated that the basalis, which is the deeper region of the endometrium or the bottoms of the glands and tissue adjacent to the myometrium, is not lost in menstruation but remains to establish the new endometrium for the next succeeding cycle.

Gray (1973), Wilson and Wilson (1978), and Pace, McCashland, and Landolt (1965) reported that the common length of the menstrual cycle is 28 days. Pace et al. (1965) stated that the menstrual cycle can be roughly divided into periods of 4, 10, 4, and 10 days. With menstruation commencing the cycle, it lasts an average of 4 days, the proliferative phase lasting about 10 days, ovulation or the freeing of the ovum into the fallopian tube, occurs about 10 days after menstruation ends or about the fourteenth day of the cycle. If fertilization does not take place within approximately 4 days, then about 10 days later the endometrium breaks down and the cycle is repeated (Pace et al., 1965).

Premenstrual Tension

Frable (1962) found that hoarseness was an unrecognized symptom of premenstrual tension. She reported that premenstrual tension has been highly acknowledged in the literature as occurring in women about seven to fourteen

days prior to menstruation and terminating with the onset of menarche. The first paper to coin the term premenstrual tension, in describing the symptoms associated with women prior to menstruation, was American gynecologist, Robert Frank (1931). "My attention has been increasingly directed to a large group of women who are handicapped by premenstrual disturbances of manifold nature. It is well known that normal women suffer varying degrees of discomfort preceding the onset of menstruation" (Frank, 1931, p. 1053). Frank (1931) associated cyclic emotional disturbance with physical molimina from ten to seven days preceding menstruation. He also stated that the cause of premenstrual tension was related to an increase in the amount of female sex hormone produced to the amount excreted, thus possibly resulting in edema.

Delaney, Lupton, and Toth (1976) stated that before and during menstruation there are two major groups of symptoms that bother women. One is the physical sensation of cramping, backache, bloatedness and others which are referred to as dysmenorrhea, and indicate an abnormality in the normal biological process. The other group is mental symptoms generally resulting in irritability or depression. Delaney et al. (1976) reported that both the physical and mental symptoms

are grouped together as the premenstrual syndrome, and may spring from the same physiological source. Parlee (1973) suggested that menstrual dysfunctions are more likely to have physiological rather than psychological origins.

> Besides feeling tense, women in their premenstrual phase are reported to feel irritable, faint, restless, sluggish, crabby, impatient, depressed, lethargic, deluded, indecisive, dizzy, nervous, nymphomaniacal, and irrational - although not all at once. The most common physical symptoms include swelling of the breasts, feet, abdomen, and vulva; hoarseness; constipation; hemorrhoids; skin eruptions such as cold sores or acne; weight gain (about three to six pounds); easy bruising; migraines; backaches; graying of hair; and peeling of fingernails (Delaney et al., 1976, p. 73).

Moos (1969) found from a review of the literature that over 150 different symptoms have been associated with the menstrual cycle. A less common disorder associated with the premenstrual phase of the cycle is spontaneous hypoglycemia, when blood-sugar values fall below the normal level (Delaney et al., 1976).

Morton (1950) described premenstrual tension as a symptom-complex that starts 10 to 14 days premenstrually, peaks shortly before menses, and disappears following the onset of the menstrual flow. Green (1965) noted that premenstrual tension usually develops 3 to 7 days

and on occasion as long as 10 to 14 days before menstruation. Additionally, he stated that it peaks 24 to 48 hours premenstrually and usually subsides 24 to 48 hours after the onset of menstruation.

Delaney et al. (1976) stated that most women exhibit only minor symptoms during the premenstrual phase. They reported that bloatedness, irritability, and depression are the most universal discomforts. Estimates of women exhibiting symptoms of premenstrual tension range from 20 to 100% (Delaney et al., 1976). Weideger (1976) reported that 50 to 75% of women experience some degree of the premenstrual syndrome. Sutherland and Stewart (1965) designed a questionnaire to determine the extent of premenstrual symptoms encountered by 150 women. They found that 39% exhibited premenstrual molimina while 3% reported no molimina. Pennington (1957) stated that 95% of American women suffer premenstrual symptoms at one time or another. Suarez-Marias (1953) found that 85% of female students in good health exhibited one or more symptoms or premenstrual tension at some time.

Delaney et al. (1976) and Parlee (1973) questioned the use of such questionnaires in determining incidence of premenstrual tension and in the terminology used in questionnaires. They stated that such questionnaires

often predict through their wording, the symptoms that they expect to isolate, and reflect a bias toward treating menstruation as a problem. Furthermore, due to their oftentimes overwhelmingly negative emphasis, they are bound to show negative results (Delaney et al., 1976; Parlee, 1973).

Parlee (1973) stated that the many symptoms associated with the premenstrual syndrome have been used somewhat broadly. She further stated that throughout the literature the premenstrual syndrome "has been taken to include the recurrence of any symptoms always at the same time in each menstrual cycle or even any combination of emotional or physical features which occur cyclically in a female before menstruation" (Parlee, 1973, p. 458). Sutherland and Stewart (1965) reported that there has been confusion of nomenclature of the premenstrual condition and confusion in defining the clinical features which constitute its essence and those features associated with it.

Morton (1950) stated that it is widely accepted that ovarian activity is greatly associated with premenstrual tension but actual etiology is as yet undetermined. In 29 women exhibiting premenstrual tension, an estrogen-progesterone imbalance with a

relative excess of estrogen, due to deficient progesterone secretion was found (Morton, 1950). Furthermore, Morton (1950) stated that this unopposed estrogen is able to display its activity in one or more of three ways. It stimulates increased epithelial proliferation and is responsible for hyperplastic changes occurring in the breast, uterus, and vaginal epithelium. It causes retention of extracellular tissue fluid and this retention is exhibited by an increase in body weight and edema, and can depend, in part, on the increased capillary permeability that takes place at this time. It alters carbohydrate metabolism by increasing sugar tolerance, thereby exhibiting a tendency toward hypoglycemia (Morton, 1950).

> Current concepts concerning etiology of the symptoms can perhaps be summarized as follows: 1) psychic factors: always present; often obviously the most prominent feature; 2) endocrine-metabolic factors: a) There is definite evidence for an estrogen progesterone imbalance, with a relative excess of the former. Since the sodium-retention effect of estrogens is well known and documented (progesterone tends to promote the renal excretion of sodium), this in turn results in: b) sodium and water retention with weight gain and a generalized form of edema, an obvious source of many of the somatic symptoms and signs and a potent factor in producing many of the central nervous system manifestations as well, since some degree of cerebral edema must also be assumed. Since the symptoms rarely if ever occur during an anovulatory cycle, it is the

> abnormal estrogen-progesterone balance, not estrogen alone, which is responsible. c) Some degree of corpus luteum insufficiency is undoubtedly present in many instances, and in certain cases an underlying, subclinical form of hypothyroidism (hypometabolic state) has been shown to be responsible for luteul deficiency and inadequate progesterone production. d) The tendency to premenstrual hypoglycemia may be a contributing factor. e) Occasionally, 17 ketosteroid excretion has been observed to be abnormal. The significance of this is not yet clear, but it could conceivably be associated with increased excretion of aldosterone, known to occur when progesterone levels are sufficiently high to inhibit the renal action of aldosterone. Rising aldosterone levels in turn might also predispose to sodium and fluid retention (Green, 1965, p. 125).

Van Gelder (1974) reported that psychical factors may be assumed in certain voice disorders of endocrine origin including dysphonias related to menstruation. Additionally, these voice disorders are usually found in women with a tendency to a constitutional or a professional abuse of their voice. Van Gelder (1974) further stated that it has long been determined that the larynx functions as a hormonal target-organ.

> Because of the close connection between the hypothalamic-hypophysary system and the psyche on the one hand, and the endocrine organs on the other, there exists a twofold relationship between psyche and voice, a hormonal-organic relationship and a psychogenic-functional one. It is often very difficult to differentiate between

> hormonal-organic factors and psychogenic functional components in these voice disorders, but this is connected with the strong influence of psychic functions on the whole hormonal system (Van Gelder, 1974, p. 257).

Effect of Menstruation on the Voice

The Singing Voice and Menstruation

Vocal roughness has been noted in the literature as being associated with premenstruation and menstruation in female singing and speaking voices which are usually normal in quality. Many of these same authors have stated that the vocal mechanism undergoes physiological changes during premenstruation and menstruation which are reflected in the quality perceptions of vocal roughness. Both the perceptual changes and the physiological changes reported in the literature as occurring in normal females during premenstruation and menstruation in singing and speaking will be reviewed.

Luchsinger and Arnold (1965) noted that singing represents a true form of physical exercise of a major part of the muscles of the body. Greene (1972a) reported that "singing requires a more exacting performance in every department than does speech" (p. 80). Bryce (1974) stated very little difference exists between the larynx of a nonsinger and the larynx of a singer upon laryngeal examination.

Luchsinger and Arnold (1965) noted that during menstruation, disorders of the singing voice occur frequently. These changes are revealed in a decrease in the quality of high notes, and singing flat on high notes or at the register passages. These perceptual changes are caused by hyperemic and slightly edematous vocal folds during premenstruation and menstruation. "Moreover, the female vocal cords reflect the menstrual changes in the body. Before or during menstruation, slight swelling or reddening of the vocal cords is frequently observed. As a result, the voice is not as good as during normal days" (Luchsinger & Arnold, 1965, p. 158). They reported that shortly before and during menstruation, women should avoid professional singing. Furthermore, many European opera singers have contracts with their company stating that they will be excused from performing at the time of menstruation. Luchsinger and Arnold (1965) noted that a menstruating singer might tend to strain her voice which could be very detrimental to the voice.

Flach, Schwickardi, and Simon (1969) examined 136 professional singers to determine the influence menstruation had on their voices. Of the 136, 104 singers showed premenstrual and menstrual voice changes. Flach

et al. (1969) recommended that the singing of larger operatic parts be avoided immediately before or during menstruation.

Van Gelder (1974) reported that many singers present menstrual dysodia. "The voice varies from dull and colorless to raucous and hoarse. In some cases there is some hyperemia, edema or even hemorrhage of the vocal cords" (Van Gelder, 1974, p. 258). Small hematomas on the vocal folds may extend if forced singing occurs (Van Gelder, 1974). He stated that edema appears to be the general symptom of the vocal folds during menstruation.

Lacina (1968) identified premenstrualis laryngopathia and vocal deterioration, not volume, resulting from congestion of the vocal folds of one-third of the female singers of the Prague Opera. Furthermore, he observed the loss of high tones, uncertainty of pitch, and small submucous hemorrhages in 42 of 100 singers before and during menstruation. Lacina (1968) found that these changes in voice did not occur regularly on one particular day of premenstruation nor were they consistent for each menstruation. Vocal rest at this time for female singers was one of his recommendations.

Kaufman (1967) noted that many women who sing professionally avoid public appearances during

premenstruation due to temporary impairment of the voice from laryngeal congestion. Hildernisse and Tarneaud (cited in Greene, 1972a) noted voice changes in female singers during menstruation. Imhofer and Nadoleczny (cited in Luchsinger & Arnold, 1965) observed sudden appearances of submucous vocal cord hemorrhages in women who were forced to sing strenuous parts during menstruation.

Graves (1917) noted that singers experience a change in the trueness of their notes and a change in voice quality prior to and during menstruation. He reported that this change in vocal quality was due to swollen mucous membranes of the nose, throat, and vocal folds. Greene (1972b) stated that ovarian changes in females can result in vocal changes by means of ingestion of the mucus membrane or edema. She reported that these vocal changes can result in huskiness during the menstrual period and that singers should not perform at this time if their voices are affected.

Brodnitz (1953, cited in Levin, 1962) stated that in the United States, singers are not excused from performing premenstrually or during menstruation as they are in many European opera companies. Furthermore, he reported that preceding or during menstruation many women have no discomfort or respiratory congestion, while

these may occur in other women in varying degrees. "As a rule no harm will come from performing during the period of menstruation if the singer is aware of the need for greater vocal care and avoids force to overcome diminished brilliance and agility of the voice" (Brodnitz, cited in Levin, 1962, p. 450). Brodnitz (1971) noted that sudden dysphonia in singers during the last few days preceding menstruation and the first few days of menses is not uncommon.

> Phoniatric investigations were carried out on 30 female subjects, ten singers, ten actresses, and ten women with no special vocal demands, with the aim of objectifying the dependence of variations in the efficiency of the noise upon the menstrual cycle and the influence of ovulation inhibitors. The methods of investigation employed included laryngological investigations, auditory judgments and electro-acoustic measurements, and primarily acoustic analysis by the sweep-tone method. The results confirmed the known reduction of vocal efficiency during menstruation. Ovulation inhibitors produced a favourable effect in that bleeding involves less severe vocal conflict than normal menstruation. On the other hand, the investigation showed that the danger of virilisation of the voice with the use of ovulation inhibitors must not be underestimated. Phoniatric checks are to be recommended for all female patients whose career demands high vocal efficiency (Wendler, 1972, Summary, p. 275).

The Speaking Voice and Menstruation

Brodnitz (1953) noted that it is important to treat the respiratory tract as a whole unit that is

sensitive to changes in hormonal balances. "The endocrine system regulates many functions of the human organism. Any imbalance or malfunctioning of this system can have a direct effect on phonation" (Damste & Lerman, 1975, p. 78). Brodnitz (1962) stated that vocal impairments during menstruation are mainly due to hormonal imbalance. "Too little is yet known about the influence of hormonal and autonomic nervous dynamics on the voice, but enough evidence is available to make endocrinological investigation an important tool of vocal examination" (Brodnitz, 1962, p. 281).

Meano (1967) stated that congestion of specific endocrine glands which are associated with other glands is a frequent characteristic of the menstrual period and influences the voice. Temporary inflammation of the vocal folds and sometimes the respiratory tract can result from menstruation (Meano, 1967). Greene (1972a) stated that this endocrine imbalance causes huskiness during menstruation. She further reported that "a slight oedema may produce hoarseness, reduction in muscular tonicity and limitations in pitch. This is not an inconvenience to the average woman but may be troublesome and cause anxiety to teachers, actors and singers" (Greene, 1972a, p. 234).

Nadoleczny (cited in Luchsinger & Arnold, 1965) reported hoarseness occurring repeatedly in an actress during menstruation. A laryngeal examination was performed to observe what was the cause of the temporary hoarseness. Laryngoscopy revealed vocal cords that were swollen, edematous, and showed a reddish sheen, while there appeared to be a diminished mucous secretion, which lead to a dryness sensation.

Frable (1962) reported that hoarseness was an unrecognized symptom of premenstrual tension in the speaking voices of women. She pointed out that large amounts of big molecules of polysaccharides in the ground substance of tissues were produced by the increased level of estrogen. After the twenty-first day of the menstrual cycle, when the level of estrogen declines sharply, these big molecules break down into smaller units. These smaller units are water binding and lead to a mucinous edema. The decreasing estrogen level also causes increased permeability of small blood vessels and of fluid in tissues thus increasing the vibrating mass of the vocal folds. Frable (1962) stated that these physiologic changes accounted for the vocal changes presented by the three cases she reported on. One of Frable's (1962) cases complained of ". . . huskiness and

flatness of the voice several days prior to the onset of her menses. She also noted vocal breaks . . ." (p. 81). The second case report noted ". . . alternating vocal hesitation and vocal explosiveness . . ." (Frable, 1962, p. 82). While, the third case presented complaints ". . . of faltering, uncertain, and difficult to control speech . . . " and speech that ". . . tended to be lower in pitch . . ." (Frable, 1962, p. 82). Thus, Frable (1962) concluded "three patients with complaints of premenstrual hoarseness, lowered vocal pitch, and vocal instability are presented" (p. 82).

