Effects of Premenstrual Symptoms on Young Female Singers

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DECLARATION

I, Maree Carol Ryan, hereby declare that this submission is my own work and that it contains no material previously published or written by another person except where acknowledged in the text. It does not contain material that has been accepted for a higher degree.

Ethical approval from the University of Sydney Human Ethics Committee was granted for the study presented in this thesis. Subjects were required to read a subject information sheet and informed consent was gained prior to data collection.

Signed: _____ Date: _____

Supervisor's signature: _____ Date: _____

Supervisor's certification

I certify the thesis of Maree Carol Ryan "Effects of Premenstrual Symptoms on Young Female Singers" to be suitable for examination.

Signed: _____ Date: _____

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ABSTRACT

Throughout the 20th Century, female operatic singers in most of the major European opera houses were given "grace days" (where they were not required to sing) in recognition of the effect of hormonal changes on the singing voice. Financial constraints in professional companies have resulted in a reduction of such considerations, but to date, there has been no systematic study of the effects of hormonal fluctuations on the quality of the female singing voice, or of its potential adverse effects on the vocal apparatus for singers who are affected by pre-menstrual syndrome.

This study investigated the effects of hormonal fluctuations on young professional female classical singers. Female and male professional singers in training (students) at the Sydney Conservatorium of Music, University of Sydney, were asked to participate as volunteers in the study by keeping daily diaries. The female singers kept a diary for two separate months beginning on the first day of menstruation, in which they recorded their daily basal temperature, mood, voice state and physical well being. The male control subjects kept daily diaries for one month. Acoustic analysis of two vocal samples taken during the second month, on days 1 and 14 of the cycle, were completed on the six most severely affected female subjects, who were identified through their diary ratings of changes in vocal quality during menstruation.

The selected students assessed their own vocal samples, presented in random order, to determine whether they could reliably identify which of their samples were affected by menstruation. Vocal staff at the Conservatorium (pedagogues), who were blind to the purpose of the study, also assessed recordings presented randomly. Results indicated that

self-perceived vocal quality varied over the course of the menstrual cycle, particularly during the first seven days of the cycle, that negative changes in mood affected the voice, and that fatigue, effort, hoarseness, weakness & peak performance were the most frequently affected vocal states. A surprising finding was that male self-perceived voice quality also varied over the course of one month of diary keeping.

There was no consistent change in direction of scores during menstrual and non-menstrual phases. Five of the six most affected singers correctly identified their performance during menstruation but pedagogues were not consistently able to do so.. These results indicate that perceived quality of the voice through changes in the menstrual cycle may not be as obvious to a highly trained observer even though they were reliably perceived by the singer.

This study demonstrates that menstruation has a discernible impact on the self-perception of female singers' vocal quality and implies that the premenstrual or menstrual female may not feel able to present her peak performance at these times of hormonal fluctuation. Further detailed research in this area may be warranted on a larger scale to elaborate a more precise clinical management of the problem.

CHAPTER 1

1.1 Background

The human female menstrual cycle is a very complex physiological function that affects many body systems. While its effect on these various body systems is well understood, the effect of the hormone cycle on the singing voice in western classical singers has not been studied empirically. The research described in this thesis originated from my work and interest in young female professional singers and arose out of my personal experience as an expert pedagogue preparing these young singers for lives as professional western classical singers.

During the course of many years' experience, I have observed what I now consider to be a relationship between menstruation and an array of symptoms such as loss of voice quality, flexibility, range, stamina and support in some female singers. Some women appear to cope better with menstrual symptoms that affect their voices, and it is an open question as to whether this is due to greater experience and technical mastery, greater emotional control and maturity, or a combination of both factors.

Both pre-menstrual and menopausal changes exert negative effects on the voice due to the temporary loss of oestrogen during the pre-menstrual phase and the permanent loss of oestrogen at menopause. Hormone replacement therapy is often prescribed to restore optimal hormone levels in both situations. In some singers, issues related to hormones and the menstrual cycle are critical to their professional careers, and pedagogues and coaches need to be aware of the vocal limitations that occur during these times. In the following

sections, each of the factors that affect the female singing voice will be described and their influences on vocal production and vocal quality highlighted.

The aim of this study was to provide more specific information on the effects of hormonal fluctuations on the young professional singer, as there is very little singer relevant research in this area. As their body encompasses their entire instrument, any physical, physiological and emotional variation will affect their voice and further education and knowledge in this area is likely to be of benefit to singers and their teachers.

The implications of the research are far reaching for both students of voice and for vocal pedagogues. This research hopes to increase specific knowledge in both singers and pedagogues about the effects of hormones on vocalization. This implies acquiring increased awareness about conditions that reduce performance skills in singers and thereby knowing when to lighten the vocal load to avoid potential trauma or permanent damage to the vocal apparatus. These factors are critical to the length and quality of a performing career and affect the consistency and reliability of the performer at all stages of her career.

1.2 Literature Review: Previous studies

The voice is an exquisite messenger of emotion (Sataloff, 1997). Frank (1931), who introduced the term “premenstrual tension”, described “a relationship between hormonal changes during the menstrual cycle and recurring psychological manifestations such as depression or irritability. These symptoms may vary monthly in incidence, number, and intensity among the affected and a given individual may experience marked variation from cycle to cycle because of factors such as stress, diet, age and general health.”

The significant proportion of training and research into the voice has involved finding the most appropriate methods for teaching vocal expertise for performance and determining how the instrument functions. Scant attention has been given to seeking information regarding the preservation of the vocal mechanism that we hope to use throughout many years in our career. It is well known in the industry, that many singers have short careers, or suffer fairly consistent injury or inconvenience due to fatigue and impairment of function. It is becoming recognized that anything that affects the body will, in turn, affect the voice. Laryngologists, physicians, speech pathologists and teachers of singing have all confirmed this lack of knowledge in the singing and speaking professions, as well as the medical profession. It is recognized that as the body is the encasement of the instrument, any benefit to a singer's general health is a benefit to the voice. Arts medicine is now a multi-disciplinary field, while voice medicine has evolved quickly and dramatically improved the care of singers with problems. However, much deeper understanding of the effect of hormones on the voice is imperative, so that enhanced management of the symptoms may be addressed.

Anecdotal evidence from the singing profession informs us that female singers are adversely affected by hormonal fluctuations as a result of the premenstrual syndrome. Singers are more sensitive to any change in their vocalization because of the complexity of the motor tasks required during singing and the profession is eager to be informed about the management of this problem. For those singers adversely affected, proper advice and management is essential, as the symptoms are cyclical and a significant proportion of their performing lives may be affected. .Very few studies have been undertaken that are helpful to the profession. In an ever-increasing competitive market, it is imperative that professional singers be able to project beautiful tone, consistency of volume and range

reliably in every performance. A singer's personal performance quality will have variability within a narrow band, which is acceptable; however, any marked variation of standards in performing is not consistent with expectations of permanent employment in opera companies. Performance careers are stressful, not only because of the requirement to maintain the highest standards, but because there are fewer permanent contracts, significant public scrutiny, the demand for perfection and the constant competition among peers. Critics can exact a heavy toll professionally if a performance is berated publicly in print and this in turn can result in a significant loss of confidence in the singer. It can also have a detrimental effect regarding the employment of that singer by the same company for the following season. Performance anxiety may also be problematic, and may be compounded by an instrument that is inconsistent and unreliable in function, causing serious consequences that may have a deleterious impact on a singer's career.

The relatively few studies to date have generally used subjects who were non-singers. To use non-singers is not commensurate with the information sought by the profession, because professional singers use the instrument in a much more demanding way, over long periods of time and with highly complex motor tasks. An example of this type of study is Silverman and Zimmer (1978), who tested subjects to reveal whether most young women with normal speaking voices, but no vocal training, exhibit premenstrual hoarseness. The methodology was also non-specific for singers because the tasks were limited and non-challenging. A professional singer uses extensive range, dynamics and volume, and the chosen tasks presented by the literature were neither exacting nor appropriate.

The aims of the five other studies had a more homogenous focus. All studies aimed to determine objectively whether changes in voice quality accompany the hormonal changes

during the menstrual cycle. In the study by Abitbol, Abitbol and Abitbol (1999), the vocal changes caused by hormonal fluctuations were to assess the prevalence of premenstrual hoarseness. In the Higgins and Saxman study (1989), it was to show that the vocal output alters because the mass of the vocal folds changes. Brown, Isenberger and Rothman (1985) wished to prove that singers with the most irregular menstrual cycles also experience the greatest vocal problems, whilst Chae, Choi, Choi, Jin and Kang (2001) sought to evaluate whether the presence of premenstrual syndrome affects female singers. Wicklund (1996) measured the correlation between premenstrual syndrome and vocal dysphonia. In essence, all the studies to date support the hypothesis that voice is affected by the menstrual cycle and its inherent physiological changes.

The concern to the singing community is that so few singers have been tested and that the types of testing were not commensurate with the tasks that professional singers have to address every day of their working lives. For example, Higgins and Saxman (1989) used small number of subjects - ten young women and five young men aged 19-26 years. They were all non-singers and were assessed using speech samples, specifically six vowel productions. None of the female subjects were taking the contraceptive pill. Temperature of the women was recorded daily to reveal ovarian hormonal fluctuation. Testing occurred every second day for thirty-three days. Results indicated that at the premenstruum and during the onset of menstruation, the magnitude of frequency perturbation (disturbance) was not notably different from the average, while at the time of ovulation there was a notable change for most subjects than by chance alone.

In the study by Brown et al (1985), sixteen women aged between eighteen and twenty-two years were chosen. Some of the subjects were trained singers and some had no training.

No information as to which results belonged to which group was given, and again, with a percentage being untrained singers, the results represent a very small number of singers. All the subjects chosen had irregular menstrual cycle, which affected the results, as research has generally shown that the more irregular the cycles, the more the hormonal fluctuations negatively affect the voice. In this study, a small number of the subjects were also taking the contraceptive pill, but no exact figures were available. Again, the use of the contraceptive pill must have had an effect on the research, because the pill stabilizes the hormonal fluctuations and hence the voice. However, the vocal testing was more appropriate to that which should be utilized for professional singers. The subjects sang through chromatic scales and phrases where their voices revealed the most difficulty in phonation. It would have been interesting to ascertain how the untrained singers in the subject group coped with the singing task; however, no such specific information was available.

Chae et al (2001) assessed 28 women over a two-month period, but again, all were non-singers. They were female nurses aged 21-30 years. Their task involved producing five seconds of sustained sound on the “ah” vowel as in “father”, but testing such as this is inadequate for both singers and non-singers.. None of the subjects took the contraceptive pill and none was consistent in taking their daily basal temperature to plot their monthly hormonal changes.

Similarly, Silverman and Zimmer (1978) chose non-singers for their study. Twenty undergraduate students aged between nineteen and thirty-six were the subject choices. The wide range of ages can create difficulty in interpreting the results because the known literature tells us that women manage their symptoms better with age. The other aspect is

that by thirty-six, some of these women may have borne children which may have a notable effect on their physiological status and thus on the results. Some consistency was noted in that none of the subjects was on the contraceptive pill and all took their daily basal temperature to plot the hormonal changes. Another consistency noted was that the subjects, being non-singers, were tested with speech samples of three-second duration. The chosen vowels were “ah”, “eu” and “u”. There were two samples taken, one at ovulation and the other at premenstruation.

Abitbol et al (1999) tested 97 women, all vocal professionals aged from 23 to 36 years old. None of them was taking the contraceptive pill and all presented with a premenstrual dysphonia. The study involved measuring oestrogen and progesterone levels, as well as vocal fold smears and cervical smears. The vocal testing was by singing “Frère Jacques”, and although this French folk song is more challenging than speaking or sustaining five vowels, it is still far removed in difficulty from the daily expectations of a professional singer, showing limited range, volume expectation or technical challenge.

Finally, in the study by Wicklund (1996), a group of 20 women were selected, aged 20 to 57 years old. Again, the diversity of age group poses a problem with consistency of symptoms. As with the earlier study of Silverman and Zimmer (1978), many women in the older age group may have borne children affecting hormones, and indeed, those approaching 50 years of age in the group may well have consisted of a number who were already menopausal. The average age of menopause is between 45 and 55 years of age and there are many symptoms that reflect hormonal changes up to five years prior to menopause, so it is plausible that several of these subjects were inappropriate for the testing criteria. However, there was an excellent questionnaire on the premenstrual

syndrome. Several areas such as mood states, voice differences and general health were addressed, as well as specific questions covering premenstrual dysphonia. Questions on general health included sleeping patterns, food cravings, headaches, smoking habits and exercise programs. The testing was done with acoustics as well as visual and glottographic testing.

Many observers have reflected on the mood states investigated in this research. Chae et al (2001) observed that one or more of the four emotional components, sadness, tension, anxiety or conflict, are present along with the diagnostic criteria for premenstrual syndrome. Davis and Davis (1993) stated that the larynx is especially sensitive and vulnerable to fatigue and that an emotion such as anger will adversely affect the voice. Sommer (1978), in her paper on stress and menstrual disorder, describes women from many published papers reporting unpleasant symptoms such as stress, irritability, nervousness and depression associated with the premenstrual and menstrual phases of the cycle.

A more recent study (Tepe, Deutsch, Sampson, Lawless, Reilly & Sataloff) in 2002, surveyed young choral singers, twenty-five years of age and younger, with a closed set questionnaire. Of almost twenty-three percent respondents, more than half reported that they had experienced vocal difficulties, concluding that it is common among young choral singers. Again, the perceptions that the singer's voice felt worse in the morning and that chronic fatigue or insomnia are all risk factors in singers, cannot be extrapolated to young professional singers undergoing good vocal training. However, self-reported symptoms should alert both the singing teacher and the medical profession to potential problems of the individual singer.

1.3 The Human Female Menstrual Cycle

The hormonal cycle in the female, from menarche (10-18 years) to menopause (45-55 years), is controlled by ovarian oestrogen. The complexities of hormonal interactions throughout the lifespan including the menstrual cycle, pregnancy and puerperium (post-natal) are controlled by changes in oestrogen secretion. Childhood and senescence are phases of minimal gonadal activity (Ganong, 1965).

A gland is any cell or organ that secretes some substance (Nourse, 1965). The adrenal gland above the kidney secretes adrenaline; the salivary glands in the mouth secrete saliva. Endocrine glands (Martin, 1998) are the chemical regulators of bodily function and they secrete substances called hormones, which serve as their chemical messengers (from the Greek “hormon” meaning “arouse to activity”) (Nourse, 1965). Each gland exerts its significant effect through the hormone/s it secretes into the blood stream. Hormonal activity always remains in a delicate balance to maintain whole body equilibrium (Nourse, 1965).

Each hormone is a substance that is produced in a specific part of the body by an endocrine gland, such as the pituitary or ovary (Martin, 1998). It passes into the blood stream where it is carried to other distant (target) organs or tissues and acts to modify their structure or function. Examples of hormones are growth hormone from the pituitary, oestrogen or progesterone from the ovary and thyroxine from the thyroid gland. Most hormones are structurally quite different; however, adrenal cortical hormones and all the ‘sex’ steroids are very similar and are all derivatives of the basic cholesterol molecule (Stein, 1998).

There is very strong evidence that a direct connection exists between the endocrine glands, the brain and the entire nervous system. Neuro-hormones, which link the nervous system and the endocrine system, demonstrate this connection, but both systems are actually separate sections of one vast body-controlling system. The maintenance of the whole body's total well-being depends upon each sector's influence on the other, and in turn, each is dependent upon the functioning of the other.

The hypothalamus is a region of the forebrain, below and between the two hemispheres, linked with the thalamus above and the pituitary gland below (Martin, 1998). It contains several important centres controlling body temperature, hunger and eating, thirst and water balance, as well as sexual function, and is closely connected with emotional activity and sleep. The region functions as a centre for the integration of hormonal and autonomic nervous activity through control of pituitary secretions (Martin, 1998). A woman's emotions can affect this part of the brain, which is demonstrated by the fact that menstruation can cease after a particularly strong emotional upset.

The hypothalamus begins to secrete its releasing hormones about four years before menarche, which is the onset of the menstrual periods and production of other physical and mental changes associated with puberty (Martin, 1998). Menarche occurs when the reproductive organs become functionally active and may take place at any time between ten and eighteen years of age (Martin, 1998). The changes are due to a series of interactions between several glands in the body. The physical changes are evident in females with the development of breasts and hips as well as secondary sexual characteristics, which include pitch and timbre of the voice.

The hypothalamus controls temperature regulation in mammals ("warm-blooded" or homeothermic animals). A group of reflex responses controlled by the hypothalamus operates to maintain body temperature within a narrow range despite wide fluctuations in environmental temperature. Normal body temperature in well individuals, taken orally, can vary between 35.8 degrees and 37.2 degrees Celsius (centigrade). There is also diurnal variation (Rhoades & Pflanzer, 1992) wherein temperature rises gradually throughout the day towards evening and then drops slowly overnight to reach a minimum in the early hours of the morning. During ovulation, there is a brief drop in body temperature, followed by a sustained rise (Williams & Wendell-Smith, 1966), attributed to progesterone, which can be clinically measured. The mean body temperature after ovulation is approximately 1^{o}C higher than that before ovulation (Rhoades & Pflanzer, 1992). This is the reason why it is normal for women in the second half of the menstrual cycle to have a temperature up to 37.4 degrees Celsius.

The pituitary gland is "the master endocrine gland of the body", controlling many other endocrine glands through its secretions (Martin, 1998). It is a pea-sized, ductless gland attached beneath the hypothalamus and is positioned in a small bony cavity at the base of the skull. It has anterior and posterior lobes, which secrete different hormones into the blood stream. These hormones in turn are regulated by specific releasing hormones produced in the hypothalamus. It controls the hormone output of the thyroid gland, the adrenal glands and the gonads (ovaries and testes), as well as the natural circadian rhythm of the body. Consequently, it controls body growth, sexual maturation, reproduction and metabolism.

The ovarian and menstrual cycles are completely under the influence of anterior pituitary secretions, which in turn are controlled by the hypothalamus and the nervous system. Gonadotrophin-releasing hormone (GnRH) begins to be secreted by the hypothalamus after about the age of twelve. This causes certain specialized cells in the pituitary gland to produce the primary hormones that act on the female ovaries. There are essentially three pituitary gonadotrophins, FSH (follicle-stimulating hormone), LH (luteinizing hormone) and LTH (luteotrophic hormone). The hypothalamus also secretes appropriate releasing hormones, FSH-releasing factor and LH-releasing factor.

FSH stimulates development and maturation of the ovarian follicle, along with production of ovarian oestrogen, and in turn is controlled by ('feedback') the amount of circulating oestrogen in the body. It also stimulates the testes to produce sperm in the male and the 'feedback' is though levels of testosterone. LH has four functions closely related to the prior actions of FSH. It not only promotes ripening of the follicle but also its rupture. It induces the formation of the corpus luteum and the consequent production of oestrogen, as well as the production of testosterone in the male (Ganong, 1965). LTH stimulates the corpus luteum production of progesterone and the mammary gland production of milk. The two steroids secreted by the ovary, oestrogen and progesterone, feedback via blood concentrations to regulate the secretion of these gonadotrophic hormones.

The autonomic nervous system involves sympathetic and parasympathetic functions, which are responsible for the control of the bodily functions that are not consciously directed (Martin, 1998). These functions include regular beating of the heart, intestinal movements, sweating, salivation and dilatation of the pupils. The two systems work in balance with each other to smoothly control the reflex actions of the body. They can also

be aroused to contribute to voluntary actions of the mind over the body like the classical “fight or flight” reactions. Herein, the human body responds to aggression by increasing heart rate and breathing, raising blood pressure, increasing muscle tension with dilatation of muscle blood supply and increasing blood sugar and body metabolic rate.

The ovary is the primary female reproductive organ producing egg cells (ova) and steroid hormones. It responds to hormones (gonadotrophins) from the anterior pituitary in a regular cyclical manner. Each ovary contains numerous follicles, which secrete oestrogen and small amounts of androgen (male sex hormone) (Martin, 1998). After ovulation, the release of an oocyte (egg), a corpus luteum forms at the site of the ruptured ovarian follicle. The corpus luteum secretes progesterone in preparation for implantation of a fertilised egg. Oestrogen and progesterone together regulate changes in the uterus throughout the menstrual cycle and pregnancy. Although all parts of the female genital tract undergo periodic changes with the influence of oestrogen and progesterone, the most obvious effects occur on the lining of the uterus (endometrium) with the resultant menstruation in the non-pregnant female.

Oestrogens are naturally occurring steroids secreted by ovarian follicles, the corpus luteum, the placenta, and, in small amounts, by the adrenal cortex and the testes. Their biosynthesis is via androgens (male sex hormones) and oestradiol is the main oestrogen secreted. Oestrone and its metabolite oestriol are the other oestrogens, in decreasing order of potency. Thereafter, there are at least ten different metabolites of oestradiol excreted in human urine (Nader, 1991). The principle effects of the oestrogens are exerted on the pituitary, the brain, the breasts and the female reproductive organs. Although these effects are multiple and varied the main control is upon ovarian follicle maturation and cyclical

changes in the endometrium. They have a ‘feedback’ effect on the pituitary gonadotrophins (FSH, LH and LTH) and increase libido in human females. The breast responds to oestrogens by enlargement at puberty and initial pigmentation of the areolae. The secondary sexual characteristics of female maturation, body configuration (narrow shoulders and broad hips, thighs that converge and hips that diverge), fat distribution (breasts and buttocks), hair distribution and the prepubertal proportions of the larynx, which retains the high-pitched female voice, are all results of oestrogen function. Various skin characteristics are also attributed to oestrogens as well as a significant cholesterol lowering effect in the blood.

Progesterone is secreted by the corpus luteum and the placenta as well as being related to the biosynthesis of steroid hormones in the body. It is mainly responsible for changes in the endometrium, has an anti-oestrogenic effect on uterine muscle and stimulates growth of secretory tissue to produce breast milk. Progesterone causes thickening of the uterine lining and induces the glandular structures to secrete nutritious fluid to nourish the fertilised egg after implantation. In a ‘feedback’ cycle with the pituitary, progesterone inhibits LH secretion and appears to be the primary hormone in salt and water retention. When progesterone is secreted late in the menstrual cycle, it contributes to the well-known premenstrual tension syndrome. It is also responsible for the basal body temperature rise after ovulation, which can be plotted on a graph, relaxation of smooth muscle and increase in the oily secretions of the skin.

Testosterone is the principal male sex steroid (androgen) and is synthesised from cholesterol in the Leydig cells of the testes. The biosynthetic pathway of all steroid hormones formed in endocrine glands (adrenal, testes and ovaries) is very similar, only

differing in the enzyme systems each uses. Testosterone is also formed in the adrenal cortex, where it is the precursor of the oestrogens (Ganong, 1965). Small amounts of oestrogens are formed in the testes as well. Androgens, including testosterone, exert a 'feedback' inhibition on the secretion of LH from the pituitary. Their main actions are developing and maintaining the male sex organs and secondary male sexual characteristics, such as muscle development, hair distribution and depth of voice (Martin, 1998). They also maintain protein anabolism (growth promotion) and to some extent are involved in maintaining spermatogenic cells in the testes.