Brodnitz (1971) stated that "the extreme complexity and interdependence of the glandular system may produce a great variety of hormonal imbalances which affect the voice" (p. 183). Furthermore, he stated that vocal quality and changes in pitch may occur frequently in association with menstruation. "The menstrual cycle may produce transient changes in the voice" (Brodnitz, 1971, p. 186).

Amado (1953) reported that huskiness occurred in some female voices prior to menstruation and stated that this was due to a hormonal imbalance which lead to a lack of muscular tonicity. Voorhees (1914) found that menstruation, as a physiological condition, may markedly

affect the quality and carrying power of the voice. He stated that "the edges of the vocal cords are extremely sensitive to slight influences" (Voorhees, 1914, p. 342). Damste and Lerman (1975) stated that a vocal disturbance in the form of hoarseness occurs in many women during premenstruation due to a light edema of the vocal folds.

Perello (1962) described a dysphonia or hoarseness which forms part of the premenstrual syndrome. He stated that the dysphonia or hoarseness is due to a thickening of the laryngeal epithelium through a growth of eosinophylic, cornified cells. Perello (1962) noted that female speaking voices are frequently hoarse, frequently drop and show slight periodic changes, however, it is usually unnoticed in everyday life but is an inconvenience to singers. The well-known connection between functional voice disorders and endocrine imbalance was mentioned by Perello (1962), in that these laryngeal symptoms of hoarseness exhibited by many women premenstrually often tend to be attributed to functional disorders. Wendler, Igel, and Steindel (1968) stated that during menstruation, the voice is often restricted. "Especially in person with heavy vocal disturbances before or during the normal menstruation we observed a distinctly lower reduction in performance during the medicamentous interval" (Wendler et al., 1968, p. 247).

Cooper (1973) reported that some women exhibit some difficulty with the voice prior to the menstrual period. He further stated that the hormones have a twofold effect on the voice. One is the direct effect upon the larynx, while the other is an indirect effect from the emotions which may be affected by the hormones, thus influencing the voice (Cooper, 1973).

Cooper (cited in Travis, 1971) stated that "constitutional factors and altered body activity or functions may lead to a laryngeal effect that may contribute to a functional misphonia, which in turn may result in an organic dysphonia" (p. 587). Cooper (cited in Travis, 1971) included hormonal changes during the premenstrual period, among others, as a condition that can result in inflammation or edema of the vocal folds. "This condition of the vocal folds may result in a slower vibratory pattern, thereby creating a lowered pitch. Unfortunately, this temporary vocal disability may become permanent" (Cooper, cited in Travis, 1971, p. 587).

Moore (1971) stated that glandular imbalance affects the voice through edema and that the voice can be influenced by the very slightest disturbance.

> Variations in gonadal function also influence fluid balance and consequently affect the voice. The most frequent evidence of this condition

> is the change of voice noticed by many women in relation to their menstrual cycles. Usually, the vocal problem lasts for only a few days, but in some women it is persistent" (Moore, 1971, p. 104).

Moore (1971) identified edema as swelling which results from serous fluid located in extra vascular spaces and stated that ". . . it is a condition that causes localized or generalized enlargement of a structure or area. When it is present in the vocal cords, it affects their mass, elasticity, and compliance, with a consequent influence on phonation" (p. 103). Moore (1971) further stated that among other causes, glandular imbalance may be considered as one of the conditions causing edema of the vocal folds.

> The multiple causes of edema and its effect on the voice when the larynx is involved stress the potential importance of this condition in the evaluation and management of voice disorders. Extra vascular fluid, whether it be caused by disease, trauma, interference with fluid distribution, medicaments, glandular imbalance or allergic reactions, modifies the behavior of the vocal cords and consequently the vocal sound. Its subtle presence serves to obscure diagnosis and complicate therapy. Its potential importance to the voice pathologist cannot be over emphasized (Moore, 1971, p. 105).

Bryce (1974) stated that a very slight difference in the mass or contour of the vocal folds can produce hoarseness. "Hoarseness may thus result from changes in the mass of

the vibrating cord as an inflammation or edema, . . ." (Bryce, 1974, p. 15). Brodnitz (1954) reported that "a low metabolic rate leads to a retention of body fluids in the surface tissues which may influence profoundly the character of the speaking and singing voice" (p. 323). Furthermore, "hormonal imbalance or metabolic disorders may not only modify vocal function directly through changes in tissues, but may affect vocal behavior through changes in moods and of the emotional balance" (Brodnitz, cited in Levin, 1962, p. 453).

Four research studies have been reported to determine if vocal roughness is indeed an oftentimes unrecognized symptom of premenstrual tension in the normal speaking voices of women. These four studies appear to be the only systematic investigations in the literature, to date, on whether vocal roughness is commonly experienced among normal females premenstrually and during the onset of menses. The following is a review of these studies.

Whitehead et al. (1974) reported on harmonic and inharmonic changes of twelve normal female voices for 32 consecutive days, during which each of the subjects experienced a complete menstrual cycle. Each subject phonated the vowels /u/, /i/, /ɑ/, and /æ/ at 75 db SPL (±1 dB). Two-second tape loops were constructed and

played into a constant bandwidth (1-Hz) wave analyzer with a component graphic level recorder attached so that a frequency-by-amplitude spectrum for each vowel was obtained. They found that for all vowels for the spectral range, 100 to 2600 Hz, averaged across the 12 subjects, there was an approximate 5 to 8 dB increase in mean spectral noise level from approximately 3 days before the menstrual period through approximately 4 days after the onset of menstruation. The increase in spectral noise levels premenstrually and during the menstrual periods was significant at the .01 level. Whitehead et al. (1974) ranked the vowels /æ/, /ɑ/, /u/, and /i/ in order from greatest to least spectral noise. Additional results revealed that for the total spectral range, 100 to 8000 Hz, there was an increase in mean spectral noise levels of 6 to 9 dB during the premenstrual and menstrual periods (Whitehead et al., 1974). These findings were significant at the .01 level. The vowel /æ/ showed the greatest amount of spectral noise, the vowels /ɑ/ and /i/ showed approximately the same, and the vowel /u/ displayed the least amount of spectral noise. Whitehead et al. (1974) also investigated the mean intensities of the fundamental vocal frequency and second harmonic for the four vowels averaged across all 12 subjects for each of 32 days. It was found that a decrease in mean intensity

level of the first two harmonics occurred about 3 days prior to menstruation and continuing through about 4 days after the onset of menstruation. Generally, the authors noted about a 4 to 6 dB decrease in spectral harmonic levels during premenstruation and menstruation for all vowels. An analysis of variance showed this decrease was significant at the .01 level (Whitehead et al., 1974). Finally, Whitehead et al. (1974) investigated the mean intensity levels of the first five harmonics for the vowels averaged across the 12 subjects. They found a 4 to 7 dB decrease in spectral harmonic levels beginning about 3 days premenstrually and continuing through 4 days menstrually. This decrease was significant at the .01 level (Whitehead et al., 1974). They concluded that these results ". . . revealed a significant increase in vowel spectral noise levels and a corresponding significant decrease in vowel spectral harmonic levels. These significant changes in the vowel spectra occurred just prior to and during a portion of the menstural period" (Whitehead et al., 1974, p. 6).

> From the results of the present study, it appears that for some female speakers, the menstrual period has a significant affect on certain vowel spectral features. Eventhough there is a day to day variation in spectral noise levels and spectral harmonic levels of vowels phonated by adult females, there appears to be a significant

> change in spectral noise levels and spectral harmonic levels prior to and during the menstrual period (Whitehead et al., 1974, p. 6).

A positive correlation has been reported between the level of spectral noise and the degree of perceived vocal roughness and an inverse relationship has been observed between perceived degree of roughness and vowel spectral harmonic levels (Emanuel, Lively, & McCoy, 1973; Lively & Emanuel, 1970; Sansone & Emanuel, 1970; Whitehead & Emanuel, 1974).

Silverman and Zimmer (1976) obtained two speech samples from the same menstrual cycle from 20 normally speaking females. Each of the subjects phonated the vowels /ɑ/, /i/, and /u/ three times each for a duration of three seconds. One of the speech samples was collected at ovulation or at midcycle, when edematous conditions do not normally occur. The other speech sample was obtained at premenstruation, when edema commonly occurs in females. Each subject recorded basal body temperature daily during a complete menstrual cycle and reported the actual dates that menstruation began, to insure that the speech samples were indeed collected at ovulation and at premenstruation. Each vowel phonation was recorded at loudness levels considered to be comfortable by the subjects. The vowel samples were

recorded and narrow-band sonagrams were made from the second production of each vowel, using a Kay Sona-Graph combined with a Kay Scale Magnifier. These vowel productions were classified regarding degree of "hoarseness," using a scale from 0 to 4, with 0 being the absence of hoarseness and 4 representing severe hoarseness. "Basically, this classification procedure involved the visual estimation of the intensity of the noise component relative to that of the harmonic component" (Silverman & Zimmer, 1976, p. 4). One of the authors rated each randomized sonagram and several days later repeated the rating task to determine intrajudge reliability. A self-agreement index of .86 was obtained. To estimate fundamental frequency, the sonagrams for the vowel /ɑ/ were randomly analyzed by one of the investigators by measuring the frequency of the tenth harmonic at 50 msec intervals and then averaging these measurements. To determine intrajudge reliability, 10 sonagrams were randomly selected and a self-agreement index of .90 was obtained.

> Inspection of the mean hoarseness ratings for each vowel as well as the average of these ratings at both ovulation and premenstruation indicated that the average subject showed essentially no tendency to become hoarse at premenstruation. The mean hoarseness ratings for the three vowels combined were 1.2 at ovulation and

1.3 at premenstruation (Silverman & Zimmer, 1976, p. 5).

"The fundamental frequency analysis revealed that there was essentially no difference between the fundamental frequency used at ovulation and that used at premenstruation by the average subject. Group means were 217 Hz at ovulation and 216 Hz at premenstruation" (Silverman & Zimmer, 1976, p. 5). Silverman and Zimmer (1976) concluded that "the results of this research do not support the contention that hoarseness is a feature of the premenstrual syndrome for the typical woman, since the typical subject in this study was no more hoarse at premenstruation than at ovulation" (p. 6).

Silverman and Zimmer (1978) replicated their 1976 study, using 27 normally speaking female subjects. Again, they found that the average subject showed no tendency of hoarseness at premenstruation. The mean ratings for the three vowels /ɑ/, /i/, and /u/ were 1.6 at ovulation and 1.8 at premenstruation and were not statistically significant. "These data, therefore, support the conclusion that premenstrual hoarseness is a rarely occurring condition among young women" (Silverman & Zimmer, 1978, p. 9). Silverman and Zimmer (1978) found that those subjects who presented vocal roughness at premenstruation during one menstrual cycle tended not to

present vocal roughness during the following cycle at premenstruation. They did not analyze fundamental frequency in this study because it was assumed that each subject's fundamental frequency is premenstruation would be basically the same as at ovulation (Silverman & Zimmer, 1978). "The finding that the typical young woman with no career demands on her voice does not become hoarse at premenstruation does not, of course, rule out the possibility that there are women who do routinely become hoarse at premenstruation . . ." (Silverman & Zimmer, 1978, p. 9).

Herrera (1978) investiaged the effects of the menstrual cycle on vowel spectral noise levels (SNLs) during a complete menstrual cycle of 30 consecutive days. Eight normal-speaking females phonated the vowel /ɑ/ at 75 dB for seven seconds. Magnetic tape loops were constructed for each vowel sample and were analyzed to produce a constant, narrow bandwidth (10-Hz) frequency-by-intensity spectrum of each sample's acoustic components. The findings indicated that four of the eight subjects exhibited an increase in the overall SNL mean associated with their phonations during menses, and two subjects showed an increase in the overall SNL mean associated with their phonations prior to menstruation. The differences between individual subject SNL means for phonations during

flow and nonflow days was not large; they ranged from -3.56 dB to 2.58 dB. Individual SNL means were averaged across flow and nonflow day phonations, respectively. The obtained SNL mean associated with phonations during the menstrual period was 17.97 dB, while the SNL mean associated with phonations during nonmenstruating days was 17.85 dB. Results from an independent one-tailed *t*-test revealed no significant difference between the means.

Summary

Perceptual rating procedures, including descriptive terminology, equal-appearing interval scales, direct magnitude estimation, and semantic differential technique have been used in quality assessment of the voice. A lack of agreement has been found among speech pathologists using descriptive terminology (Jensen, 1965; Kreul & Hecker, cited in Wayte, 1971; Michel & Wendahl, cited in Travis, 1971; Perkins, 1977; Thurman, 1954). It has been found that in utilizing equal-appearing interval scales, listeners are able to rate isolated, sustained vowels and connected speech samples with satisfactory intrajudge and interjudge reliability (Emanuel, Lively, & McCoy, 1973; Lively & Emanuel, 1970; Sansone & Emanuel, 1970; Sherman, 1954; Sherman & Linke, 1952;

Whitehead & Emanuel, 1974). Moreover, median roughness ratings (MRRs) are the only perceptual term enjoying a high degree of positive linear relationship with an objective physical measure, i.e., spectral noise levels (SNLs).

A number of authors have noted voice changes in normal speaking women, prior to and during menstruation, on a perceptual basis and have reported that these voice changes are related to physiological changes in the vocal folds (Amado, 1953; Brodnitz, 1954, 1962, cited in Levin, 1962, 1971; Cooper, cited in Travis, 1971, 1973; Damste & Lerman, 1975;Frable, 1962; Graves, 1917; Greene, 1972a; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971; Perello, 1962; Voorhees, 1914; Wendler et al., 1968; Wyatt, 1941). One investigation presented mean spectral noise levels and mean spectral harmonic levels averaged across 12 subjects over 32 consecutive days and found a significant increase in mean spectral noise levels and a decrease in spectral harmonic levels at premenstruation and during the onset of menses (Whitehead et al., 1974). Additionally, one study found slightly greater overall SNL means for eight subjects during the menses than non-menstrual days, but this difference was not statistically significant (Herrera, 1978). However, two investigations

have reported that subjects exhibited no more "hoarseness" at premenstruation than at ovulation and that there was no significant difference in the estimation of fundamental frequency at premenstruation and ovulation (Silverman & Zimmer, 1976, 1978).

This study was designed with the following aims in mind. It is hoped that this investigation will be of value in determining what differences can be demonstrated between median vocal roughness ratings associated with and without menstrual flow during a complete menstrual cycle of 30 consecutive days. Furthermore, this study will determine the interjudge and intrajudge reliability associated with normal female production of the vowel /ɑ/ during a complete menstrual cycle of 30 consecutive days.

CHAPTER III

RESEARCH DESIGN

The purpose of this study was to determine the differences between median vocal roughness ratings for normal female adult voices over a complete menstrual cycle of 30 consecutive days for the isolated sustained vowel /ɑ/; and to determine the interjudge and intrajudge reliability associated with ratings of vocal roughness. Eight normal-speaking females individually phonated the vowel /ɑ/ normally. Each vowel production was recorded on magnetic tape. The productions were then re-recorded in random order and were presented to a panel of trained judges who rated each for roughness.

Research Questions

The following research questions were investigated:

1. What differences can be demonstrated between median vocal roughness ratings associated with and without menstrual flow?

2. What is the interjudge and intrajudge reliability associated with normal female production of the vowel /ɑ/ during a complete menstrual cycle over 30 consecutive days?

Subjects

The subjects consisted of eight adult females ranging in age from 20 to 30 years. This age range had the effect of precluding variations in age associated with adolescence or advanced age. Each subject completed a questionnaire regarding information about her menstrual period and use of oral contraceptives and hormones, prior to subject selection (Appendix A). The criteria for subject selection were phonemic accuracy of the vowel /ɑ/, normal voice quality, menstruation within the past 28 to 30 days, and no use of oral contraceptives within the past five years.

The following is a summary of the responses from the questionnaries completed by the eight subjects. None of the subjects was taking oral contraceptives at the time of the investigation. One subject had taken oral contraceptives for a period of three months, five and one-half years prior to the study. One of the eight subjects took 3 grains of thyroid daily. None of the other six subjects had ever taken any other hormones during or prior to this study. Each of the subjects had experienced a menstrual period within the past 28 to 30 days prior to this investigation. A complete menstrual cycle ranged from 25 to 30 days, and the length of

menstruation ranged from 4 to 7 days.

Judges

Eleven trained judges consisted of three speech-language pathologists having ASHA certification and eight graduate students in Speech-Language Pathology at Texas Woman's University. The speech-language pathologists and graduate speech-language pathology student judges were chosen to provide homogeneity regarding exposure to voice disorders.

Speech Sample

Each subject produced the vowel /ɑ/ normally on each of 30 consecutive days. Thus 240 vowel /ɑ/ samples were obtained. The vowel /ɑ/ was selected because it represented the middle of the roughness continuum for the vowels /i/, /u/, /ɑ/, /ʌ/, and /æ/ produced by females (Lively, 1969). Each vowel production was sustained for seven seconds at 75 dB sound pressure level (SPL) (± 1 dB) re: .0002 dyne/cm^2 at a mouth-to-microphone distance of 15.24 centimeters (6 inches).

Instrumentation

The instrumentation utilized in this study consisted of: (a) an audio recording system; (b) an audio playback system; and (c) a calibration system.

Audio recording system

The audio recording system consisted of a sound level meter (Bruel and Kjaer, Type 2203) with an attached condensor microphone (Bruel and Kjaer, Type 4145), and a magnetic reel to reel tape recorder (Teac, Model 7030 GSL). The magnetic tape recorder had a frequency response of 25-26,000 Hz with a signal to noise ratio of 60 dB when operated at a tape speed at 15 inches per second. The output of the sound level meter was led to the input of the tape recorder by way of a 10K ohm attenuator. The calibrated VU meter of the tape recorder served as a vocal-intensity-monitoring-meter which the subjects were able to observe to adjust their phonations to the required intensity for this investigation.

Audio playback system

The audio playback system, used for presentation of the recorded vowels to the judges for roughness rating severity, consisted of (a) a high fidelity magnetic tape recorder (Sony, TC-377); (b) an amplifier (Sony, TA-1150); and (c) a loud speaker (Superscope, S-312).

Calibration system

A sound level meter (Bruel and Kjaer, Type 2203) was utilized in calibration of the audio recording system. The VU meter of the tape recorder was used as the subjects'

intensity indicator. A 1000 Hz square wave reference tone produced by the sound level meter was played into the tape recorder so as to calibrate the VU meter. The intensity of this tone was 77.1 dB SPL as determined by the K factor of the microphone (1.1 dB SPL) plus the reading of the sound level meter's dial when recording (70 dB SPL) plus 6 dB SPL. The input of the tape recorder was adjusted for a 2.1 dB deflection of the VU meter in response to the 77.1 dB SPL input. Therefore, a needle deflection of O dB on the VU meter indicated 75 dB SPL. This deflection on the VU meter had been marked with a line to indicate the level each subject was required to maintain during the recordings. The reference tone was then recorded and played back to adjust the tape recorder's output level to match its input level. Therefore, a O dB deflection on the calibrated VU meter was produced when the vowel productions were recorded and played back.

Procedures

The procedures employed in this study included: (a) recording of the subjects' productions of the test vowel; (b) presentation of the recorded vowel productions to judges for roughness ratings.

Recording Procedure

All experimental vowel samples were obtained in a sound treated room (IAC Model 405A) with a low ambient

noise level at the Texas Woman's University Speech and Hearing Clinic, Denton, Texas. Instructions were read to each subject prior to phonation of the vowel /ɑ/ (Appendix B). Each subject was familiarized with the experimental procedures and then seated to begin. The microphone was placed at a 0° angle of incidence to, and 15.24 centimeters (6 inches) in front of, the subject's mouth. The mouth-to-microphone distance was measured before each phonation and the subject's head was held to insure that she did not move during the recording. The subject was able to observe the intensity of her phonations by way of the VU meter of the tape recorder.

Each subject sustained normal productions of the vowel /ɑ/ for seven seconds at 75 dB SPL (± 1 dB). Subjects were informed to begin and end each test phonation through the use of hand signals. Each vowel production was carefully monitored by the investigator. If the subject did not maintain the required intensity for the required length of time or did not accurately produce the vowel /ɑ/, the phonation was repeated until an acceptable one was achieved. Each subject made a test production of the vowel /ɑ/ everyday for 30 consecutive days.

Rating Procedure

The 240 normal seven-second vowel productions were randomized through a tape dubbing procedure for presentation to the eleven trained judges. The vowel recordings were judged in an acoustically-isolated room (IAC Model 405A) with the judges seated in a semi-circle facing the loud-speaker. The judges were instructed to listen and rate each vowel according to his/her perception of roughness. A five-point equal-appearing interval scale was utilized for roughness rating by each judge. A rating of "1" represented least severe vocal roughness, and a rating of "5" represented most severe.

A preliminary rating of all vowel productions was made by the investigator prior to the listening session, and four vowel productions, two representing "1" and two representing "5" on the roughness rating scale were selected. These four vowels were played to the judges prior to the rating session to provide a reference point for the extremes of the rating scale. A copy of the instructions read to the judges prior to the rating session is presented in Appendix C.

The rating session was approximately one hour and forty-five minutes in length with two five-minute breaks. The final series of vowels consisted of 20 productions,

selected randomly from the 240 samples, and were included to evaluate intrajudge reliability. Median scale values of the judges ratings for each vowel production were computed to provide an index of roughness for each phonation.

Summary

Eight normal-speaking adult females produced the vowel /ɑ/ normally for seven seconds at 75 dB SPL (± 1 dB) re: .0002 dyne/cm^2 for 30 consecutive days. The subjects completed questionnaires (Appendix A) regarding their menstrual cycles. Eleven trained judges rated 240 test phonations on a five-point equal-appearing interval scale. Twenty test phonations were randomly selected and rated again to evaluate intrajudge reliability. A median of the judges roughness ratings was computed as an index of roughness for each phonation.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The purpose of this study was to investigate the effects of the menstrual cycle of median vocal roughness ratings (MRRs). Eight normal-speaking adult females produced the vowel /ɑ/ over a period of 30 consecutive days, during which each subject experienced a complete menstrual cycle. The number of days of actual menstrual flow ranged from 4 to 7 days. The speech samples were produced at 75 dB, SPL, ±1 dB, and were sustained for seven seconds. A total of 240 samples was obtained. Additionally, 20 samples were included for intrajudge reliability ratings. Randomized tape recordings of each of the 260 vowel productions were rated by a group of 11 judges using a five-point equal-appearing interval scale. Estimates of interjudge and intrajudge reliability associated with the listening task were obtained and analyzed.

To determine across all eight subjects the effect of the menstrual cycle on the MRRs, the daily MRR means for each subject were rearranged so that on day 15 each

subject began her menstrual period. It was also arranged in such a way as to facilitate observation of the MRR means for each subject during premenstruation, which Frable (1962) stated began one to two weeks prior to menses. Table 1 presents for Subject 1 the MRR means for the vowel /ɑ/ prior to, during, and following the menstrual period. The MRR means associated with phonations prior to the menstruation period ranged from 1.56 to 3.0, with an overall mean of 2.24. The highest MRR of 3.0, occurred one day preceding the onset of the menstrual flow. For this subject, the MRR means associated with phonations during the menstrual period ranged from 1.78 to 2.57, with an overall mean of 2.27. It can be seen that the highest MRR mean, 2.57, occurred on the first and second days of menstrual flow. The MRR means associated with phonations following the menstrual period ranged from 1.42 to 2.95, with an overall mean of 2.26. Table 1 indicates that for Subject 1 the overall MRR mean was slightly greater during the menstrual period than the overall MRR means prior to or following the menstrual period. Figure 1 graphically presents Subject 1's MRR means for the vowel /ɑ/ on each of the 30 consecutive days. It may be seen that the MRR means fluctuate to the extent that a definitive trend is not readily apparent.

TABLE 1

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 1'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	1.89	2.57	2.29
	2.25	2.57	2.65
	2.14	2.0	2.95
	2.25	2.42	2.19
	2.06	1.78	2.56
	1.75		1.78
	1.56		2.11
	2.69		2.19
	2.64		1.42
	1.95		2.42
	2.56		2.25
	2.14		
	2.42		
	3.0		
Over-all Mean	2.24	2.27	2.26

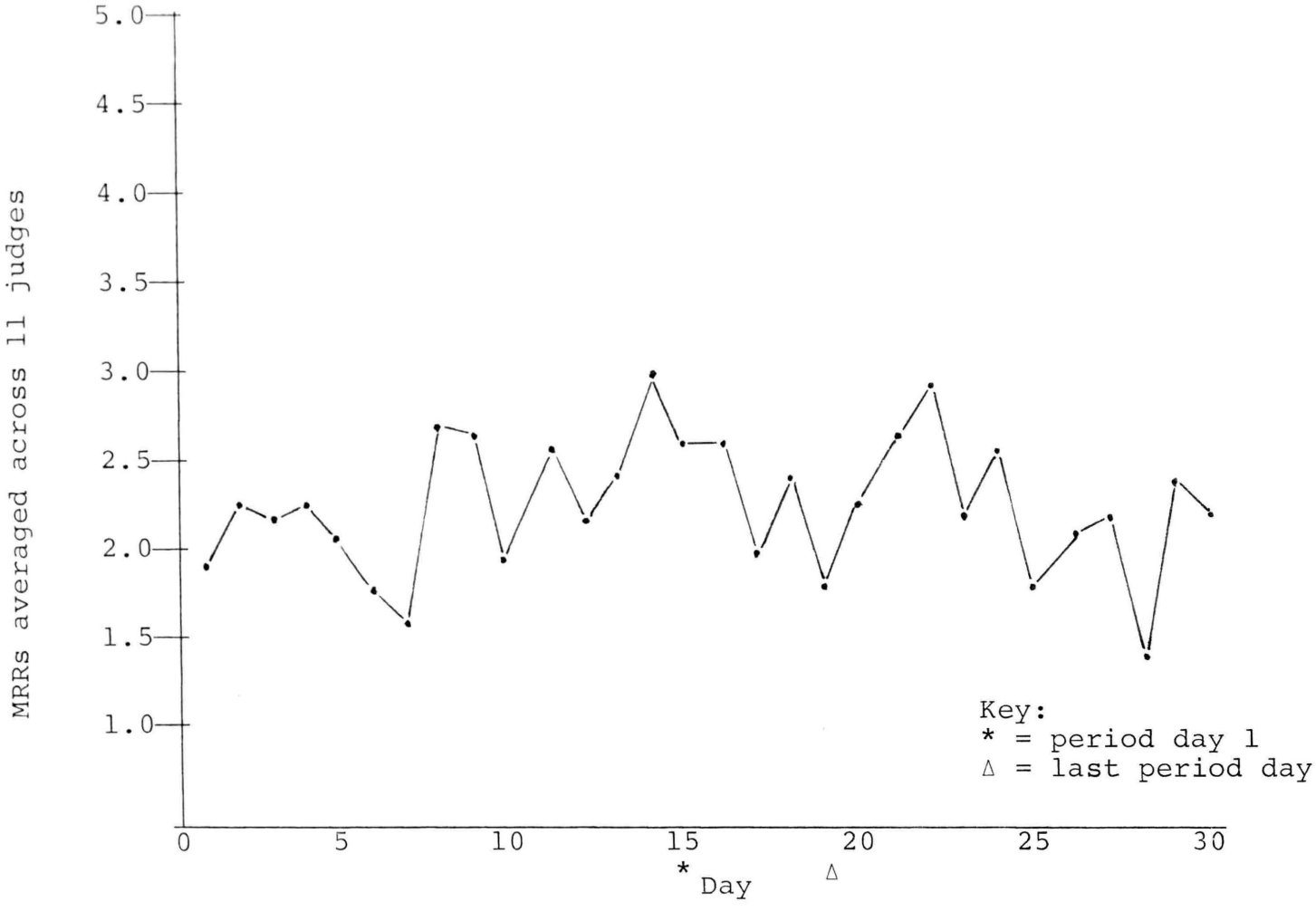

Figure 1. Subject 1's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

Table 2 presents the Subject 2 the MRR means for the vowel /ɑ/ prior to, during and following the menstrual period. The MRR means associated with phonations prior to the menstrual period ranged from 1.57 to 4.64, with an overall MRR mean of 3.08. The MRR means associated with phonations during the menstrual period ranged from 1.78 to 3.69, with an overall mean of 2.76. The MRR means associated with phonations following the menstrual period ranged from 1.29 to 4.64, with an overall MRR mean of 2.86. In this instance, the overall MRR mean was slightly greater prior to menstruation than the overall MRR means during or after the menstrual period. Figure 2 graphically presents Subject 2's MRR means for the vowel /ɑ/ on each of the 30 consecutive days. Considerable MRR fluctuation is apparent.

Table 3 presents for Subject 3 the MRR means for the vowel /ɑ/ prior to, during, and following the menstrual period. The MRR means associated with phonations prior to the menstrual period ranged from 1.05 to 2.55, with an overall mean of 1.82. The MRR means associated with phonations during the menstrual period ranged from 1.75 to 2.29 with an overall MRR mean of 1.98. The MRR means associated with phonations following the menstrual period ranged from 1.65 to 2.64, with an overall mean of 2.02.