The menstrual cycle is the sequence of events in sexually mature non-pregnant women whereby an egg cell (ovum) is released from the ovary at regular intervals until the menopause (Martin, 1998). It is the recurring process of new oocyte formation, corpus luteum formation and ovarian hormone production. The cycle is usually divided into two phases – the follicular phase followed by the post-ovulatory luteal (progestational) phase of 11-14 days (Williams & Wendell-Smith, 1966). The full cycle usually lasts about 26-28 days and varies in length dependent on the length of the follicular phase. Early in the follicular phase, small amounts of oestrogen are released stimulating release of LH and thereby stimulating more oestrogen production. By about the fourteenth day after onset of menstruation, oestrogen levels in the blood have increased approximately six-fold under the influence of FSH (Llewellyn-Jones, 1986).As both oestrogen and LH gradually increase they inhibit release of FSH and stimulate ovulation. Each stimulated follicle produces oestrogen for about one month. However, the corpus luteum (a temporary endocrine gland, which appears yellow) is formed in the mature or ruptured follicle, while the other follicles regress after ovulation. The Latin word for yellow is 'luteus' - hence luteinizing, or yellow-making hormone. The corpus luteum then produces progesterone,

the second main female sex hormone, which causes the lining of the uterus (endometrium) to thicken in preparation for pregnancy.

Menstruation (menses) is the stage of the menstrual cycle when the endometrium is shed because fertilisation has not occurred (Martin, 1998). The rising levels of oestrogen reduce the level of FSH secreted by the pituitary. The blood vessels supplying the lining of the uterus deteriorate and breakdown causing bleeding and shedding of the uterine endometrium. The normal duration of discharge varies from three to seven days, but within weeks, the cycle has regenerated the endometrium in preparation to receive a fertilised ovum.

Premenstruum is that part of the menstrual cycle immediately preceding menstruation (Martin, 1998). Premenstrual tension is a condition affecting some women for up to ten days before menstruation. It includes symptoms of nervousness, irritability, emotional disturbance, headache and sometimes, overt depression. The syndrome appears to be associated with the accumulation of salt and water in the tissues and generally disappears soon after menstruation begins. The hormone progesterone is thought to be a causative element (Martin, 1998) inducing the symptoms which include weight gain, abdominal bloating, cerebral oedema (contributing to memory loss, mood alterations and headaches) and premenstrual vocal fold oedema. The signs and symptoms of the premenstrual syndrome can be classified (Nader, 1991) as somatic (body states), affective (mood states), pain and behavioural states, such as food cravings, insomnia and fatigue. Other theories, including oestrogen withdrawal, aldosterone secretion and a relative deficiency in vitamin B_6 have been proposed to explain the premenstrual tension syndrome.

The prevalence of reactions to pre-menstrual syndrome range from 30-40%, whilst severe symptoms probably occur in less than 10% of cases (Nader, 1991). This variation in reaction is due in part to the fluctuations of oestrogen and progesterone concentrations during the menstrual cycle resulting in differing symptoms and, in part, by the way in which individuals cope with the physiological changes at that time of month. The symptoms may be mild, moderate to intense whilst the cyclical nature and variation of symptomatology is individual (Nader, 1991).

As the larynx is a hormonal target organ, with its morphology being affected by these two sex hormones (Amir & Biron-Shental, 2004), it is understandable that some singers are adversely affected by their changing body states. Some singers may be affected emotionally, whilst others manifest physical aspects at laryngeal level, i.e. a sizeable increase in the bulk of the cords will result in a lower pitch (Frable 1961), and yet others may find the bloating effect of fluid retention throughout the body affects their ability to support their voice effectively. Some singers are affected by the changes and some are not (Isenberger, Brown & Rothman, 1985). As a pedagogue of thirty years experience working with professional voice users, my knowledge of singers and their instruments support these facts and the huge variability of their symptoms and emotions.

In summary, the complexity of the human female menstrual cycle affects all aspects of female physiology as well as women's emotional well-being. The interaction of the hypothalamic, pituitary and gonadal hormones through their direct effects and their feedback control systems produce, in the majority of females, a regular series of events of a cyclical nature. Variations in symptoms and signs of these events are well documented

and the symptoms may affect the production of the voice and performance quality of some female professional singers.

1.4 Hormones and Vocal Quality

1.4.1 Introduction

The female evolves physiologically from childhood under the influences of oestrogens, progesterone and testosterone. These hormones underpin the changes in a woman's voice, which evolves throughout her life.

Rubin (2001) stated that nothing is static about the larynx or the vocal tract. A characteristic element about each individual voice is timbre, which is hormone dependent. Voice changes in the general population are usually not of significant concern. However, for singers, any variation in vocal quality becomes a serious issue because their livelihood is affected directly by daily performance. Exacerbation of these changes occurs by the use of greater vocal range and power, which will expose the voice more readily to a wider range of difficulties and inadequacies. Singers are also more susceptible because of greater fine muscle usage and hence fatigue during vocalization, which can result in occupational vocal chord abuse. Such conditions require the facilitation of vocal changes (Chae, Choi, Choi, Jin & Kang, 2001) because any hard working singer, like any athlete, is susceptible to injury.

Singers rely on their entire body to produce sound that is pleasing aesthetically and powerful enough to carry through a large auditorium and over an orchestra. For professional singers to excel, particularly operatic singers, physical mastery of respiratory control and strength is required. Achievement of extensive pitch, range and flexibility also requires precise control. Singers are vocal athletes, who rely not only on physical strength

but who are dependent on skills of efficiency, coordination and precision (Harvey, 1997). Physical and vocal stamina, as well as a high level of fitness, are required to perform a lengthy recital or operatic role. This also requires experience and skill to sustain and monitor the necessary effort over a long period.

By necessity and experience, singers are very aware of their bodies throughout performances and if the health of the body is disordered at any time, impairment of vocal function is a direct and immediate result (Bradley, 1980). Sensitivity to body function enables a singer to control unwanted effects of physiological changes. If not addressed, a negative effect on optimal vocal function, whether technical, emotional or physical, may limit the singer from realising her full potential as an artist. Consequently, they become aware of any slight variation in the quality or the quantity of the sound produced and are able to make adjustments to maximise their performance. Because any unpredictability of their instrument is a potential source of concern and frustration, maintaining good physical condition gives the singer the benefit of understanding and anticipating any change in vocal function or character. This is an essential skill for any young singer contemplating a career.

Because a female singer's instrument is her entire body and mind, any premenstrual changes affecting any organ system of the body may potentially affect her performance adversely. Known disorders may affect the larynx, eyes, respiratory function, energy levels, metabolism, appetite, weight control, nervous system, psyche and interpersonal relationships (Nix, 1998). Illness, injury or other numerous natural bodily processes may create vocal problems. The extreme complexity and interdependence of the glandular

system may produce a great variety of hormonal imbalances, which affect the voice (Brodnitz, 1971).

Hormonal fluctuations are among the most common, unresearched and often perplexing causes of vocal dysfunction (Emerich, Hoover & Sataloff, 1996). Rubin (2001) found that in one study, 15.6% of 360 women treated for voice disturbances were suspected to have endocrinologic causes (Timonen, Sonninen & Wichmann, 1962, out of Rubin). Essentially, the larynx and the voice as an instrument, is extremely sensitive to endocrine changes. Hormone receptors for oestrogen, progesterone and androgen are present in the human vocal folds (Newman, Butler, Hammond & Gray, 2000) as detected by immunohistochemical staining. Depending upon the receptor type, their association varies significantly statistically by age and gender, as well as position within the nucleus or the cytoplasm of the cells. In 2003, a group of researchers (Altman, Haines, Vakkalanka, Keni, Kopp & Radosevich, 2003) determined that the human larynx also contains thyroid hormone receptors. These findings add significantly to the former theories of hormonal control of the voice in both genders, however, our understanding of the regulatory processes governing nuclear and cytoplasmic receptors is incomplete (Stein, 1998).

Alterations in the bulk and shape of the vocal folds produce these changes, which result in perceptual and physical changes of the voice such as muffling, sluggishness, decreased range and loss of vocal efficiency and accuracy. If the findings of this study support the commonly held beliefs of the professional singing community, education and awareness about the influence of endocrine changes on the singing voice should become a high priority. For some singers, the cyclical nature of their negative vocal variation and

susceptibility, often assumed to be psychogenic or anxiety related, may indeed be related to underlying endocrine changes of the female hormonal cycle.

1.4.2 Puberty

During puberty, there are major changes to the laryngeal anatomy because of the "hormonal earthquake" (Abitbol et al, 1999). Puberty is the onset of sexual maturity in the body and usually occurs between the ages of ten and eighteen depending upon the timing of the onset of menses (menarche). Before puberty, there is no progesterone production in the body (Abitbol et al, 1999). Increased secretion of oestrogen and cyclical production of progesterone create the vocal qualities associated with female voice, while an increase in testosterone is responsible for the vocal qualities associated with male voice.

The female vocal folds grow from 1.5 to 4 millimetres, or thicken and elongate as much as 34% (Rubin, 2001), while the male vocal folds grow between 4 and 11 millimetres, or thicken and elongate as much as 60% in length. The length of the vocal folds determines the vocal character, because the female voice drops 2.5 semitones and averages a fundamental frequency of 220 to 225 Hz change when their voice change has been completed (Rubin, 2001). However, the male voice drops approximately one octave (13 semitones) to a mean fundamental frequency of 130 Hz at age 18 to 20 (Rubin, 2001). On maturity, lower voice types in females and males have a longer larynx than that of their colleagues with higher pitched voices. Voice mutation occurs because of laryngeal growth (Sataloff, 2000) along with the changing angle of the thyroid cartilages in the male, and the length of vocal folds is related to final larynx size and the changes in the whole vocal tract.

Major vocal change is induced by this surge in hormones. The rapid acceleration in growth of the larynx results in frequent breaking and instability of the voice, particularly for males who are more affected, and often causes emotional discomfort. The vocal folds can also grow asymmetrically causing further vocal insecurity. It is not unusual for young boys to cease singing during his period. Young women may also be affected but the physical changes in the larynx are not as marked. Their vocal changes are often less obvious and they continue their singing during this period of change.

1.4.3 Pregnancy

The voice changes in pregnancy have been called “laryngopathia gravidarum” (Sataloff et al, 1993). Any pregnant women who experiences loss of normal vocal facility during pregnancy, without physical damage to the apparatus, can be given an assurance that their dysphasia only occurs for the duration of the pregnancy. The hormones progesterone, oestrogen, human chorionic gonadotrophin (HCG) and human placental lactogen (HPL) are produced in the pregnant woman (Ganong, 1965).

During pregnancy, professional singers commonly report changes in vocal quality. Imre (out of Brodnitz, 1971) examined two hundred pregnant women and found a high incidence of hoarseness and deepening of the voice. Any asymmetry caused by swelling of the folds may induce lack of control, loss of volume and lack of flexibility. Although such changes are usually temporary, vocalization during pregnancy should be approached with a degree of sensitivity and care because excessive strain may result in small bleeds within the vocal cords, called submucous haemorrhages (Imre, out of Brodnitz, 1971). It is important for singers to be aware of these potential problems so that excessive vocalization

through their professional workload can be reduced to avoid permanent damage to the vocal apparatus.