TABLE 2

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 2'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	4.64	1.78	1.29
	3.55	2.65	2.14
	4.64	3.55	3.0
	2.25	3.69	2.29
	3.0	2.14	3.55
	2.65		2.65
	1.57		3.06
	3.14		4.64
	2.69		3.0
	3.56		2.25
	2.78		3.55
	3.06		
	2.75		
	2.86		
Overall Mean	3.08	2.76	2.86

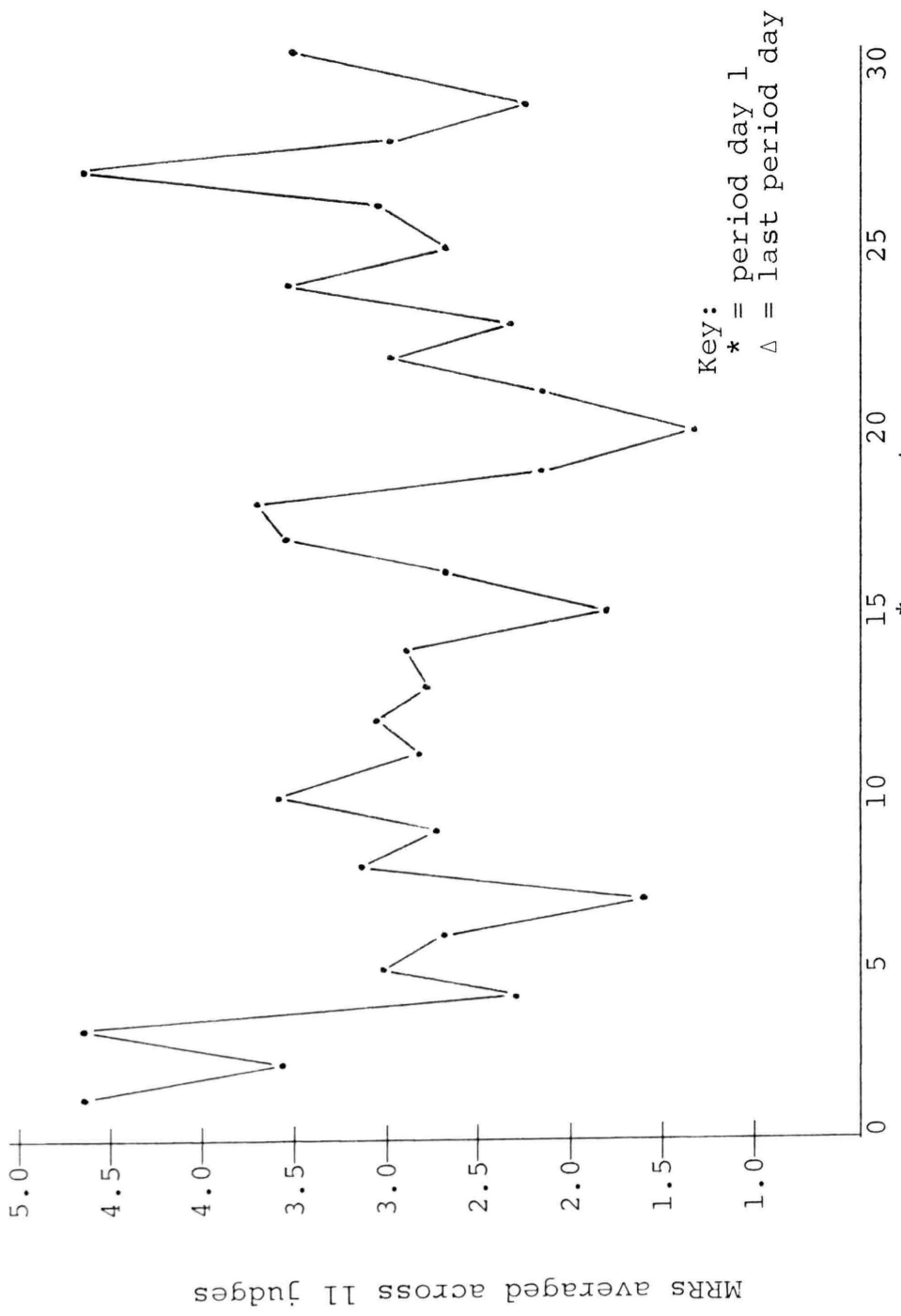

Figure 2. Subject 2's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

Table 3 indicates that for Subject 3 the overall MRR mean was slightly less during the menstrual period than following menstruation; however, the overall MRR mean was slightly greater during the menstrual period than prior to menstruation. Figure 3 graphically presents Subject 3's MRR means for the vowel /ɑ/ on each of the 30 consecutive days. Considerable MRR fluctuation is apparent.

Table 4 presents for Subject 4 the MRR means for the vowel /ɑ/ prior to, during, and following the menstrual period. The MRR means associated with phonations prior to menstruation ranged from 1.89 to 3.55, with an overall MRR mean of 2.72. The MRR means associated with phonations during the menstrual period ranged from 1.89 to 3.67, with an overall mean of 2.74. The MRR means associated with phonations following the menstrual period ranged from 1.81 to 3.73, with an overall MRR mean of 2.67. Table 4 indicates that for Subject 4 the overall MRR mean was slightly higher during menstruation than prior to or after the menses. Figure 4 graphically presents Subject 4's MRR means for the vowel /ɑ/ on each of 30 consecutive days. Considerable MRR fluctuation is apparent.

Table 5 presents for Subject 5 the MRR means for the vowel /ɑ/ prior to, during, and after the menstrual period.

TABLE 3

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 3'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	1.89	1.75	1.67
	2.42	1.95	2.29
	2.42	2.29	1.65
	1.56	1.94	2.0
	2.55		1.85
	1.94		2.29
	1.65		2.56
	2.0		2.64
	1.19		1.94
	1.19		1.67
	1.95		1.95
	1.86		1.67
	1.85		
	1.05		
Overall Mean	1.82	1.98	2.02

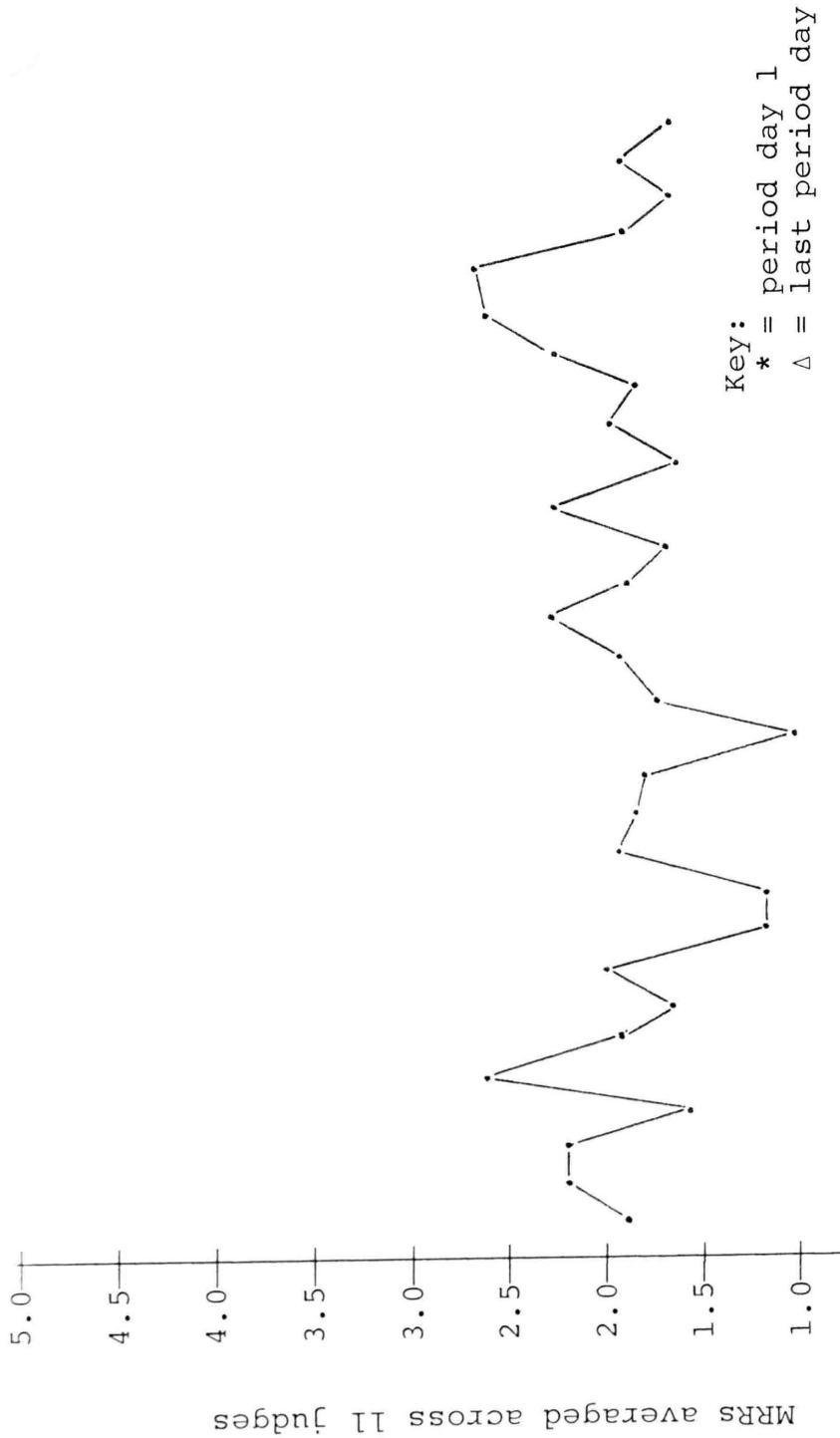

Figure 3. Subject 3's MRR means for the vowel /a/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

TABLE 4

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 4'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	2.81	2.42	2.29
	3.08	1.89	2.0
	2.67	3.67	2.71
	2.89	3.42	3.64
	2.29	2.29	2.08
	2.89		2.56
	3.14		3.06
	2.56		1.81
	2.73		2.58
	2.81		2.94
	2.14		3.73
	3.55		
	2.67		
	1.89		
Overall Mean	2.72	2.74	2.67

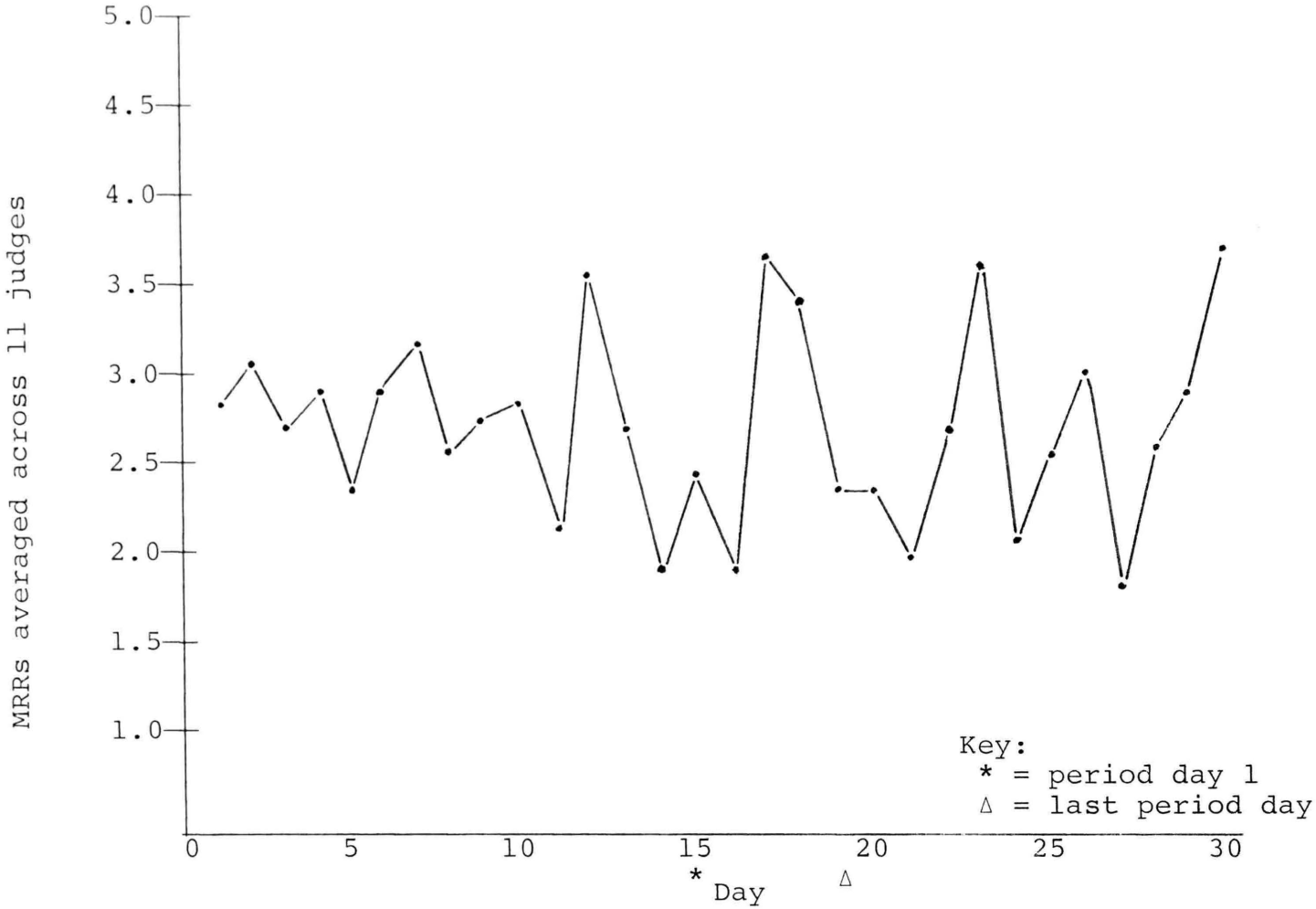

Figure 4. Subject 4's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

The MRR means associated with phonations prior to menstruation ranged from 2.75 to 4.91, with an overall MRR mean of 3.83. The MRR means associated with phonations during the menstrual flow ranged from 3.69 to 4.65, with an overall mean of 4.0. The MRR means associated with phonations after menstruation ranged from 1.42 to 4.91, with an overall mean of 3.62. Table 5 indicates that for Subject 5 the overall MRR mean was slightly higher during menstruation than those prior to or after the menstrual flow. Figure 5 graphically presents for Subject 5 the MRR means for the vowel /ɑ/ on each of the consecutive 30 days. Considerable MRR fluctuation is apparent, and it may be seen that this subject presented a voice associated with greater roughness than the other subjects.