On clinical examination, it was found that the vocal cords manifest redness, swelling and small submucous haemorrhages, which were more apparent than in non- pregnant females. Imre's research (out of Brodnitz, 1971) revealed that these symptoms disappeared with cessation of the pregnant state.

As pregnancy advances and a woman's uterus expands, her abdominal support is progressively compromised. A professional singer relies on extremely strong and well-coordinated abdominal musculature, which comprises the major groups of muscles such as internal and external obliques, latissimus dorsi and rectus abdominis. The thoracic muscles for breathing, internal and external oblique muscles are also affected by significant changes, as are the pelvic girdle muscles, which supply support to the abdomen. Any singer whose abdominal support is compromised substantially should be discouraged from singing until the abdominal disability is resolved (Sataloff et al, 1993). The fatigue of pregnancy also creates a negative effect on the voice because the physical stamina and strength as well as the abdominal coordination expected in the vocal professional may not be possible during this period.

1.4.4 Pre–Menstrual Syndrome (PMS)

All women do not experience the premenstrual syndrome, and when evident is highly variable in symptomatology (Chae et al, 2001). Symptoms may vary from mild to severe,

as well as varying from cycle to cycle. In more severe cases, it can lead to disruption of general life style affecting occupational and social functioning.

The syndrome continues to elude diagnosis with no theory being fully substantiated scientifically (Nader, 1991). Although theories abound as to the reason for premenstrual symptoms, as yet there is no convincing evidence to support any of these possibilities as the definitive cause (Davis & Davis, 1993). It appears to be of primary concern in the literature, which continually seeks information regarding voice problems among trained singers during the menstrual cycle. The general body of all the literature surveyed continues to substantiate this through the many theories available.

When the symptomatology involves a singer's body and emotions, it becomes of serious concern to the performer. There appears to be a genetic factor or a familial predisposition to symptoms in women and in the general population about 25-50% of women report symptoms. However, there is no evidence of any correlation between race, culture, marital status or educational level and the symptomatology (Davis & Davis, 1993). Psychological, physical and vocal effects of premenstrual syndrome have a wide range of symptoms and individuals experience differences from cycle to cycle, probably because of factors such as personal stress levels, diet, health and age.

Lacina (out of Chae et al, 2001) reported that many female singers had difficulties with intricate phonation control before each menstruation, deterring them from scheduling concerts whilst in the premenstrual phase. In this specific population, he noted that 75% experienced some physical change. "Singers notice changes in voice more readily than

non-singers, because they employ a greater voice range and also because occupational vocal cord abuse facilitates changes in vocal cords" (Chae et al, 2001).

Shala Nader (1991) commented that the pathophysiology of the syndrome remains elusive, continuing to remain so throughout the collective literature, and as a result the treatment is essentially empirical. Her findings were that in the general population the prevalence is approximately 30-40%. Abitbol (Abitbol, de Brux, Millot, Masson, Mimoun, Pau & Abitbol, 1989) noted that in their study, 75% of female singers were affected and that female voice performers may experience special problems with vocalization during the premenstrual phase. Abitbol, et al (1989), Jurgen Wendler (1972), Brodnitz (1979), Lushinger (1965) and Perello (1962) all support similar conclusions, that there are acoustic and physiological changes to the voice just prior to and during the menses. Brodnitz (1979) recommended avoidance of any unnecessary vocal strain during the menstrual period to prevent lasting damage to the voice. It has further been recommended that females whose career demands a higher degree of vocal efficiency should have regular physical examination of their vocal chords to maintain optimal vocal health and function. A sensitive support team of vocal teacher, accompanist, vocal coach and doctor, all aware and skilled in management of these presenting difficulties, should be an adjunct to a singer's career, as premenstrual syndrome adds yet another dimension of anxiety to an already stressful life.

Sataloff (1993) advises that singers with premenstrual syndrome should sing with a lighter mechanism than normal, should minimize their rehearsal times and avoid singing when their symptoms are most severe. Awareness of such advice to reduce vocalization when a singer is most affected could possibly create more anxiety if a performance cannot be

rescheduled. Although the most severe symptoms occur around the last week of the cycle and can encroach upon the menses, it is probably quite impractical to schedule singing engagements around the menstrual calendar. During a significant period of the 20th Century, female operatic singers in most of the major European opera houses were given "grace days" (where they were not required to sing) in recognition of the effect of hormonal changes on the singing voice (Sataloff, 1991)(Brodnitz, 1971). Financial constraints in professional companies in more recent times have resulted in changes to this policy, with a potential loss of income for the singer.

According to Sataloff, "laryngopathia premenstrualis" is caused by physiological, anatomical and psychological alterations because of endocrine changes (Sataloff et al, 1993). He notes that the common vocal symptoms associated with this premenstrual phase include a loss of high notes, vocal instability and fatigue, uncertainty of pitch, decreased vocal efficiency, reduced vocal power and flexibility, and huskiness. He concludes that the physiological correlations to these perceived vocal changes are related to the drop in oestrogen levels on or about day twenty-one in the menstrual cycle. Smith-Frable (1961) comments on the vocal instability, vocal "breaks", hoarseness, huskiness and a loss of vocal control, which Sataloff et al (1993) specifically call "laryngopathia premenstrualis". Smith-Frable adds that pelvic discomfort, oedema, temporary weight gain, emotional outbursts, restlessness, irritability, breast tenderness and headaches are among the known symptoms of PMS. He continues that other factors affecting women are the feeling of social isolation and both decreased efficiency and motivation. A review by Silverman and Zimmer (1978) lists similar symptoms.

A diagnosis of premenstrual syndrome is only established if symptoms resolve for at least those days between the end of the menstrual period and ovulation, i.e. approximately days seven to fourteen of the cycle. Typically, symptoms are most severe during the "paramenstruum", the interval that begins about the twenty-fourth day of the cycle and continues until approximately the fourth day of the menses ('period'). Davis and Davis (1993) isolated four temporal patterns for the establishment of premenstrual syndrome. Firstly, the onset of signs and symptoms occur about two to ten days prior to the beginning of menstruation. These signs continue until the menstrual period begins or even into the first twenty-four hours of the period. Secondly, there are the onset of signs and symptoms at ovulation (about fourteen days prior to the onset of menstruation), which last for a few days, and are followed by some symptom-free days. The third temporal pattern is the onset of signs and symptoms at ovulation, which continue uninterrupted until the beginning menstruation or even into the first 24 hours of the period. Finally, there are the onset of signs and symptoms at ovulation, which continue through to nearly the end of the menstrual period and these women complain that they "have only one good week a month".

Abitbol et al (out of Emerich et al, 1996) agrees that the alteration in oestrogen levels cause laryngeal water retention, oedema of interstitial tissues and venous dilatation. The laryngeal tissues begin to absorb water as the oestrogen levels begin to drop, which in turn causes vocal fold swelling with engorged blood vessels and increased vocal fold mass. The small blood vessels supplying the vocal chords become more "leaky" causing fluid to accumulate in the chords. Concomitantly, polysaccharides break down into smaller molecules in the vocal chords, bind water more readily and lead to greater fluid retention. Consequently, the vocal chords swell with fluid causing the vocal symptoms described.

The changing ratio of oestrogen to progesterone results in fluid retention and asymmetry of the vocal folds, which can be visualized by videostroboscopy.

Lushinger and Arnold (1965), out of Wilson and Purvis (1980), stated that upon observation of the vocal folds, just prior to and during menstruation, it revealed that they were swollen and oedematous with quite a marked reduction in mucous secretion. This could give the singer a feeling of dryness and hoarseness. Abitbol et al (1999) noted that dynamic vocal exploration by televideo-endoscopy showed congestion, microvarices, and oedema of the posterior third of the vocal folds with a loss of vibratory amplitude. Brodnitz (1971), in a case report from the same review, indicated similar negative effects of menstruation on a professional singer's voice. Wendler (1972) (out of Rubin, 2001), in an acoustic and physiological study of thirty females, reported a reduction in vocal efficiency during the premenstrual and menstrual periods.

In the 1890's, Bayer and Oppenheim (out of Davis & Davis, 1993) reported menstrual related hoarseness, laryngeal haemorrhage and tracheal disorders. Since that time, other studies have shown vocal fold oedema and congestion, laryngeal joint stiffness and even instances of complete aphonia (Smith-Frable, 1961; Abitbol et al, 1989). These physical changes inevitably cause problems related to pitch, volume, quality of sound and the flexibility of the instrument. General physical attributes such as endurance and vitality, and vocal characteristics of pitch stability and voice quality, are altered by premenstrual fatigue because the larynx is especially sensitive and vulnerable. Good vocal production requires good physical condition and integrated control of physical and mental processes. Abdominal muscle tone and respiratory endurance, upon which the singing voice depends, are impaired when a singer is fatigued. Consequently, the singer will attempt to

compensate for lack of strength and coordination by instinctively using inappropriate muscle groups to support the tone, such as the accessory neck muscles. This secondary, uncoordinated and unsupported vocalization results in a forced tone and has the potential to initiate vocal damage such as a small vocal chord haematoma. Educating singers about the correct management of their premenstrual syndrome requires a more sophisticated approach.

Abramson et al (out of Emerich et al, 1996) agrees with such observations by adding that altered metabolic activity by oestrogen sensitive cells could have an effect on the quality of the voice. Vocally, it can present several symptoms such as breathiness, 'breaks' in phonation, a loss of the high notes in the range and fatigue. Brodnitz (1971) adds huskiness and a lowering of pitch to the symptomatology. Change in the overall size and mass of the vocal folds results in changes to the vibratory characteristics of the chords, which is a serious consequence for any professional singer. Wicklund (1996) stated that swelling of the vocal folds have been confirmed by acoustic measures of vocal range and quality. In addition, otolaryngologists have reported cases of alterations in the appearance of the vocal folds of singers just prior to the onset of menstruation, specifically vascular changes and increased oedema (Higgins & Saxman, 1989). These statements are supported by Weiss (1988), (out of Emerich et al, 1996), who commented, "when a woman experiences lower oestrogen levels, she performs poorly on complex motor tasks, including phonation". Chae et al (2001) confirmed that the vocal chords are hormonal target organs and that singers report anecdotally distressing vocal alteration during the several days preceding the menses. Such issues of reduced beauty and efficiency of sound are very serious for the professional artist.

In 1968, Lacina reported that the changes to the voice appear proportional to the presenting severity of the premenstrual symptoms and added that it is unquestionable that vocal strain during the menstrual period leads to premature deterioration of the voice and impairment of vocal quality. Lushinger (out of Silverman & Zimmer, 1978) agrees that “nothing can be more obvious than that a female singer needs rest during the days of her cycle”. Smith-Frable (1961) stated that the vocal changes preceding menses are unrecognized symptoms of premenstrual tension. Because the incidence in the general population of voice change is 20-50%, intricate changes in voice are obviously present in many women with no voice training, which supports the views of Smith-Frable.

Despite the growing evidence of physical symptoms for singers during this period, the effect of the menstrual cycle on voice continues to be an area of much debate and investigation (Chae et al, 2001). More recently, Chernobelsky (2002) studied fifteen healthy female classical singers, final year students of music college, and fifteen vocally abusive female classical singers, first year at music college. He found that premenstrual hyper-changes (hyperaemia and oedema of the vocal folds) were a result of combined abuse- and menses-related influence on the larynx, and further that, abuse- and menses-related changes of the larynx appear very similar although resulting from different causes. Problems with a less well-developed vocal technique are increased with vocal use and decrease with rest. Hormone related effects might be compounded in vocally abusive singers who use their voice around menses, constituting a high-risk group for the development of vocal nodules (Chernobelsky, 2002).

1.4.5 The Oral Contraceptive Pill

Most contraceptive pills are a combination of synthetic oestrogen and progesterone. The aim is either to maintain a consistent level of both of these hormones throughout the cycle or to emulate the menstrual cycle by varying the proportions of the hormones, but essentially to prevent ovulation, and thereby, pregnancy. Because there is no conclusive evidence to date of a connection with taking the pill and negative vocal effects, professional singers cannot yet be certain that their fears in this regard are justified (Boulet & Oddens, 1996).

During the 1960s and the 1970s, some concern was expressed in a number of reports that stated that there appeared to be some virilization in the voices of women using oral contraception. The relatively high progesterone content of some pills is most likely to produce androgen-like changes while oestrogen has no known negative effect on the female voice (Sataloff, 1995). Sataloff also expresses concern regarding the number of hormone preparations containing a small amount of testosterone. More recently, contraceptive pills use lower levels of both oestrogen and progesterone making virilization of sound less likely.

Female singers use the contraceptive pill relatively infrequently because of the perceived changes that the medication may have on their instrument. Range or quality of sound may be affected negatively after a relatively short time of using the oral medication. There has been anecdotal evidence about the possible negative effects, which may include a loss of high notes, but there has been no scientific evidence to support this (Comins, 2002). However, it appears that these changes are reversible upon ceasing the medication.

The two synthetic hormones, oestrogen and progesterone, have a negative affect on the voice in only 5% of women (Boulet & Oddens, 1996). However, singers are understandably cautious about ingesting anything that may affect the function or tone quality of their voice. It was reported by the same researchers that 29% of women found changes to their voice whilst taking the pill, for which they were unable to find either physical or vocal reason.

Women who suffer severe symptoms on a cyclical basis find that the pill appears to balance the unevenness of hormone levels and that this is a very positive aspect. In turn, this results in more even vocalization over the entire cycle, because the drug provides them with the same amount of oestrogen and progesterone throughout the cycle (Ledger et al, out of Comins, 2002). The same study hypothesised that hormonal consistency of the singer on the pill may be of benefit because water retention in the tissues may be reduced and vocally this would be highly preferable. Consequently, the steady state of hormones in the pill would limit any vocal changes because of oedema, including any asymmetry of the vocal folds, and the effects would probably be less evident to both the singer and the audience.

The oral contraceptive pill is convenient and reliable in avoiding pregnancy. In the United States, the estimate is that 30% women use the contraceptive pill (Rubin, 2001). However, women on the pill may experience less vocal change because of the stabilisation of their hormones. When it is evident to the singer and the vocal teacher that there are extreme imbalances in the hormonal levels, the pill may be considered as a means of stabilising the hormonal changes and hence the voice (Brown et al, 1982).

Studies that are more recent (this thesis commenced in 2002) tend to negate a lot of the anecdotal evidence and papers included in the original literature search. It is not yet clear from the present studies whether the current, modified hormonal balance in women on the pill affects vocal quality any differently from the "natural" hormonal cycle (Amir et al, 2002). Amir et al, in papers published in 2003 and 2004, went on to suggest that results for singers taking oral contraceptive medication (low-dose monophasic preparations) do not show an adverse effect on the voice. In fact, Amir, Kishon-Rabin and Muchnik (2003) suggested that voice stability is associated with the smaller hormonal fluctuations induced by the contraceptive pill. However, they also stated that because the volunteers were students, in a comparative study between those taking the medication and those not taking it, "these results cannot be readily applied to professional singers". They went on to say that, voice quality among pill users was typically better than that of the control subjects (Amir et al, 2004).

In conclusion, if a singer decides to use the oral contraceptive pill, careful monitoring of its effects and/or side effects might be advisable initially, especially listening for obvious voice changes. She can also take advice from a medical practitioner in tailoring the hormone content, thereby ingesting the smallest doses available to ensure protection from pregnancy and a safe level of hormone for the voice.

1.4.6 Menopause

Generally, the menopause or 'climacteric' occurs in women between the ages of 45–55 years. During this time, fertility gradually declines with the loss of ovarian function and the loss of trophic actions of oestrogens, and secondary symptoms such as vasomotor

dysfunction, hot flushes, night sweats and sleep disorders may occur in some women (Emerich, Hoover, Sataloff, 1996). The constellation of symptoms can begin up to five years prior to the climacteric and can include emotional and psychological changes, such as depression, mood swings, irritability and lack of self-confidence.

This most prominent hormonal change is in fact a ten to twenty fold drop in oestradiol levels while there is a relative increase in circulatory progesterone and androgen (Khaw 1992, out of Sataloff). The ovaries gradually reduce their production of oestrogen to almost zero. The menstrual periods become irregular and may vary in quantity as progesterone production is reduced. Finally, with the complete cessation of cyclical bleeding, the secretions from the ovaries change with further reduction of oestrogen leaving the remaining androgens freer to act. In opposition to oestrogen, these small amounts of androgens cause thickening of the glandular secretions of cervical mucosa and drying out of the seromucous glands throughout the body.

Because the ovaries have stopped producing oestrogen, masculinization of the voice occurs and can vary from individual to individual depending on each woman's hormone profile and percentage body fat. Further, decrease in oestrogen causes vocal fold oedema with subsequent increase in swelling of the vocal folds and vocal fold thickening (Abitbol et al, 1989). Because this results in an increase in the mass of the vocal folds, there may be a resultant change in the characteristics of the vocal folds, which alters the quality of the sound (Emerich et al, 1996). Boulet and Oddens (1996, out of Rubin) state that the loss of oestrogen resulted in problems of voice emission because of changes to the vocal folds causing a loss of suppleness. This is especially noted by people most sensitive to the quality of their voice for their livelihood, such as singers, actors, ministers of religion, the

legal profession and schoolteachers. Voice professionals feel as if this hormonal disturbance has a negative effect on their vocal career and emotional lives. The findings of spectrographic analysis confirm that certain harmonics of the voice are lost (Abitbol, Abitbol, Abitbol, 1999) and show a thirty-percent reduction in the calling voice, the projected voice and the singing voice as well as revealing that there was a feeling of flatness of tone and loss of colour.

Loss of timbre, brilliance, colour, flexibility, volume, upper notes and vocal fatigue have been reported (Harris, 1992; Nadoleczny, 1926; out of Rubin, 2001). Singers have also noted such symptoms as a lowering of vocal intensity, vocal fatigue, decreased range with a loss of the high notes and a loss of timbre in the spoken and singing voice (Abitbol et al, 1999). For the professional singer, this is evident in poor performance of some of the complex motor tasks involved in singing, including loss of high notes, fatigue, instability of sound, uncertainty of pitch, decreased vocal efficiency, huskiness and reduced power and flexibility (Emerich et al, 1996).

The vocal muscles are also affected because of androgenic effects on voluntary (striated) muscle movement. There are also a number of other age-related physiologic symptoms including a general decrease in lung power, atrophy of the laryngeal muscles with stiffening of the laryngeal cartilages and loss of the elastic and collagen fibres (Emerich et al, 1996). There is reduced hydration of the free edges of the vocal folds and any dryness during phonation leads to rapid vocal fatigue and to decreased ease of phonation (Abitbol et al, 1999). These symptoms are exacerbated if a singer practises their vocal exercise program infrequently.

Both sexes undergo changes at about 50 years of age, although problems with emission of the voice control of the instrument and attainment of the highest registers seems to occur more typically in female singers than in male singers (Boulet & Oddens, 1993). This same study stated that 65% of women believed that these vocal changes were related to menopause. These changes are progressive and slow vocal deterioration is first noticed in the high notes and in pianissimos (passages sung as softly as possible). Singers also report some loss of speed in staccato, loss of range, loss of intensity and loss of formants in the high notes. Boulet & Oddens (1993) stated that there is anecdotal evidence of professional singers who experienced loss of brilliance and power, as well as decreased ability to reach high notes during the climacteric and after the menopause. The voice problems reported by male singers related to similar phenomena (Boulet & Oddens, 1996) the complaints being hoarseness, a duller voice, increased vocal fragility/sensitivity and problems in transition from the middle to the higher registers; this was after elimination of those male singers whose voice symptoms could be attributed to disease states.

There is some consistency of symptoms between menopause and the premenstrual syndrome, because the hormonal changes are similar at both times. Coincidentally, there is also a striking histological resemblance between smears taken of the cervix and those of the vocal folds (Abitbol et al, 1989). Not surprisingly, oestrogen target cells were found in the larynx in the late 1980s and more recently (Chernobelsky, 1998), while Newman et al (2000) demonstrated progesterone and androgen receptors in the vocal folds and Altman et al (2003) demonstrated thyroid hormone receptors in the human larynx.

Both the premenstrual phase and menopause result in a drop in oestrogen and Sataloff (2001) states that the changes in voice occur because of the decrease in oestrogens and the

relative increase in androgens. Sataloff (1996) recommends that, rather than abandon their singing careers, singers should use hormone replacement therapy (HRT) to reverse these changes, because oestrogen has an organ preserving effect on the larynx. Lindholm et al (1997) concluded that at least the early postmenopausal years are associated with vocal changes and that HRT counteracts this phenomenon. With the maintenance of appropriate hormone levels, consistent vocal training, and physical exercise, women should be able to continue to sing well into their sixties and seventies. Abitbol (1999) noted that the improvement in sound was marked after four to six months of HRT.

The type of medication for professional singers should always be cautiously chosen. Emerich et al (1997, out of Rubin) noted that singers on combined (oestrogen and progesterone) hormone replacement did not respond as well as those only on oestrogen. They cautioned that while testosterone will not usually affect the voice, a number of hormone replacement medications contain small amounts of testosterone. These researchers advised that the dose of HRT should be minimised and adjusted according to serum oestrogen levels, with close medical follow-up for vocalists.

While most women will show tolerance to androgens, a significant number of women notice changes in their voices because of androgens. Androgens may produce permanent lowering of the fundamental frequencies, especially in females, and coarsening of the voice (Sataloff, 1995). However, Damste (out of Emerich et al, 1996) recommended that under no circumstances should androgens be given to female singers, even in small amounts, (if there is any reasonable therapeutic alternative) as they cause irreversible unsteadiness in the voice, rapid changes of timbre, and lowering of the fundamental

frequency. Therefore, singers need to be well informed about the intrinsic danger of androgen use and its potential to masculinize the voice.

Sataloff (1991) also reported that conjugated oestrogens (salts or esters of equine oestrone) may be preferable to oestradiol, whilst Lindholm et al (1997) stated that at least the early postmenopausal years are associated with vocal changes and that HRT counteracts this phenomenon. They went on to confirm that HRT action seems to be more pronounced with oestrogen than with a combination of oestrogen and progestin. Sataloff (1995) suggested that the baseline oestrogen levels of professional singers should be obtained at around thirty-five, so that at menopause declining oestrogen levels can be readily recognised and rectified. He stated that participation in this practice would allow endocrinologists or gynaecologists to tailor hormonal replacement therapy to the patient's past individual hormone profile. Oestrogen replacement is helpful in prevention of the typical voice changes that can follow menopause and professional voice users who are concerned about safeguarding their current vocal profile should be offered HRT at the time of menopause. This, of course, would need to be under medical supervision appropriate to the individual vocalist and the doctor would need to take into account any relevant contraindications.