Table 6 presents for Subject 6 the MRR means for the vowel /ɑ/ prior to, during, and following the menstrual period. The MRR means associated with phonations prior to menstruation ranged from 1.15 to 4.14, with an overall MRR mean of 2.26. The MRR means associated with phonations during the menstrual flow ranged from 1.42 to 3.0, with an overall mean of 2.11. The MRR means associated with phonations after menstruation ranged from 1.42 to 3.73, with an overall mean of 2.61. Table 6 indicates that for Subject 6 the overall MRR mean was slightly lower during menstruation than those prior to or

TABLE 5

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING AND FOLLOWING SUBJECT 5'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	4.29	3.69	4.19
	3.73	4.65	4.91
	3.0	3.81	1.42
	3.42	3.95	3.86
	3.55	3.92	3.67
	3.67		3.14
	4.91		3.19
	4.42		3.57
	2.75		3.29
	3.94		4.64
	4.0		3.89
	4.14		
	3.14		
	4.64		
Overall Mean	3.83	4.0	3.62

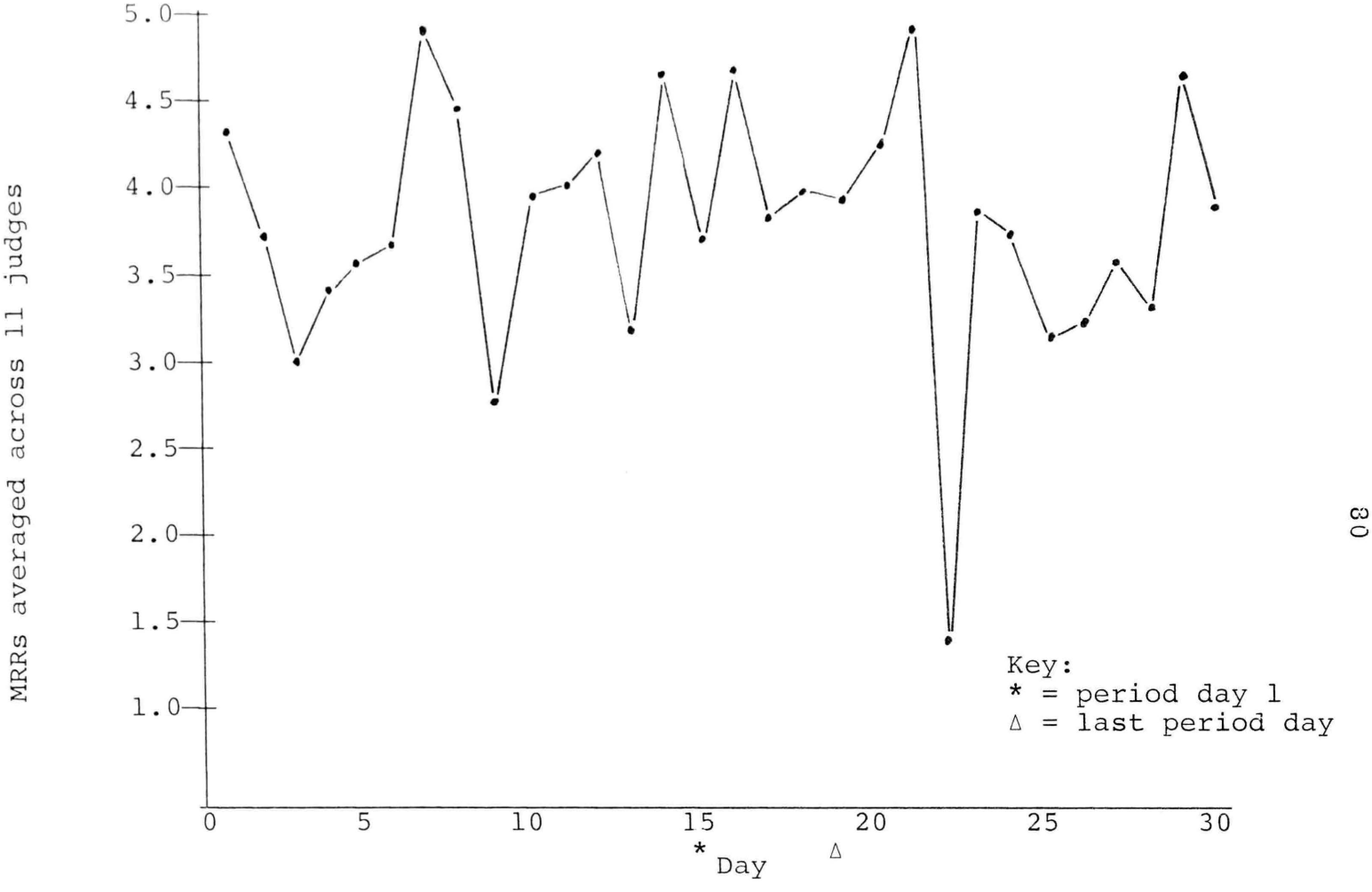

Figure 5. Subject 5's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

following the menstrual period. Figure 6 graphically presents for Subject 6 the MRR means for the vowel /ɑ/ on each of the 30 consecutive days. Again, considerable MRR fluctuation is apparent.

Table 7 presents for Subject 7 the MRR means for the vowel /ɑ/ prior to, during, and after menstruation. The MRR means associated with phonations prior to menstruation ranged from 1.75 to 3.25, with an overall MRR mean of 2.51. The MRR means associated with phonations during the menstrual period ranged from 1.64 to 3.55, with an overall MRR mean of 2.59. The MRR means associated with phonations after menstruation ranged from 1.78 to 4.25, with an overall MRR mean of 2.75. Table 7 indicates that for Subject 7 the overall MRR mean was slightly greater during the menstrual period than prior to menstruation, but was slightly greater following the menstrual period than during menstruation. Figure 7 graphically shows Subject 7's MRR means for the vowel /ɑ/ produced on each of the consecutive 30 days. Considerable MRR fluctuation may be seen.

Table 8 presents for Subject 8 the MRR means for the vowel /ɑ/ prior to, during, and after the menstrual period. The MRR means associated with phonations prior to menstruation ranged from 1.55 to 3.75, with an overall

TABLE 6

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 6'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	1.75	1.55	1.42
	1.67	2.14	2.25
	4.14	2.42	3.67
	1.15	3.0	3.07
	3.06	1.42	3.73
	2.55		3.42
	2.0		2.86
	2.55		1.78
	1.75		1.92
	1.75		2.25
	2.19		2.29
	2.65		
	2.75		
	1.67		
Overall Mean	2.26	2.11	2.61

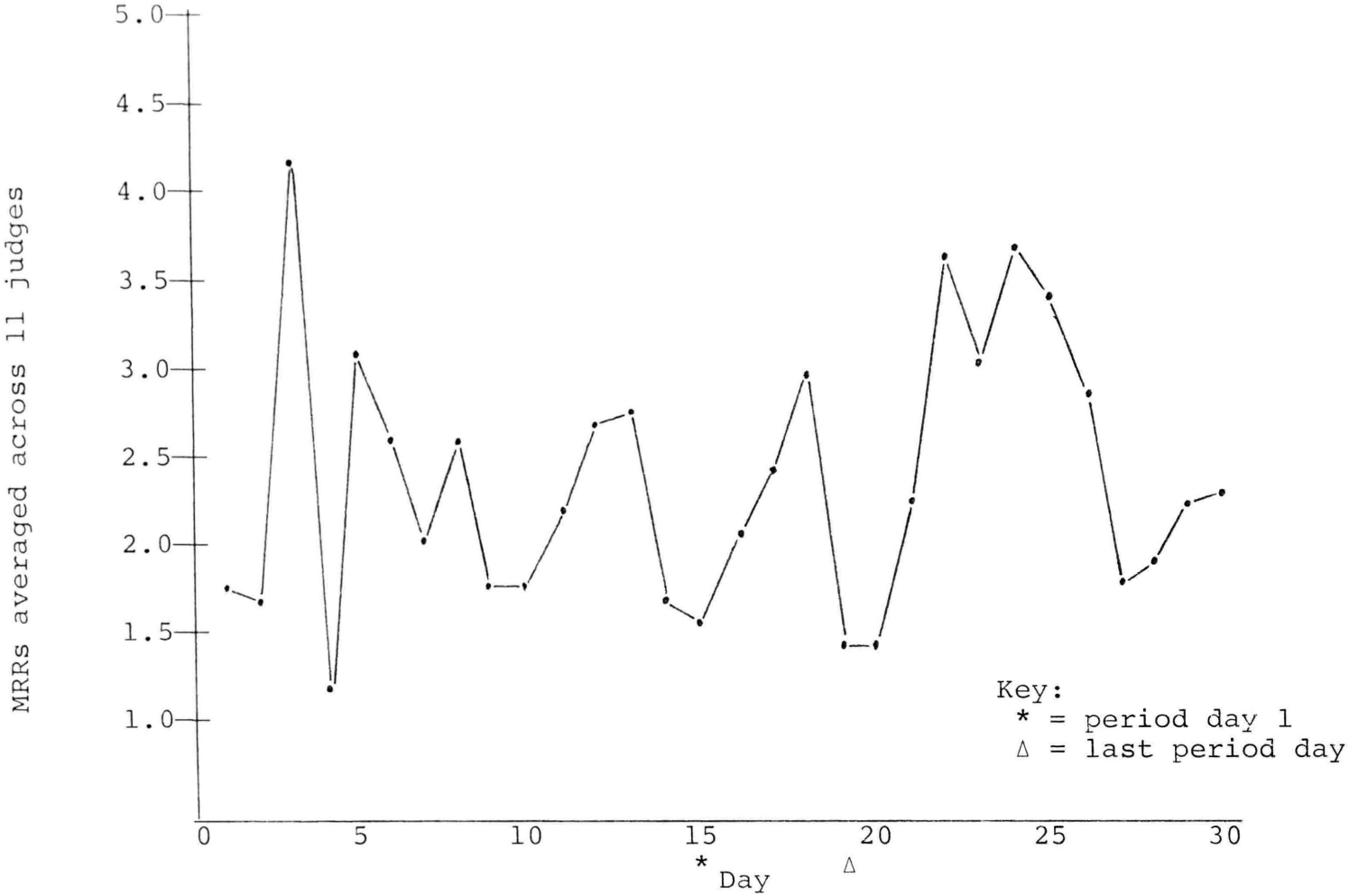

Figure 6. Subject 6's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

TABLE 7

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 7'S MENSTRUAL PERIOD

	Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
	2.25	1.64	3.11
	2.11	2.64	3.55
	3.14	2.25	2.65
	2.94	3.55	2.11
	3.0	2.78	2.42
	2.25	2.65	2.86
	1.75		4.25
	1.86		2.71
	2.0		1.78
	3.08		2.08
	2.67		
	2.14		
	2.71		
	3.25		
Overall Mean	2.51	2.59	2.75

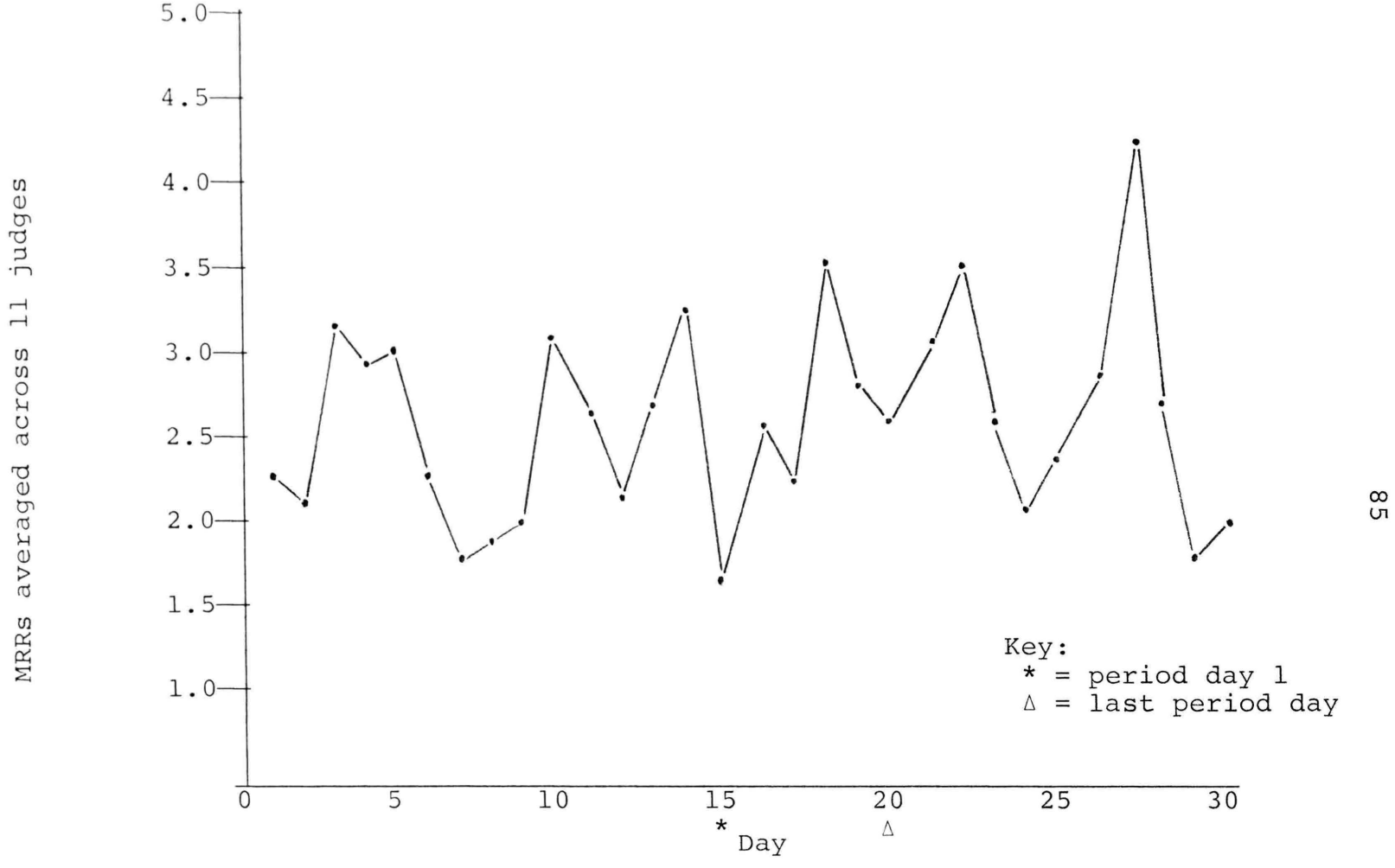

Figure 7. Subject 7's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

MRR mean of 2.55. The MRR means associated with phonations during the menstrual period ranged from 2.05 to 3.0, with an overall MRR mean of 2.43. The MRR means associated with phonations after the menstrual period ranged from 2.14 to 3.67, with an overall MRR mean of 2.77. Table 8 indicates that for Subject 8 the overall MRR mean was slightly less during menstruation than prior to or proceeding menstruation. Figure 8 graphically shows Suject 8's MRR means for the vowel /ɑ/ produced on each of the consecutive 30 days. Considerable MRR fluctuation is apparent.

To determine the overall effects of the menstrual cycle on the MRR means for all eight subjects, the MRR means were averaged across the eight subjects for each of the 30 days. Figure 9 graphically presents these data. Figure 9 reveals no definitive increase in the MRRs averaged over all subjects during the premenstrual or menstrual period days. However, it is noted that the mean MRRs rose consistently during the first four days of the menstrual period, from 2.19 on day 15 to 3.07 on day 18.