1.4.7 Other Endocrine Medications

There are other endocrine medications that may beneficially affect the voice. However, medications used to treat disorders in any part of the diencephalic-pituitary-axis should be monitored closely for possible changes in vocal function because of their potential laryngeal effects. Brodnitz (1971) warns that the steadily increasing use of therapeutic hormones, and of hormone related drugs, has sharply increased the potential incidence of

iatrogenic disorders of the voice. He stated that 14.1% of voice disorders could be traced to some endocrine cause, whilst 15% of disorders are caused by hormone-related drugs. With hormonal imbalances (pregnancy) or deficiency states (thyroid deficiency) Brodnitz warned that changes in pitch and quality occur frequently. Examples include the hormone treatments that have been used in the management of endometriosis (androgens), fibrocystic breast disease (progesterone), menstrual dysfunction (oral contraceptive pill) and hormonal imbalance (Pattie, Murdoch, Theodoros & Forbes, 1998, out of Rubin 2001). The tremendous complexity and interdependence of the various glandular systems can potentially produce a great diversity of hormonal imbalances, which in turn may affect the voice.

The medical profession, who may well be unaware of potential dangers to the voice, use anabolic steroids (e.g. corticosteroids) widely in such illnesses as chronic arthritis, renal failure, breast cancer and osteoporosis. Whenever synthetic derivatives of testosterone are incorporated into hormonal treatments for women, such as the oral contraceptive pill, the potential of androgenic side effects on the voice is of significant concern. Brodnitz suggests that vocal disorders may be the first clue to the fact that there is a possible diagnosis of endocrine imbalance or deficiency. The unsteadiness of voice, lack of vocal quality control and a lowering of pitch are serious (Sataloff, 1995) effects on the singing voice.

The adverse effects of androgens include permanent lowering of fundamental frequencies and coarsening of the voice, characterised by a sharp lowering of basic pitch to a masculine level, general roughness in quality, cracking or breaks in the vocal range and discernible difficulty in controlling the instrument during speech and singing. Virilization

of the voice is not a reversible situation and cessation of the medication has no effect. However, not all women are affected, and it is not possible to determine beforehand those who will react unfavourably. Singers need to be aware that it is essential to cease medication at any hint of hoarseness or any other change of voice (Brodnitz, 1971).

Thyroid deficiency results in a rough, hoarse sound with limitation of the upper vocal range, general vocal fatigue and often a feeling of a lump in the throat. Thyroid replacement may restore vocal efficiency but the “ring” is lost with even a mild degree of hypothyroidism (Sataloff et al, 1993). Altman et al (2003) demonstrated that thyroid hormone receptors are present in the human larynx, suggesting a potential role of thyroid hormone in normal laryngeal development, physiology and function. The anxious, sweaty, nauseous professional singer with prominent eyes and an overactive thyroid (Sataloff, 1994) will have adverse effects on the voice also.

Insulin imbalances such as diabetes mellitus may also cause a dry voice (Comins, 2002). Anecdotal personal communications from female singing students suggest that both low blood sugar levels (hypoglycaemia) and poor levels of hydration (inadequate fluid intake) affect the voice in a negative manner, making vocalization more difficult through lack of physical energy and concentration.

Virtually all medications have some laryngeal effect (Sataloff, 1995). Hormone imbalances affect voice. Hormone therapies restore voice (Sataloff, 1994).

1.5 Hormones and Emotion

Frank (1931) introduced the term “premenstrual tension”, to describe “a relationship between hormonal changes during the menstrual cycle and recurring psychological manifestations such as depression or irritability. These symptoms may vary monthly in incidence, number, and intensity among the affected and a given individual may experience marked variation from cycle to cycle because of factors such as stress, diet, age and general health.”

Laryngologists, voice specialists and professional singers all recognize that one’s mental state can affect vocal performance and that there can be several causative factors to this mental state. When altered emotions are part of cyclical change in the premenstrual period (premenstrual tension syndrome), then the affected performer may find that the development of their professional career is considerably and consistently altered. Many vocalists may be aware of change in their voice around that time, because the professional singer is so perceptive to the slightest change in their instrument, but may not be aware that those same changes are the result of bodily function and cannot be managed easily. The lack of predictability and variable nature of the symptoms, as well as the variable intensity of the outcome, may result in difficulties of diagnosis and management.

The human voice is a complex, daily changing instrument and the premenstrual tension syndrome can add unnecessary anxiety to the already demanding life of a performing artist. Understanding the symptoms and familiarity with their effect can placate the disappointment in a performance that is not of the ideal or expected standard. This inconsistent change causes dissatisfaction to the professional singer who constantly

attempts to adapt to the variation. Whilst the experienced singer can often control performance nerves in a positive way, she must also learn to deal with the physical symptoms of pre-menstrual tension, if her livelihood is not going to be affected adversely. During premenstruum, the female singer is still expected to display the same level of professionalism and courtesy toward her peers. However, if she is feeling unusually susceptible to criticism from her fellow performers, conductors and directors, as well as being in a highly emotionally charged state, then her professionalism may be undermined. Such singers may react inappropriately with anger and hostility acquiring a reputation for being difficult, unreliable, uncooperative and volatile. Consequently, if it affects them on a cyclical basis, their reputation and ultimately their career will be compromised. In the highly competitive world of the opera singer, such behaviour is undesirable.

The wide assortment of psychological, neurological and interpersonal aspects of premenstrual symptoms includes tension, loneliness, morbid or pessimistic thoughts and paranoia. Chae et al (2001) noted sadness, tension, anxiety or conflict with other individuals, plus withdrawal from social activities. Brown and Hollien (1982) noted that depression occurs just prior to and during the first days of menses. Abitbol et al (1989) stated that nervousness, irritability and depression characterized the presence of premenstrual tension. Smith-Frable (1961) noted that the symptoms included unreasonable emotional outbursts, restlessness and irritability. Davis and Davis (1993) noted that behavioural changes may be variable in incidence each month. Any given individual may experience variation of symptoms from cycle to cycle because of such unpredictable factors as stress, their general health, diet and age.

Premenstrual tension syndrome is not regarded as a psychiatric disorder because it does not meet the criteria for such a diagnosis. Firstly, many of the symptoms, which are related to the luteal phase of the menstrual cycle, are physical rather than emotional in origin. Secondly, it is a disorder that is not permanent, and subjects respond within the normal range to psychological evaluation. Some law schools make their students aware that premenstrual tension syndrome can be utilized as a legal defence for temporary insanity in cases of manslaughter, personal injury, arson, assault, child abuse and marital strife. A few insurance companies now reimburse for the cost of treatment for premenstrual syndrome (Davis & Davis, 1993).

Electroencephalogram (EEG) changes have been noted during the premenstrual phase of the cycle. Mood changes, loss of memory and headaches could all be related to fluid retention and brain swelling. Similarly, a number of major PMS symptoms, including anxiety, irritability, depression, and abdominal cramping, may be regarded as dysfunction of the central nervous system (CNS). This suggests that hormone level variations during the menstrual cycle have effects on brain chemistry (Davis & Davis, 1993).

The voice is also an exquisite messenger of emotion (Sataloff, 1997). Over many years of experience, highly skilled singers learn how to adjust their mood states and control the anxiety associated with performance. However, the more challenging aspect is the uncertain factors caused by symptoms of premenstrual tension syndrome. Profound emotional disorders have long been known to contribute to the functional losses of audition, phonation and other performances of speech. Less severe neurologically induced symptoms such as muscle tension and rapid heart rate that affect a performing artist may manifest prior to performance as “pre-performance nerves”. Whatever the source of

muscle tension, nervousness or loss of control of emotions, these symptoms can cause major disruption to a singer's technique, especially when they are sensitive to minute vocal changes.

Physiologically, the heightened emotional state may be expressed by shouting and/or crying which increases pressure on the vocal apparatus. Along with difficulty in sleeping, and muscular tension, manifest in tightness of the shoulders, chest, jaw and neck, difficulty in phonation may become apparent as the muscles work against each other. This further adds to the frustration, anxiety and tension to an already stressed singer who becomes more confused and frustrated that her voice is not functioning in the best possible condition.

Potentially this sets up a vicious circle, which becomes more difficult to control with time. Confidence in one's performance, which a singer has worked for so many years to achieve, can easily fall prey to hypersensitivity to criticism, uncertainties, irritability, despair, and consequently, further self-criticism. These feelings can severely limit a career in that the symptoms could make a singer question their career choice and negatively destabilise their motivation to practice and improve their skills.

In order to survive in the highly competitive world of professional singing, singers must have a very positive sense of self-worth, strength of mind, and absolute self-assurance in their own special talent and future. Any negative thoughts can disarm the singer of the energy and confidence necessary to continue. The resulting self-doubts will be exasperating for supporters such as singing teachers, coaches, directors and conductors and are likely to result in a decrease of enthusiasm necessary for that particular artist.

It is essential for a singer's well-being to gain the key knowledge about such symptoms, which can have a devastating effect on their individual performances and their whole career, as an awareness can result in assistance, support and understanding from professional colleagues and supporting allied personnel. Difficulties would manifest themselves in the weekly exposure to singing lessons and rehearsals as well as in the work and home environments. The singing teacher, with major input into the career, could become disillusioned and perturbed that someone of such obvious talent with excellent career prospects could be so uncooperative, crushed and unfocused on a regular or cyclical basis. The relationship between the two is then spoiled, as any new technique or interpretative ideas and career suggestions will not be received in an atmosphere of collaboration and interest. Throughout this process, the singer may be totally unaware of these cyclical emotional changes unless they have gained knowledge of the hormonal effects on the singing voice.

It is more than likely that many a talented singer has experienced emotional aspects of the pre-menstrual syndrome and its effect on their inter-personal relations. Such symptoms usually begin prior to menarche and would continue through to menopause, often becoming more intense with age. Premenstrual tension could arguably affect an individual singer's professional and personal relationships, and the success of her career (Davis & Davis, 1993).

The recognition of such florid effects of premenstrual symptoms by the teacher would be almost essential, if progress is being delayed or sporadic. A referral to a physician, more especially an endocrinologist, for assistance would be most beneficial along with emotional support from a designated support group rather than just by colleagues. By

understanding of the symptoms and admitting that there is a problem the singer, with medical support to reduce or alleviate the cyclical nature of the symptoms (Nader 1991) may find confidence and the emotional strength to achieve the vocal, personal and professional potential that is evident in her work.

Allaying the fears and anxieties along with understanding, support and explanation are essential aspects in management of these problems. Awareness of other family members with these symptoms may help to create better awareness and greater acceptance of the consequences, because a genetic element appears to exist with the premenstrual tension syndrome. The significant degree of psychological trauma that may exist is deserving of sympathetic handling particularly when the career aspirations may have been so significantly affected (Davis & Davis, 1993).

Medication such as tranquillisers and sedatives are rarely necessary and essentially undesirable because of the interference with fine motor control and the potential to frustrate a singer further, who finds the instrument difficult enough to handle at such times.

It is essential for singers to become better educated and aware of the large range of body changes that can occur, so that they are able to adjust to the challenges. Sataloff (2002) stated that singers are trained to discern subtle differences in the supernormal to near-perfect range in which the professional performer's body must operate. According to Lusingher, in marked premenstrual tension, physical, intellectual and emotional performance is reduced through the discomfort experienced during these days.

Arranging singing engagements around the menstrual cycle may assist the performer. However, variability in the menstrual clock due to various circumstances such as illness, stress or menstrual synchrony with family or associates, needs to be noted.

The skilled singer can utilize pre-performance anxiety in a generally positive manner to enhance the level of excitement in the performance. However, pre-menopausal physical changes, which cannot be controlled or utilised constructively may cause a singer to feel that her instrument is not in its usual condition. This can severely undermine her level of confidence and control.