To compare MRRs associated with the menstrual period to MRRs associated with nonmenstrual days, overall MRR means for each of the subjects and differences between the

TABLE 8

MRR MEANS FOR THE VOWEL /ɑ/ PRIOR TO, DURING, AND FOLLOWING SUBJECT 8'S MENSTRUAL PERIOD

Prior to Menstrual Period	During Menstrual Period	Following Menstrual Period
2.78	2.14	3.67
1.91	2.05	3.56
1.81	3.0	3.08
2.0	2.56	2.14
1.55	2.19	2.64
3.08	2.78	2.55
3.75	2.29	2.19
3.55		2.55
2.64		2.55
1.58		
2.14		
2.78		
2.57		
3.56		
Overall Mean 2.55	2.43	2.77

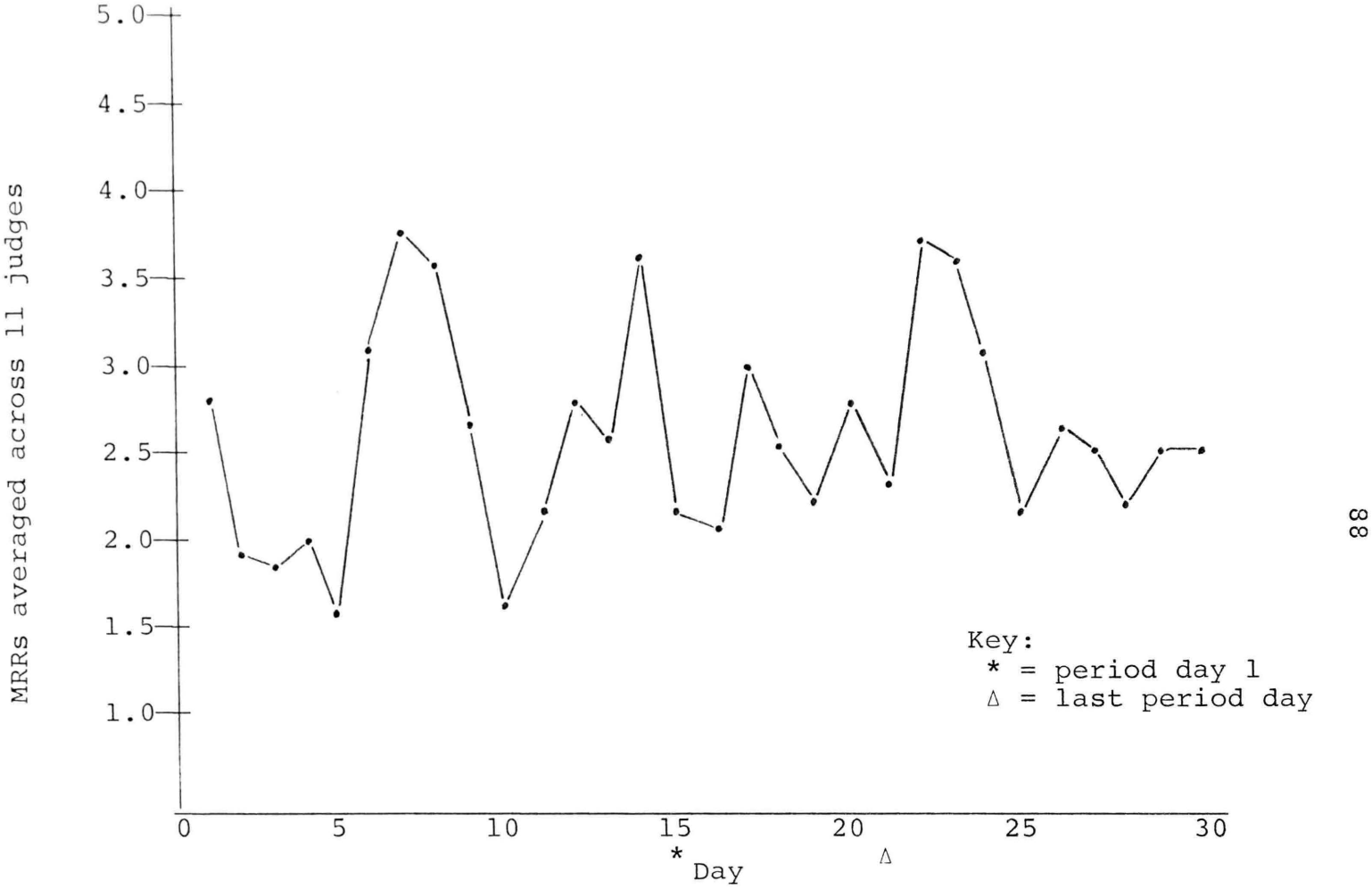

Figure 8. Subject 8's MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across 11 judges over 30 consecutive days.

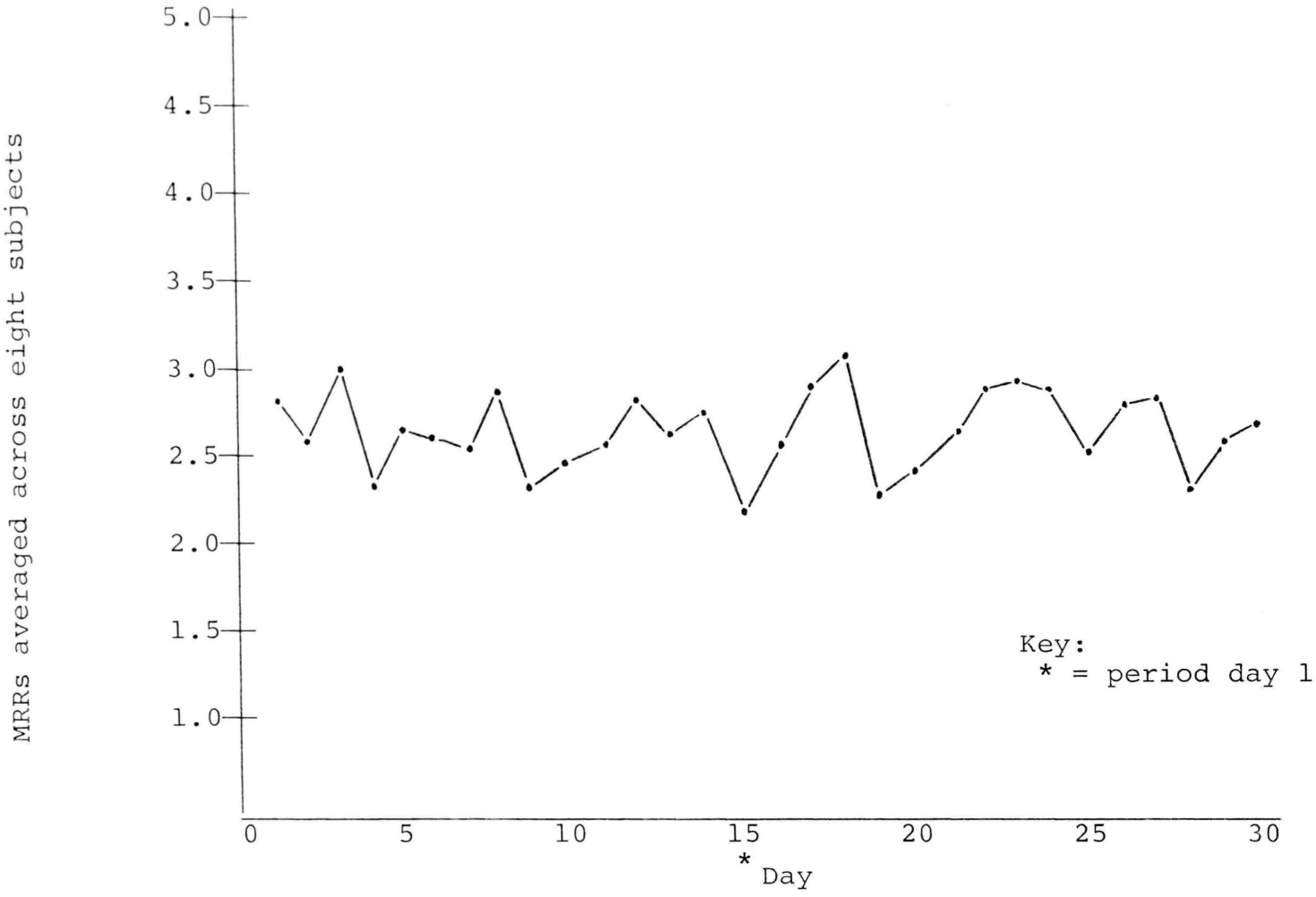

Figure 9. Overall MRR means for the vowel /ɑ/ on a five-point equal-appearing interval scale averaged across eight subjects for each of the 30 consecutive days.

means were computed. Table 9 presents these data. Table 9 shows that the differences between the means for each of the subjects ranged from -.30 to .27. The table also reveals an overall MRR mean, averaged over the menstrual period days, of 2.62, with a standard deviation of.77, and an overall MRR mean, averaged over nonmenstrual days, of 2.65, with a standard deviation of .81. To further determine if there was a significant difference between the overall MRR mean associated with the flow days and the nonflow days, an independent one-tailed t-test was employed, and the level of significance was set at .05. The unpaired t-test ($t=.26$; $d.f.=238$) failed to reach significance. Therefore, no significant difference between the overall MRR mean obtained for the flow days and the overall MRR mean obtained for the nonflow mean days was concluded.

To determine the reliability of voice quality judgments associated with a menstrual cycle of 30 consecutive days, both interjudge and intrajudge reliability were assessed. Interjudge reliability was assessed by separately comparing each judge's ratings to the ratings of the other judges, ±1 scale value. Table 10 presents percentages, mean percentage, and standard deviation of interjudge rating agreement, ±1

TABLE 9

MRR MEANS AND DIFFERENCES BETWEEN MEANS FOR SUBJECT'S MENSTRUAL AND NONMENSTRUAL DAY PRODUCTIONS

Subject	Menstrual MRR Means	n	Nonmenstrual MRR Means	n	Differences
1	2.27	5	2.24	25	.03
2	2.76	5	2.98	25	-.22
3	1.98	4	1.91	26	.07
4	2.74	5	2.70	25	.04
5	4.0	5	3.73	25	.27
6	2.11	5	2.41	25	-.30
7	2.59	6	2.61	24	-.02
8	2.43	7	2.64	23	-.21
Overall Mean	2.62	n=42	2.65	n=198	
Standard Deviation	.77		.81		

TABLE 10

PERCENTAGES, MEAN PERCENTAGE[a], AND STANDARD DEVIATION[b] OF INTERJUDGE RATING AGREEMENT, ±1 SCALE VALUE, ASSOCIATED WITH A COMPLETE MENSTRUAL CYCLE FOR 240 VOWEL PRODUCTIONS

	JUDGE									
Judge	2	3	4	5	6	7	8	9	10	11
1	91	87	84	80	82	85	86	90	78	94
2		88	87	85	81	88	83	92	80	97
3			74	77	73	82	77	86	80	86
4				79	76	88	80	87	83	84
5					79	83	77	85	74	85
6						76	88	81	75	80
7							78	85	88	86
8								89	80	83
9									85	91
10										78

[a]Mean percentage is 83.

[b]Standard deviation is 5.35

scale value, for the experimental sample of 240 vowels. This table reveals that the lowest percentage, 73%, was obtained when the vowel ratings of Judge 3 were compared to those of Judge 6. Furthermore, this table shows that the highest percentage obtained was 97% when the vowel

ratings of Judge 2 were compared to those of Judge 11. Additionally, the mean percentage of interjudge agreement shown in Table 10 was 83%, ±1 scale value, with a standard deviation of 5.35%. Table 11 presents percentages, mean percentage, and standard deviation of intrajudge rating agreement for the first and second ratings of the 20 vowel productions in the reliability sample, ±1 scale value. It can be seen that the lowest percentage, 75%, was obtained for Judges 4 and 5. The highest percentage of intrajudge agreement, 95%, was obtained by Judges 1 and 11. Further, the mean percentage of intrajudge agreement shown in Table 11 was 84%, ±1 scale value, with a standard deviation of 7.00%. Thus, both interjudge and intrajudge reliability appeared adequate for the purposes of this study.

TABLE 11

PERCENTAGES, MEAN PERCENTAGE[a], AND STANDARD DEVIATION[b] OF INTRAJUDGE RATING AGREEMENT, ±1 SCALE VALUE, ASSOCIATED WITH A COMPLETE MENSTRUAL CYCLE FOR TWO RATINGS OF 20 VOWEL PRODUCTIONS

Judge										
1	2	3	4	5	6	7	8	9	10	11
95	90	85	75	75	80	85	80	85	80	95

[a]Mean percentage is 84.

[b]Standard deviation is 7.00.

Discussion

This study was designed to investigate the effects of the menstrual cycle on median roughness ratings (MRRs) of the vowel /ɑ/ produced by eight females over 30 consecutive days. Estimates of interjudge and intrajudge reliability associated with those ratings were obtained. The MRRs and reliability scores associated with a complete menstrual cycle were evaluated statistically.

The findings from this study indicated that there were individual differences between the overall MRR mean associated with phonations during the menstrual period and the overall MRR means associated with phonations prior to and following menstruation. With the exception of three subjects, the findings of this study showed that for individual subjects there was not an increase in the overall MRR mean associated with phonations during menses. One subject revealed a higher overall MRR mean during premenstruation. Physiological changes in the vocal mechanism may possibly account for these four subjects who displayed a higher overall MRR mean during menstruation and premenstruation than following menstruation. Changes in the vocal mechanism prior to and during menstruation have been attributed to a hormonal imbalance of estrogen and progesterone, causing temporary inflammation

and edema of the vocal folds (Amado, 1953; Brodnitz, 1962, 1971; Cooper, 1973; Frable, 1962; Greene, 1972a; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971; Wyatt, 1941). "The extreme complexity and interdependence of the glandular system may produce a great variety of hormonal imbalances which affect the voice" (Brodnitz, 1971, p. 183). Additionally, Brodnitz (1971) reported that "the menstrual cycle may produce transient changes in the voice" (p. 186). "Variations in gonadal function also influence fluid balance and consequently affect the voice. The most frequent evidence of this condition is the change of voice noticed by many women in relation to their menstrual cycles" (Moore, 1971, p. 104). Frable (1962) stated that hoarseness was an unrecognized symptom of premenstrual tension due to an increase in polysaccharides in the ground substance of tissues produced by increased estrogen levels. During the premenstrual phase of the cycle the estrogen level decreases sharply causing the polysaccharides to break down into smaller units which are water binding. The permeability of small blood vessels increases as does fluid in the tissues, thus increasing the vibrating mass of the vocal folds premenstrually (Frable, 1962). For four of the eight subjects such physiological changes in the vocal

mechanism may account for the increase observed in the MRRs. However, four of the subjects exhibited higher MRR means associated with phonations following the menstrual period. The differences exhibited between the individual subject MRR means for phonations during the menstrual period and the nonflow days ranged from -.30 to .27, showing the size of the MRR differences was not large. Thus, the meaningfulness of these MRR differences was ambiguous due to the small rating differences for each subject between flow and nonflow days and to the varied direction of the differences among the eight subjects.

Individual MRR means were averaged to determine the overall effects of the menstrual cycle on the vowel MRRs. The obtained MRR mean associated with phonations during menstruation was 2.62, while the obtained MRR mean associated with phonations during nonmenstruating days was 2.65. Results from an independent one-tailed t-test revealed no difference between the mean at the .05 level of significance. This finding would suggest that there was no significant difference in the MRRs associated with phonations during menstruation and the MRRs associated with phonations during nonmenstruating days.