1.6 Aims of the Study

Professional singers are expected to present on stage with a consistency of range, even, clear and beautiful vocal quality and the same reliability in every performance, to project above the volume of the orchestra. Any unpredictability in their instrument is a source of anxiety and frustration, while controlling any variable is of paramount importance.

Brodnitz (1979) noted that singers notice even minor impairments of vocal function. Professional survival in an ever increasingly competitive market is dependent on a singer's ability to produce beauty and consistency of the highest standard. Professional singers must track the source of any variation and be in a position technically, musically and emotionally to combat any change and bring the instrument back under control. An inability to achieve a consistency of the highest standard could well limit their potential as an artist. In turn, this can negatively affect self-esteem, potential income and prestige among their professional colleagues.

Clearly, from the studies and empirical reviews to date, pre-menstrual syndrome negatively affects many singers. Interest in the effect of menstruation has appeared in the literature for more than forty years. Smith-Frable (1962) concluded that hoarseness was a recognised symptom of premenstrual syndrome, while Sataloff (1993) stated that professional voice users needed to become educated about the influences of endocrine changes on the voice. Lacina (1968), of the National Theatre in Prague, wrote that menstrual dysphonia affected one-third of the female singers in that opera house. European opera houses typically excused singers from singing during the premenstrual and early menstrual days, the so-called “grace days” (Sataloff, 1996).

Because the singer’s body is their entire instrument, it is of paramount importance for them to be sensitive to and understand their physical condition. Vocal professionals are curious to discover the basis for any vocal problems. Any changes which have a negative effect on their sound is part of the knowledge a professional singer must possess. Without such knowledge, a singer’s stressful life as a performer will have added and unnecessary anxiety. An instrument maintained at optimal function and beauty gives the singer confidence and relaxed phonation.

Nix (1998) commented that it would not be possible to schedule singing engagements, lessons, rehearsals, competitions, auditions, and examinations around a singer’s menstrual calendar; learning to recognize, prepare and manage symptoms becomes the only solution that is viable. Chae et al (1997) recommend that singers deter from scheduling concerts while in the premenstrual phase.

The available literature presents variable results and reviews on the seriousness of this problem. However, professional singers commonly complain of vocal fatigue, loss of range, changes in vocal quality and other factors several days each month during which certain physiological changes prevent the normal use of the larynx. According to past studies, for some singers these changes are minor, but for others the situation has repercussions that are more serious.

I have noted that there are several inconsistencies in recording of symptoms in the literature to date. This is due, in part, to the range of females chosen, i.e. professional singers and non-singers, and the wide range of age groups, including some menopausal subjects. The methodology is also open to scrutiny because the vocal testing ranged from spoken vowels or sustained tones through to singing a nursery rhyme. The testing of vocalization in this manner hardly supports or challenges the results from the literature which state that premenstrual tension gives singers hoarse voice and vocal fatigue (Wicklund, 1996), a drop in volume and quality (Abitbol et al, 1999), and breathiness (Isenberger & Brown 1982). The testing methodology does not challenge range, control or quality of sound, and studies of this kind have little relevance for a professional voice user.

Brodnitz (1979), having requested phonated vowels rather than sung tones, has not taken into account the substantial demands on a singer's voice and body, as well as the high quality of expected performance every day of their working lives. The type of sample taken must challenge the already known body of knowledge about vocal symptoms to be able to inform artists accurately of the extent of variation caused by the premenstrual syndrome.

It is not relevant to professional singers to give results of sound quality from untrained non-singers {three studies (Chae, et al, 1997), (Isenberger & Brown, 1982) and (Higgins & Saxman, 1989)}. Professional singers and full-time singers in professional training deserve far more accurate and sensitive information.

Wicklund (1996) used a range of women up to the age of fifty-seven. Sataloff (1996) states that menopause occurs in women from their late forties to their early fifties as fertility declines with loss of ovarian function. An accurate symptomatology of pre-menstrual syndrome is inaccurate if a number of subjects are pre-menopausal. The significant loss of oestrogen in menopause results in vocal change, but this is different to the premenstrual syndrome where there is fluctuation of hormone levels, despite that fact that both conditions are similar in that there is a decline in oestrogen with a relative rise in progesterone.

An alternate concern is that in several studies, research subjects were taking oral contraceptive medication. As it is known that these hormones reduce the larger hormonal fluctuations of the natural menstrual cycle (Isenberger, 1982) this would again create fewer variables in the results. Singers taking the oral contraceptive pill demonstrated significantly smaller variance for all variables tested (Amir, et al, 2002).

In the studies to date, there have been a number of methodologies employed. However, none has used audiotapes evaluated by the singers themselves or by vocal pedagogues. My research hopes to demonstrate that vocal variance by audiotape recording, taken within the premenstrual / menstrual phase and during the remainder of the cycle, can be objectively assessed by the singers themselves or by vocal pedagogues.

Three studies have used self-evaluating questionnaires, which I will also use, but not self-evaluating audio testing. This aspect is critical because of the perception that professional singers are more sensitive to minor changes in vocalization that may not be discernible to a listener, even a pedagogue. The study that I will undertake extends current research in that it may reveal the audience cannot hear a difference whilst the singer is convinced there is a difference. The increased effort to produce, support and project the expected quality and quantity of sound may be an awareness of the singer but not aurally perceived.

This research could result in a significant reduction in a singer's anxiety if their sound remains professionally acceptable and perceptually unaffected during the critical few days every month. Information such as this would be a major contribution to the literature. However, if perceptual changes do occur, the singer could manage the problem with certain recommendations from voice and/or medical professionals.

Further information needs to available for professional singers. Studies using only semi-professional or professional singers and protocols that are more challenging would then be able to evaluate any results more effectively and accurately.

CHAPTER 2

The University of Sydney Human Ethics Committee approved this study. All documentation pertaining to the study is reprinted in Appendix 1.

2.1 METHOD

2.1.1 Participants

All participants in this study were students of western classical voice enrolled at the Sydney Conservatorium of Music, The University of Sydney, from the degree courses of Diploma of Opera, Bachelor of Music (Performance) and Bachelor of Music (Education). The pedagogue listeners were all members of the Vocal Unit Staff at the Conservatorium. Students and pedagogues were invited to participate by letter. All were given participant information sheets and consent forms were signed prior to enrolment in the study.

Table 1: Participant characteristics. Allocated number in study, gender, age in years, years of singing experience, voice type, and for females only, cycle length (days), cycle regularity, use of contraception.

Participant	Gender	Age (years)	Years singing experience	Voice type	Cycle length (days)	Cycle regular	Contraception	Pregnant
1	F	19	3	soprano	28	Y	N	N
2	M							
3	F	26	9	soprano	32	Y	N	N
4	F	27	16	soprano	24-30	N	N	N
5								
6	M							
7	F	25	12	soprano	28	Y	Y	N
8	F	22	8	soprano	29	Y	Y	N
9								
10	F	18	2	soprano	21	Y	N	N
11	F	24	7	soprano	30	Y	N	N
12	F	22	5	soprano	27	Y	Y	N
13	F	18	6	soprano	29	Y	N	N
14	M							
15	M							
16	F	23	5	soprano	30	Y	Y	N
17	F	21	8	soprano	28	Y	Y	N
18	F	21	5	mezzo soprano	35-40	N	N	N
19	F	25	10	soprano	28	N	N	N
20	F	22	16	soprano	30	Y	N	N
21	F	21	6	mezzo soprano	27	Y	N	N
22	F	19	2	soprano	26	N	N	N
23								
24	F	20	8	soprano	28	Y	Y	N
25	F	23	7	soprano	29	Y	Y	N
26	F	21	6	soprano	28	Y	Y	N
27	F	18	9	soprano	25	Y	Y	N
28	F	25	5	soprano	29	Y	N	N
29	F	25	10	soprano	30	Y	Y	N
30	M							
31	M							

Male subject details were not completed in the diary by participants.
Incomplete participants (3) dropped out of the study.
Distribution: 22 females – 20 sopranos – 2 mezzo-sopranos
6 males – 1 tenor – 1 counter-tenor – 4 baritones

2.1.2 Instruments

The diary was custom designed for this study and covered questions on physical symptoms, voice and mood states. The female participants were asked to record their daily temperature and their menstrual cycles. Diaries were bound in thirty-six-page booklets. Participants were asked to complete one page per day for each day of the observation period.

2.1.2.1 Physical symptoms questions

Physical symptoms recorded were those described most commonly in the literature (Wicklund, 1996) as occurring in the pre-menstrual part of the cycle, with additional space for comments regarding the severity of the symptoms. The female subjects were asked whether they were using hormonal contraception.

TODAY, did you:

		not at all severe ... very severe
experience cramps?	NO___YES	_____
feel fatigued?	NO___YES	_____
feel nauseous?	NO___YES	_____
feel bloated? (eg breasts?)	NO___YES	_____
experience food cravings?	NO___YES	_____
have headaches?	NO___YES	_____
change in appetite?	NO___YES	_____
feel dizzy?	NO___YES	_____
have difficulty sleeping last night?	NO___YES	_____

Data regarding state of “well being”, symptoms of inter-current illness (unwell), unrelated physical symptoms (body pain) and alcohol consumption (alcohol intake) were collected as these factors are also known to affect voice production and quality.

2.1.2.2 Voice questions

Items included in the questionnaire used to rate voice quality were selected on the basis that they are commonly used by vocal pedagogues and students to describe the voice and which occurred in the literature as descriptors of vocal health and quality (Abitbol et al, 1999; Rubin, 2001; Sataloff, 2000).

Thinking about your singing **today**, to what extent do you agree or disagree with the following:		
	Strongly agree	Strongly disagree
My voice felt in peak form	_____	
My voice felt fatigued	_____	
It took a lot of effort to sing	_____	
My ability to support my sound was affected	_____	
My voice seemed hoarse or husky	_____	
My voice felt muffled, weak or breathy	_____	
I could not extend to the top of my range	_____	
I was not able to control my voice as easily	_____	
My voice felt “sluggish”	_____	
My voice sounded flat in pitch	_____	

2.1.2.3 Mood state questions

Words used to describe mood states were selected from each of the subscales of the Profile of Mood States (POMS) (McNair & Droppleman, 1981). Other vocal researchers (Abplanalp et al, 1979; Wicklund, 1996) have taken a similar approach to mood description in vocal research.

Below is a list of feelings that people have. For each feeling, cross ONE number for the answer that best describes HOW YOU ARE FEELING **RIGHT NOW**. The numbers refer to these phrases

0 = Not at all, 1 = A little, 2 = Moderately, 3 = Quite a lot, 4 = Very

Relaxed	(0)	(1)	(2)	(3)	(4)
Discouraged	(0)	(1)	(2)	(3)	(4)
Annoyed / Irritable	(0)	(1)	(2)	(3)	(4)
Sad / depressed	(0)	(1)	(2)	(3)	(4)
Unable to Concentrate	(0)	(1)	(2)	(3)	(4)
Energetic	(0)	(1)	(2)	(3)	(4)
Forgetful / confused	(0)	(1)	(2)	(3)	(4)
Tense / anxious	(0)	(1)	(2)	(3)	(4)
Exhausted	(0)	(1)	(2)	(3)	(4)
Cheerful	(0)	(1)	(2)	(3)	(4)
Angry	(0)	(1)	(2)	(3)	(4)
Fatigued	(0)	(1)	(2)	(3)	(4)
Happy	(0)	(1)	(2)	(3)	(4)

2.1.2.4 Temperature chart

The temperature chart was based on the chart used by the Family Planning Association of Australia and modified to suit the current study. Recording of basal temperature and change, "ovulation shift", during the female menstrual cycle followed protocols based on physiology references and previous studies (Nix, 1998; Rhoades & Pflanzer, 1992; Williams & Wendell-Smith, 1966).