Additionally, this study assessed interjudge and intrajudge agreement to determine the reliability of the voice quality judgments associated with a complete

menstrual cycle over 30 consecutive days. A five-point equal-appearing interval scale was used to rate 240 /a/ phonations by 11 judges. The mean percentage of inter-judge agreement was 83%, ±1 scale value, with a standard deviation of 5.35%. The intrajudge reliability sample consisted of 20 phonations. The obtained mean percentage of intrajudge agreement was 84%, ±1 scale value, with a standard deviation of 7.00%. These findings regarding the degree of interjudge and intrajudge reliability obtained for the ratings of roughness are generally consistent with previously reported studies employing five-point equal-appearing interval scales (Emanuel, Lively & McCoy, 1973; Hanson, 1970; Lively & Emanuel, 1970; Sansone & Emanuel, 1970; Whitehead & Emanuel, 1974). These findings, in general, support the use of five-point equal-appearing interval scales as a reliable means of rating phonations along a roughness continuum. The fact that the reliability scores obtained for this study were not higher could be related to fatigue. For example, the eleven judges were asked to rate 260 normal phonations during one sitting, lasting approximately one hour and forty-five minutes in length, with two 5-minute breaks. After the rating session was finished, several judges stated, and two judges wrote on their

rating sheet that the rating session would have been less tiring had it been divided over a period of 2 days. Additionally, because normal speakers were utilized as subjects, the range of roughness associated with the vowel productions was reduced. A reduction in the range of roughness to be rated would increase the difficulty of rating these samples as compared to rating samples presenting a wider range of roughness.

Whitehead et al. (1974) investigated the effects of the menstrual cycle on the voice. Whitehead et al. (1974) had 12 normal-speaking adult females phonate over a period of 32 consecutive days, and obtained spectral noise levels (SNLs) for each subject. The subjects phonated the vowels /ɑ/, /i/, /u/, and /æ/ at 75 dB, SPL, for seven seconds. Using a constant bandwidth (1-Hz) wave analyzer, they found a significant increase in vowel SNLs of 5 to 8 dB initiating, on the average of, 3 days before the menstrual period and ceasing on the fourth day into the menstrual cycle. The findings of Whitehead et al. (1974) lend support to the hypothesis that vowel SNLs increase during menstruation.

Silverman and Zimmer (1976, 1978) investigated the acoustic changes of the voice during the menstrual cycle. They instructed 20 normal-speaking adult female subjects

to phonate the vowels /ɑ/, /i/, and /u/ three times each for three seconds duration at loudness levels the subjects considered comfortable. The three vowel phonations were recorded three times each at ovulation, when no edematous conditions are typically present, and three times each at premenstruation, when the typical subject frequently experiences edematous conditions. To determine the exact day of ovulation and premenstruation, each subject recorded her basal body temperature. Silverman and Zimmer (1976, 1978) utilized a 45-Hz bandwidth Kay Sonagraph to obtain narrow-band sonagrams of each vowel production. One of the investigators visually assigned "hoarseness" values for the test vowel sonagraphs on the basis of the observed intensity of the noise components relative to that of the harmonic components. They found that hoarseness was not a feature of the premenstrual syndrome and their findings did not lend support to the hypothesis that vowel SNLs increase during premenstruation.

It is of interest that a 45-Hz bandwidth spectrographic analyzer was used in obtaining SNLs in the investigations conducted by Silverman and Zimmer (1976, 1978). The narrower the bandwidth filter, the finer the analysis of the vowel acoustic components has been well documented in the literature (Lively & Emanuel, 1970; Nessel, 1960; Sansone & Emanuel, 1970;

Whitehead & Emanuel, 1974). Whitehead et al. (1974) employed a 1-Hz bandwidth spectrographic analyzer. Spectral data may have varied greatly by utilizing a 45-Hz bandwidth, as was used by Silverman and Zimmer, by not providing sufficient resolution to detect the possible increases in SNLs associated with the menstrual cycle. Furthermore, the spectrum was rated and measured by visually estimating the noise component intensity relative to that of the harmonic component by one of the investigators in the Silverman and Zimmer (1976, 1978) studies. Whereas, direct measurements in each 100-Hz section of the spectrum in dB SPL were made of the lowest observable peak graphic level recorded stylus marking, and a SNL mean for each phonation was obtained by Whitehead et al. (1974). Thus, pertinent spectral data may have been concealed due to the type of analyzer, and the measurement procedure utilized by Silverman and Zimmer (1976, 1978). Additionally, Silverman and Zimmer (1976, 1978) stated that the three vowel samples were produced ". . . at loudness levels the subjects considered comfortable" (Silverman & Zimmer, 1976, p. 4; 1978, p. 8). The subjects in the investigation of Whitehead et al. (1974) were instructed to phonate the four test vowels at a constant 75 dB SPL, ±1 dB. Denes and Pinson (1973) reported that the intensity

of speech varies considerably even when maintaining it steadily at a normal conversational level. They further stated that vowels are the strongest sounds but that a three-to-one range exists. For example, at a normal conversational level, the strongest vowel /ɑ/ is usually pronounced at three times the intensity level of the weakest vowel /i/ (Denes and Pinson, 1973). The vowels /ɑ/ and /i/ were among the vowel phonations included in both the studies of Whitehead et al. (1974) and Silverman and Zimmer (1976, 1978). The fact that a constant intensity level was not maintained in the Silverman and Zimmer (1976, 1978) studies, thus creating variability in intensity among subjects and between subjects, may further have obscured spectral data. Furthermore, Silverman and Zimmer (1976, 1978) used the term "hoarseness" associated with their normally speaking subjects. Since the term "hoarseness" implies an acoustic judgment associated with possible vocal fold pathology (Michel & Wendahl, cited in Travis, 1971) and not a visual estimation of sonagrams, Silverman and Zimmer's (1976, 1978) use of the term "hoarseness" is questionable. Acoustic perceptual judgments of the subjects' vocal quality were not investigated for the study by Whitehead et al. (1974) nor for the studies by Silverman and Zimmer (1976, 1978).

Herrera (1978) investigated the effects of the menstrual cycle of vowel spectral noise levels (SNLs) using the same speech samples collected for this present study. Magnetic tape loops were constructed for each vowel sample and were analyzed to produce a constant, narrow bandwidth (10-Hz) frequency-by-intensity spectrum of each sample's acoustic components. The findings indicated that four of the eight subjects exhibited an increase in the overall SNL mean associated with their phonations during menses, and two subjects showed an increase in the overall SNL mean associated with their phonations prior to menstruation. The differences between individual subject SNL means for phonations during flow and nonflow days was not large; they ranged from -3.56 dB to 2.58 dB. Individual SNL means were averaged across flow and nonflow day phonations, respectively. The obtained SNL mean associated with phonations during the menstrual period was 17.97 dB, while the SNL mean associated with phonations during nonmenstruating days was 17.85 dB. Results from an independent one-tailed t-test revealed no significant difference between the means.

The present findings revealed minimal increases in the MRR mean associated with phonations during the menstrual period for three of the eight subjects. One

subject exhibited an increase in the MRR mean during premenstruation. When the MRR means associated with flow day phonations and those associated with nonflow day phonations were separately averaged across the eight subjects, however, differences between these overall MRR means were not statistically significant.

In relating the present findings to Silverman and Zimmer (1976, 1978), Herrera (1978), and Whitehead et al. (1974), a possible trend may be evidenced. Silverman and Zimmer (1976, 1978), on the basis of visual inspection of spectrography, employing a 45-Hz filter bandwidth, found no significant differences in interharmonic components relative to the harmonic components. Herrera (1978) indicated slightly greater overall SNL means for eight subjects during the menses than nonmenstrual days, but this difference was not statistically significant. Whereas, Whitehead et al. (1974), utilizing spectrographic analysis, employing a filter bandwidth of 1-Hz, found significantly larger SNL means associated with the menses for each of 12 subjects. Thus, it may be speculated that utilizing suitable methods of spectrographic analysis, differences between inharmonic energy associated with vowel productions during the menses and nonmenstruating days may be obtained. Nonetheless, the present findings

suggest that such differences may not be perceptible to the clinician's ear. These findings, however, should not be interpreted to preclude the potential utilization of narrow-band acoustic spectrography to detect changes in laryngeal disposition.

Generalizations from the present study are restricted due to the small sample size. Therefore, these findings indicate a need for further research to: (a) investigate the possible perceptual changes in vocal quality associated with the menstrual cycle through listener judgments over a larger sample group; and (b) specify the spectral features of the voice associated with the menstrual cycle over a large sample group. Additionally, it would appear desirable to relate observed changes in vocal fold structure-physiology to both spectral noise levels and listener judgments of vocal roughness.

CHAPTER V

SUMMARY AND CONCLUSIONS

Perceptual voice changes in women preceding or during the menstrual period have been noted in the literature (Amado, 1953; Brodnitz, cited in Levin, 1962, 1971; Cooper, cited in Travis, 1971, 1973; Damste & Lerman, 1975; Delaney et al., 1976; Flach et al., 1969; Frable, 1962; Greene, 1972a; Lacina, 1968; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971; Perello, 1962; Wendler, 1972). The perceptual voice changes exhibited by women prior to or during menses have been related to physiological alterations in the vocal mechanism (Brodnitz, 1962, cited in Levin, 1962, 1971; Cooper, cited in Travis, 1971, 1973; Damste & Lerman, 1975; Frable, 1962; Graves, 1917; Greene, 1972a; Kaufman, 1967; Luchsinger & Arnold, 1965; Meano, 1967; Moore, 1971; Perello, 1962; Van Gelder, 1974; Wyatt, 1941). These authors have noted that perceptual voice changes have been attributed to the physiological changes in the vocal mechanism associated with premenstrual tension. Frable (1962) described premenstrual tension as a clinical entity commencing 7 to 14 days prior to the menstrual period. Morton (1950) described premenstrual tension as a symptom-complex that

begins 10 to 14 days premenstrually. The etiology of premenstrual tension is unknown; however, the supply and interaction of estrogen and progesterone have presently been considered as possible causes (Frable, 1962; Morton, 1950). Vocal folds of normal-speaking adult females have been described as hyperemic, edematous, and swollen during premenstruation and menstruation (Cooper, cited in Travis, 1971; Damste & Lerman, 1975; Frable, 1962; Greene, 1972a; Luchsinger & Arnold, 1965; Perello, 1962; Van Gelder, 1974). During premenstruation and menstruation, the female voice has been referred to as being any one or more of the following: hoarse, husky, lower in pitch, unstable, raucous; hesitant, explosive, faltering, and flat (Amado, 1953; Brodnitz, 1971; Cooper, cited in Travis, 1971, 1973; Frable, 1962; Greene, 1972 a & b; Lacina, 1968; Luchsinger & Arnold, 1965; Meano, 1967; Perello, 1962; Van Gelder, 1974).

Four investigations have been reported to determine the effect of the menstrual cycle on the spectral features of the voice (Herrera, 1978; Silverman & Zimmer, 1976, 1978; Whitehead et al., 1974) Whitehead et al. (1974) reported that 12 normal-speaking adult female phonated four sustained vowels at 75 dB, SPL, for a period of 32 consecutive days. They found significant increases in

spectral noise levels (SNLs) averaged across the 12 subjects during premenstruation and menstruation for each vowel studied. Whitehead et al. (1974) utilized a constant bandwidth (1-Hz) spectrographic analyzer for this investigation. Silverman and Zimmer (1976) had 20 normal-speaking adult females phonate three sustained vowels at a loudness level the subjects considered comfortable at ovulation, when edematous conditions were not present, and at premenstruation, when edematous conditions were present. To obtain a spectrum of each vowel production, they used sonagraphic analysis (45-Hz bandwidth). On the basis of observed intensity of noise components relative to that of harmonic components, "hoarseness" values were assigned by one of the investigators. Silverman and Zimmer (1976) found that hoarseness was not a feature of the premenstrual syndrome. In an exact replication of their 1976 investigation, Silverman and Zimmer (1978) again found that hoarseness was not a feature of the premenstrual syndrome. Herrera (1978) investigated the effects of the menstrual cycle on vowel spectral noise levels (SNLs) using the same speech samples collected for the present study. Magnetic tape loops were constructed for each vowel sample and were analyzed to produce a constant, narrow bandwidth (10-Hz) frequency-by-intensity spectrum

of each sample's acoustic components. Findings indicated slightly greater overall SNL means for eight subjects during menstrual days than nonmenstrual days, but this difference was not statistically significant.

The purpose of this investigation was to determine the effects the menstrual cycle has on median vocal roughness ratings (MRRs). Eight normal-speaking adult females phonated the vowel /ɑ/ over a period of 30 consecutive days, during which each subject experienced a complete menstrual cycle. The number of days of actual flow ranged from 4 to 7 days. The speech samples were produced at 75 dB, SPL, ±1 dB, were sustained for seven seconds, and magnetic tape recordings of each production were made. Using a five-point equal-appearing interval scale, 11 judges rated randomized tape recordings of each vowel production. Estimates of interjudge and intrajudge reliability associated with the rating session were obtained and analyzed.

To determine the effects of the menstrual cycle on vowel MRRs, the daily MRR means for each subject were rearranged so that on day 15 each subject began her menstrual period. This also facilitated observation of the mean MRRs for each subject during premenstruation. The MRR means of the phonations for each subject prior to,

during, and following menstruation were computed. Results revealed that for three subjects, the overall MRR means for each subject's phonations during the menstrual period were greater than the overall MRR means prior to or following the menstrual period. The overall MRR means were higher prior to menstruation than during or after the menses for one subject. The differences between individual MRR means for phonations during flow and non-flow days was not large; it ranged from -.30 to .27. However, due to the differences observed between flow and nonflow MRR means which were very small and due to the varied direction of the differences among subjects, the meaning of these MRR differences was ambiguous.

Individual means were averaged and MRR means associated with the total flow and nonflow day phonations were obtained in order to determine the overall effects of the menstrual cycle on the vowel MRRs. The MRR mean associated with phonations during the menstrual period was 2.62, while the MRR mean associated with vowel productions during the nonmenstrual days was 2.65. An independent one-tailed t-test indicated that there was no significant difference between means at the .05 level. This finding would suggest that although small increases in the MRRs associated with phonations during the menstrual

period were evident for some individual subjects, on the average, these differences were not statistically significant.

Additionally, interjudge and intrajudge reliability were assessed, to determine the reliability of voice quality judgments associated with a complete menstrual cycle. Interjudge reliability was determined by separately comparing each judge's ratings to the ratings of the other judges, ±1 scale value. Interjudge reliability was obtained from a total of 240 vowel productions. The mean percentage of interjudge agreement was 83%, ±1 scale value. A standard deviation of 5.35% was derived. Intrajudge reliability was obtained for the first and second ratings of the 20 vowel productions in the reliability sample, ±1 scale value. The mean percentage of intrajudge agreement was 84%, ±1 scale value, with a standard deviation of 7.00%. The interjudge and intrajudge reliability obtained for the ratings of roughness in the present investigation are generally consistent with previously reported studies utilizing five-point equal-interval scales (Emanuel, Lively, & McCoy, 1973; Hanson, 1970; Lively & Emanuel, 1970; Sansone & Emanuel, 1970; Whitehead & Emanuel, 1974). In general, these findings support the use of five-point equal-appearing interval

scales as a reliable means of rating phonations along a roughness continuum.

In relating the present findings to those of Silverman and Zimmer (1976, 1978), Herrera (1978), and Whitehead et al. (1974), a possible trend may be evidenced. The narrower the bandwidth filter, the more significant increase in vowel SNLs immediately prior to and during menses is noted. It may be speculated that utilizing suitable methods of spectrographic analysis, differences between inharmonic energy associated with vowel productions during the menses and nonmenstruating days may be obtained. Nonetheless, the present findings suggest that such differences may not be perceptible to the clinician's ear. These findings, however, should not be interpreted to preclude the potential utilization of narrow-band acoustic spectrography to detect changes in laryngeal disposition.

Generalizations from the present investigation are limited due to the small sample size. Due to the fairly small differences in MRR means for phonations during the menstrual period and those during the nonflow days, the findings suggest a need for further research to: (a) investigate the possible perceptual changes in voice quality associated with the menstrual cycle through listener judgments over a larger sample group; and (b) specify the

spectral features of the voice associated with the menstrual cycle over a large sample group. Additionally, it would appear desirable to relate observed changes in vocal fold structure-physiology to both spectral noise levels and listener judgments of vocal roughness.

APPENDICES

APPENDIX A

SUBJECT QUESTIONNAIRE

Name:

Date:

Birthdate:

Age:

Are you presently taking oral contraceptives:

Have you taken oral contraceptives in the past?

Are you presently taking any type of hormone other than oral contraceptives?

Have you taken any type of hormone other than oral contraceptives in the past?

If so, what hormone(s)?

Have you had a menstrual period within the last 28 to 30 days?

How often do you experience a complete menstrual cycle (number of days)?

How many days do you menstruate?

Is your menstrual flow heavy, average, or light?

APPENDIX B

INSTRUCTIONS TO THE SUBJECTS

In this experiment you will phonate the vowel /ɑ/ (as in father) normally. You should produce the vowel loudly enough so that the needle on the VU meter is on the heavy black line for seven seconds. Be very careful to keep the needle steady on the black line.

You have to be a constant six inches from the microphone. I will measure the distance from the microphone to your mouth before each phonation and then keep my hand on your head to make sure you do not move during the recording.

I will be watching both the clock and the VU meter. If you do not keep the needle on the black line for the appropriate amount of time, I will ask you to re-record the vowel. Also, if you do not produce the vowel /ɑ/, we will re-record the production. Before actually making the recording, you will have an opportunity to practice the normal /ɑ/ production at the proper intensity.

Are there any questions?

APPENDIX C

INSTRUCTIONS TO THE JUDGES

You are asked to listen to 260 samples of the vowel /ɑ/ produced by adult females. The vowel samples will be presented to you one at a time, and you are asked to judge each in relation to a five-point scale of severity of vocal roughness perceived.

Each vowel is to be rated on a scale of equal-appearing intervals with scale values of "1", "2", "3", "4", and "5". "1" represents least severe vocal roughness and "5" represents most severe. Do not attempt to rate vowel samples between any two scale points. The vowel samples may vary according to parameters other than roughness; however, you are asked to ignore these variations. Restrict your attention to the degree of roughness perceived.

Four samples representing the extremes of the judgment scale will be presented first to help you locate the extremes of the scale. The first two samples will represent least severe vocal roughness ("1") and the second two will represent most severe ("5"). You may listen to these productions as many times as you wish before the judging begins.

The vowels to be judged will be presented to you in random order. There will be a short interval between productions and each will be preceded by a number announcement.

You are to judge each of the vowel samples in relation to the five-point scale of severity of vocal roughness. Record on your response sheet the scale value from "1" to "5" you think each production should be assigned. As you are asked to scale <u>your perception</u> of the severity of vocal roughness, there are no right or wrong scale values. For this reason, be sure to make your judgments independently. Record the scale value assigned to each vowel to the right of its number on your response sheet. You may hear each vowel production to be judged as many times as you wish. Be sure to record a judgment for every vowel sample. Leave no blank spaces. If you need to hear a production again, let me know at that time and I will play it back.

Are there any questions?

REFERENCES

REFERENCES

Amado, J. H. Tableau general des problemes poses par l'action des hormones sur le developpement du larynx. Annals of Otolaryngology, 1953, 70, 117-137.

Bauer, H. Die beziehungen der phoniatrie zur endokrinologie. Folia Phoniatrica, 1968, 20, 387-393. (Summary)

Boone, D. R. The voice and voice therapy. Englewood Cliffs, N. J.: Prentice-Hall, 1971.

Bowler, N. W. A fundamental frequency analysis of harsh vocal quality. Speech Monographs, 1964, 31, 128-134.

Brackett, I. P. Parameters of voice quality. In L. E. Travis (Ed.), Handbook of speech pathology and audiology (2nd ed.). New York: Appleton-Century-Crofts, 1971.

Brodnitz, F. S. Keep your voice healthy. New York: Harper and Brothers, 1953.

Brodnitz, F. S. Voice problems of the actor and singer. Journal of Speech and Hearing Disorders, 1954, 19, 322-326.

Brodnitz, F. S. Functional disorders of the voice. In N. M. Levin (Ed.), Voice and speech disorders: medical aspects. Springfield, Ill.: Charles C. Thomas, 1962.

Brodnitz, F. S. The holistic study of the voice. Quarterly Journal of Speech, 1962, 48, 280-284.

Brodnitz, F. S. Hormones and the human voice. Bulletin of the New York Academy of Medicine, 1971, 47, 183-191.

Bryce, D. P. Differential diagnosis and treatment of hoarseness. Springfield, Ill.: Charles C. Thomas, 1974.

Cooper, M. Modern techniques of vocal rehabilitation for functional and organic dysphonias. In L. E. Travis (Ed.), Handbook of speech pathology and audiology (2nd ed.). New York: Appleton-Century-Crofts, 1971.

Cooper, M. Modern techniques of vocal rehabilitation. Springfield, Ill.: Charles C. Thomas, 1973.

Damste, P., & Lerman, J. An introduction to voice pathology. Springfield, Ill.: Charles C. Thomas, 1975.

Delaney, J., Lupton, M. J., and Toth, E. The curse. New York: E. P. Dutton & Company, Inc., 1976.

Denes, P. B., & Pinson, E. N. The speech chain: the physics and biology of spoken language. Garden City, N. Y.: Anchor Press, 1973.

Diehl, C. F. Introduction to the anatomy and physiology of the speech mechanism. Springfield, Ill.: Charles C. Thomas, 1968.

Emanuel, F. W., Lively, M. A., & McCoy, J. F. Spectral noise levels and roughness ratings for vowels produced by males and females. Folia Phoniatrica, 1973, 25, 110-120.

Emerick, L., & Hatten, J. Diagnosis and evaluation in speech pathology. Englewood Cliffs, N. J.: Prentice-Hall, 1974.

Flach, M., Schwickardi, H., & Simon, R. Welchen einfluss haben menstruation und schwangerschaft auf die ausgebildete gesangsstime? Folia Phoniatrica, 1969, 21, 199-210. (Summary)

Frable, M. A. S. Hoarseness, a symptom of premenstrual tension. Archives of Otolaryngology, 1962, 28, 66-68.

Frank, R. The hormonal causes of premenstrual tension. Archives of Neurology and Psychiatry, 1931, 26, 1053-1057.

Graves, W. P. Gynecology. Philadelphia: W. B. Saunders Company, 1917.

Gray, H. [Anatomy of the human body] (C. M. Goss, Ed., 29th ed.). Philadelphia: Lea & Febiger, 1973. (Originally published in 1858.)

Green, T. H., Jr. Gynecology, essentials of clinical practice. Boston: Little, Brown & Company, 1965.

Greene, M. C. L. The voice and its disorders (3rd ed.). Philadelphia: J. B. Lippincott Company, 1972. (a)

Greene, M. C. L. Disorders of the voice. New York: The Bobbs-Merrill Company, Inc., 1972. (b)

Herrera, R. H. Vowel spectral noise levels associated with the menstrual cycle. Unpublished master's thesis, Texas Women's University, 1978.

Isshiki, N., Okamura, H., Tanabe, M., & Morimoto, M. Differential diagnosis of hoarseness. Folia Phoniatrica, 1969, 29, 9-19.

Isshiki, N., Yanagihara, N., & Morimoto, M. Approach to the objective diagnosis of hoarseness. Folia Phoniatrica, 1966, 18, 393-400.

Jensen, P. J. Adequacy of terminology for clinical judgment of voice quality deviation. The Eye, Ear, Nose, and Throat Monthly, 1965, 44, 77-82.

Kanter, C. E. Diagnosis and prognosis in cleft palate speech. Journal of Speech and Hearing Disorders, 1948, 12, 211-222.

Kaufman, S. A. The ageless woman. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967.

Kreul, E. J., & Hecker, M. H. L. Descriptions of the speech of patients with cancer of the vocal folds. Part II: Judgments of age and voice quality. The Journal of the Acoustical Society of America, 1971, 49, 1283-1287.

Lacina, O. Der einfluss der menstruation auf die stimme der sangerinnen. Folia Phoniatrica, 1968, 20, 13-24. (Summary)

Laguaite, J. K. Adult voice screening. Journal of Speech and Hearing Disorders, 1972, 37, 147-151.

Lauersen, N., & Whitney, S. It's your body: a woman's guide to gynecology. New York: Grosset & Dunlap, 1977.

Lively, M. A. Spectral noise levels and roughness severity ratings for normal and simulated rough vowels produced by adult females. Unpublished doctoral dissertation, University of Oklahoma, 1969.

Lively, M. A., & Emanuel, F. W. Spectral noise levels and roughness severity ratings for normal and simulated rough vowels produced by adult females. Journal of Speech and Hearing Research, 1970, 13, 503-511.

Luchsinger, R., & Arnold, G. E. [Voice-speech-language clinical communicology: its physiology and pathology] (G.E. Arnold and E. R. Finkbeiner, trans.). Belmont, California: Wadsworth Publishing Company, 1965. (Originally published, 1949.)

Meano, C. [The human voice in speech and song] (A. Khoury, rev., ed., and trans.). Springfield, Ill.: Charles C. Thomas, 1967.

Michel, J. F., & Wendahl, R. Correlates of voice production. In L. E. Travis (Ed.), Handbook of speech pathology and audiology (2nd ed.). New York: Appleton-Century-Crofts, 1971.

Moll, K. Objective measures of nasality. Cleft Palate Journal, 1964, 1, 371-374.

Moore, G. P. Organic voice disorders. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1971.

Moos, R. H. Typology of menstrual cycle symptoms. American Journal of Obstetrics and Gynecology, 1969, 103, 390-402.

Morris, H., & Spriestersbach, D. C. Appraisal of respiration and phonation. In F. L. Darley & D. C. Spriestersbach (Eds.), Diagnostic methods in speech pathology (2nd ed.). New York: Harper & Row, 1978.

Morton, J. H. Premenstrual tension. American Journal of Obstetrics and Gynecology, 1950, 60, 343-352.

Murphy, A. Functional voice disorders. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1964.

The National Institute of Neurological Diseases and Blindness, Communication Disorders Research Training Committee, Third regional workshop on the rehabilitation codes and communication disorders (PHS Grant No. B-3676). n.p., 1967.

Nessel, E. Uber das tonfrequenzspektrum der pathologisch veranderten stimme. Acta Otolaryngologica Supplementum, 1960, 157, 3-45.

Osgood, C., Suci, G., & Tannebaum, P. The measurement of meaning. Urbana, Ill.: University of Illinois Press, 1967.

Pace, D. M., McCashland, B. W., & Landolt, P. A. Physiology and anatomy. New York: Thomas Y. Crowell Company, 1965.

Parlee, M. B. The premenstrual syndrome. Psychological Bulletin, 1973, 80, 454-465.

Pennington, V. M. Meprobamate (Miltown) in premenstrual tension. Journal of the American Medical Association, 1957, 164, 638-640.

Perello, J. La disphonia premenstrual. Acta Oto-Rhino-Laryngologica Ibero-Americana (Barcelona), 1962, 23, 561-563.

Perkins, W. H. Speech pathology: an applied behavioral science (2nd ed.). St. Louis: The C. V. Mosby Company, 1977.

Proceedings of the workshop on nomenclature of communication disorders (PHS Grant No. B-3676). Bethesda, Maryland: n.p., 1962.

Rees, M. Some variables affecting perceived harshness. Journal of Speech and Hearing Research, 1958, 1, 155-168.

Sansone, F. E., & Emanuel, F. W. Spectral noise levels and roughness severity ratings for normal and simulated rough vowels produced by adult males. Journal of Speech and Hearing Research, 1970, 13, 489-502.

Sherman, D. The merits of backward playing of connected speech in the scaling of voice quality disorders. Journal of Speech and Hearing Research, 1954, 19, 312-321.

Sherman, D., & Linke, E. The influence of certain vowel types on degree of harsh voice quality. Journal of Speech and Hearing Disorders, 1952, 17, 401-408.

Shipp, T., & Huntington, D. A. Some acoustic and perceptual factors in acute-laryngitic hoarseness. Journal of Speech and Hearing Disorders, 1965, 30, 350-359.

Silverman, E., & Zimmer, C. H. The effects of the menstrual cycle on voice quality. Paper presented at the annual meeting of the American Speech and Hearing Association, Houston, November 1976.

Silverman, E., & Zimmer, C. H. Effect of the menstrual cycle on voice quality. Archives of Otolaryngology, 1978, 104, 7-10.

Small, A. M. Psychoacoustics. In F. D. Minifie, T. H. Hixon, & F. Williams (Eds.), Normal aspects of speech, hearing, and language. Englewood Cliffs, N. J.: Prentice-Hall, 1973.

Suarez-Marias, E. L. The psychophysiologic syndrome of premenstrual tension, with emphasis on the psychiatric aspect. International Record of Medicine, 1953, 166, 475-486.

Sutherland, H., & Stewart, I. A critical analysis of the premenstrual syndrome. Lancet, June 5, 1965, 1180-1183.

Thurman, W. The construction and acoustic analysis of recorded scales of severity for six voice quality disorders. Unpublished doctoral dissertation, Purdue University, 1954.

Van Gelder, L. Psychosomatic aspects of endocrine disorders of the voice. Journal of Communication Disorders, 1974, 7, 257-262.

Voorhees, I. W. Vocal fatigue in singers and speakers. Transactions of the American Academy of Opthalmology and Otolaryngology, 1914, 19, 340-348.

Wayte, R. F. Some relationships between spectral harmonic levels and vocal roughness for vowels produced by adult females. Unpublished doctoral dissertation, University of Oklahoma, 1971.

Weideger, P. Menstruation and menopause. New York: Alfred A. Knopf, 1976.

Wendler, J. Zyklusabhangige leistungsschwankungen der stimme und ihre beeinflussung durch ovulationshemmer. Folia Phoniatrica, 1972, 24, 259-277. (Summary)

Wendler, J., Igel, H., & Steindel, E. Variations in vocal efficiency due to the menstrous cycle and how to influence them by ovulation inhibitors. International Association of Logopedics and Phoniatrics, 1968, 14, 247. (Summary)

West, R. The rehabilitation of speech (2nd ed.). New York: Harper & Brothers, 1947.

West, R., & Ansberry, M. Rehabilitation of speech (4th ed.). New York: Harper & Row, 1968.

Whitehead, R. L., & Emanuel, F. W. Some spectrographic and perceptual features of vocal fry, abnormally rough, and modal register vowel phonations. Journal of Communication Disorders, 1974, 1, 305-319.

Whitehead, R. L., Kohler, R. R., & Schlueter, S. The effect of the menstrual cycle on female vowel spectra. Paper presented at the annual meeting of the American Speech and Hearing Association, Las Vegas, November 1974.

Wilson, D. B., & Wilson, W. J. Human anatomy. New York: Oxford University Press, Inc., 1978.

Wyatt, G. L. Voice disorders and personality conflicts. Mental Hygiene, 1941, 25, 237-250.