2.1.3 Procedure

2.1.3.1 Stage 1

The twenty-one (21) female singing students were asked to commence recording their temperature, day of cycle, mood and vocal states, physical symptoms and intercurrent illnesses in their daily diaries on day 1 of their menstrual cycle. Six (6) control males also recorded data, taking day 1 as the day on which they were given their diaries.

2.1.3.2 Stage 2

The six (6) female singers who indicated in their diaries that their menstrual cycle most affected their singing voices were audio-taped on two occasions, firstly on day 1 of their menstruation and again at mid-cycle. The students involved and the voice teachers at the Conservatorium assessed these samples to determine whether voices affected by hormonal

fluctuations could be reliably identified perceptually, when assessors were blind to the conditions under which the samples were produced.

2.1.4 Recording

2.1.4.1 Musical tasks recorded

The musical task recorded was twenty (20) seconds of a Puccini aria, *O Mio Babbino Caro* from the opera, *Gianna Schicchi*. This extract challenged each singer in range extension, sustained support of the voice, accuracy of intonation (pitch), flexibility of phrasing and movement through the registers, as well as language facility.

We recorded arpeggios and other scale patterns and *messa di voce* at each session, but final analysis was confined to the aria extract as it revealed all the information appropriate to this study. Both musical tasks were chosen as very specific to the singing voice, in contrast to the many other studies conducted on the speaking and singing voices. This was a significant methodological advance in that vocal effects of the menstrual cycle might only be observed at the extreme range or technical challenge of the vocal stimulus. The nearest tests to western classical singing in previous studies have been chromatic scales and phrases (Brown et al, 1985), or a rendition of “Frère Jacques”, a French folk song (Abitbol et al, 1999). Both these tasks are still far removed in difficulty from the daily expectations of a professional singer who requires wider range and greater volume in pieces of music of much greater technical challenge.

2.1.4.2 Recording Method

The recordings of the female singers who reported being most affected by the hormonal fluctuations were made at various times of the monthly cycle (day 1 and mid-cycle) when hormonal changes were noted from the information acquired by the self-evaluating questionnaire.

The acoustic signals were recorded digitally (Behringer Ultragain preamplifier/Marantz CDR 630) via a high-quality microphone (AKG C-477) positioned on a head boom a constant 7 cm distance from the subject's lips. That was so that direct energy of the performers' voice was recorded rather than room reflections, enabling us to use a studio environment with low ambient noise. For calibration of absolute sound pressure levels (SPL), this was coupled to the microphone, at a distance of 7cm and played immediately following each recording session at the same recording gain. A sound level meter (Rion NL-06 SPL) was used to measure the SPL, which was noted for the two tones.

The taped samples were randomly aggregated onto a CD and both the pedagogues and the singers rated the vocal quality of the samples on a simple vocal quality rating scale. The singers also indicated whether the sample was taken during menses or at another time in the cycle.

2.2 Study Design

Participants recruited into the study were given a package, which included the self-evaluating questionnaire, a temperature chart and a student information form. All

participants had a half-hour briefing prior to study commencement so that they understood how to complete the temperature chart and daily diary. Males completed only the vocal and general health sections of the daily diary and did not complete the temperature chart.

Descriptive statistics were performed on demographic characteristics. Parametric and time series analyses were examined with regard to perceived hormonal effects on the voice. Acoustic analysis assessed the actual changes in voice quality over the menstrual cycle.

2.3 Hypothesis

The study was undertaken because, as a vocal pedagogue of 26 years experience, anecdotal evidence suggested that young western female classical singers affected by the premenstrual syndrome manifest significant vocal impairment. The multiplicity of the symptoms has a variable negative effect on the voice of young singers to the extent that they feel insecure in their performance. This suggested that further research was necessary in a clearly defined group with appropriately set tasks.

The hypothesis was that young female singers would manifest changes in their singing voice, which could be self-detected, but also manifest changes in such a way as to be detectable by vocal pedagogues or an audience. The young male singers would act as controls with no apparent symptomatology. Failure of consistency and reliability of the voice could then be predicted by the fluctuations of the menstrual cycle, the mood states of the performer and their physical symptomatology.

CHAPTER 3

RESULTS

3.1 Description of sample

One female singer with 17 days of missing data was omitted from analyses (ID #12) leaving 27 singers. Where there were some missing diary days, these appeared to occur randomly. One female singer (ID #17) had 8 days missing and one male singer (ID #6) had 6 days missing. Of the remaining 25 singers, 11 had complete data and the remainder had between 1-4 days missing. Thus, there were a total of 32 missing days for the voice quality variables out of 696 days recorded (4.6%).

Of the 27 singers with sufficient Phase I data to be included in longitudinal analyses, 6 were male and 21 were female. Of the 6 males, 5 completed the diaries for 28 days and one completed the diaries for 26 days. Of the 21 females, 14 completed the diaries for 28 days, three for 27 days, three for 25 days and one for 18 days.

3.2 Analysis

Five types of analyses were conducted:

i. descriptive analyses using the entire data file of 28 singers; frequencies, box plots and t-tests were used to explore characteristics of the singers and associations between voice quality parameters and personal characteristics.

ii. cross-sectional analyses in which the data for the 27 singers with adequate diary recording were used; mean voice quality parameters were used to explore differences by day and gender, non parametric and parametric correlations were used to explore relationships between mood, feelings and voice quality, regression was used to describe relationships between mood and voice quality and one-way analysis of variance was used to examine linear trends in mood and voice quality over the first 7 days of the cycle in females.

iii. longitudinal analyses in which data for the 27 singers with adequate values were used and in which missing values for each singer were replaced by their mean value for their cycle up to day 25. Missing data was not replaced past the last day of recording. General linear modelling with repeated measures analysis was used to test for day and gender effects and to obtain means plots and effect sizes. When sample models were repeated using Mixed Models with autoregressive covariance matrices (AR(1)), the P values for the effect of gender and day of cycle were very similar to the repeated measures ANOVA effects for gender effects and similar for day effects.

iv. perceptual analysis of six female singers was completed by recording specific musical tasks during various times of the monthly cycle (day 1 and mid-cycle) when hormonal changes were noted from the information acquired by the self-evaluating questionnaire. The taped samples were randomly aggregated onto a CD and both the pedagogues and the singers rated the vocal quality of the samples on a simple vocal quality rating scale. The singers also indicated whether the sample was taken during menses or at another time in the cycle.

v. measurement of agreement: mood and voice quality variables for the 19 singers who completed both phase I and phase II were compared. The difference for each day in phase I and II and the mean of the phase I and phase II measurements for the same day were computed and then plotted to assess agreement.

3.3 Statistical methods

A total of 27 singers, of whom 6 were male and 21 were female, provided sufficient data to be included in longitudinal analyses. Of the 6 males, 5 completed the daily diaries for 28 days and one completed the diaries for 26 days. Of the 21 females, 14 completed the diaries for 28 days, three for 27 days, three for 25 days and one for 18 days. In order to include singers in longitudinal analyses, missing values were replaced by the singer's mean value for their cycle but missing data was not replaced past the last day of recording.

Linear mixed models were used to measure the independent effects of cycle (days 24-4 compared with days 5-23), gender and contraceptive pill use included in binary form on voice quality and mood. The effect of contraceptive pill use was tested in females only. An autoregressive covariance matrix was used to allow for values closer together to be more correlated than values further apart. This covariance structure provided a lower-2 restricted log likelihood than either an unstructured matrix or compound symmetry matrix and was therefore used in the mixed models. The residual values for the models were normally distributed with no major outliers and therefore assumptions for the models were met. Repeated measures general linear models were then used to examine trends using a linear polynomial contrast in mood and voice quality over the first 4 days of the cycle. In addition, deviation contrasts were used in females only, to identify days where values were

significantly higher or lower than the mean value for all time points. There was insufficient data to undertake this analysis in males. Relationships between voice quality measurements and mood were examined using Pearson's correlation coefficients.

3.4 Results

3.4.1 Characteristics of Singers

The characteristics of the 27 singers are shown in Table 2. None of the female singers was pregnant and only four reported having an irregular menstrual cycle.

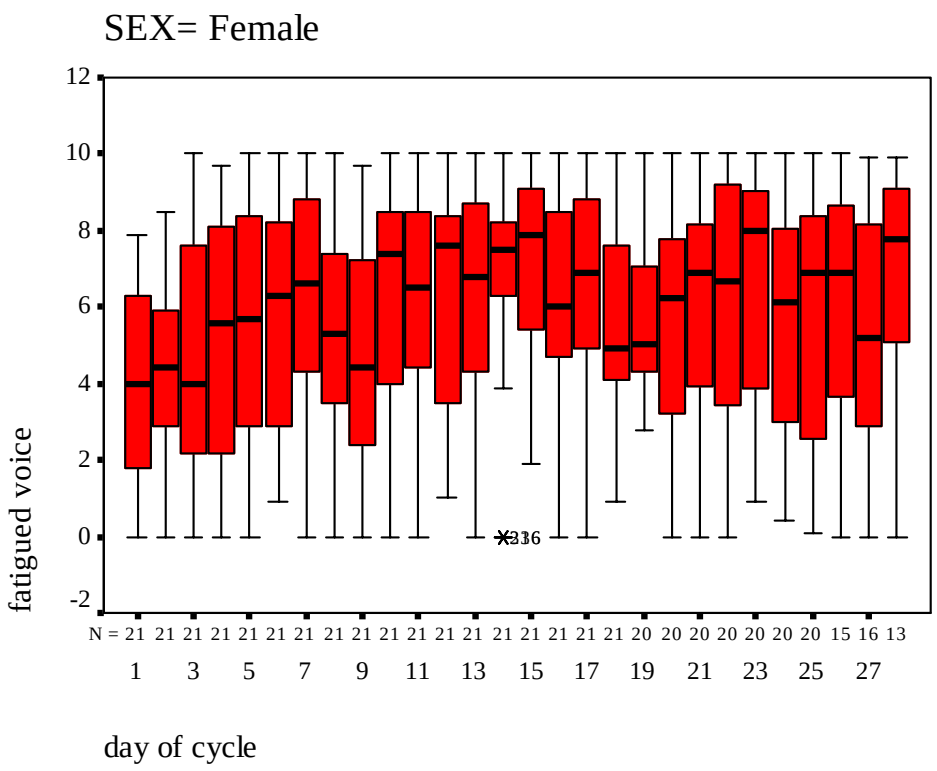
Table 2: Characteristics of singers

	Total sample	
	Males	**Females**
Total number	*6*	*21*
Soprano	-	19 (91%)
Mezzo soprano	-	2 (9%)
Baritone	4 (67%)	-
Tenor	1 (17%)	-
Counter tenor	1 (17%)	-
Age range (years)	19-29	18-27
Singing (years)	3-9	2-16
Oral contraceptive pill	-	9 (43%)
Regular cycles	-	17 (81%)

Although 17/21 (81%) of females singers reported regular menstrual cycles and 10/21 (43%) reported using an oral contraceptive, neither of these factors were related to the voice quality variables as measured on the first day of the cycle with P>0.15 for all associations (Appendix 2). The box plots of temperature in females showed that there was no apparent relationship between temperature and day of cycle (Appendix 3).

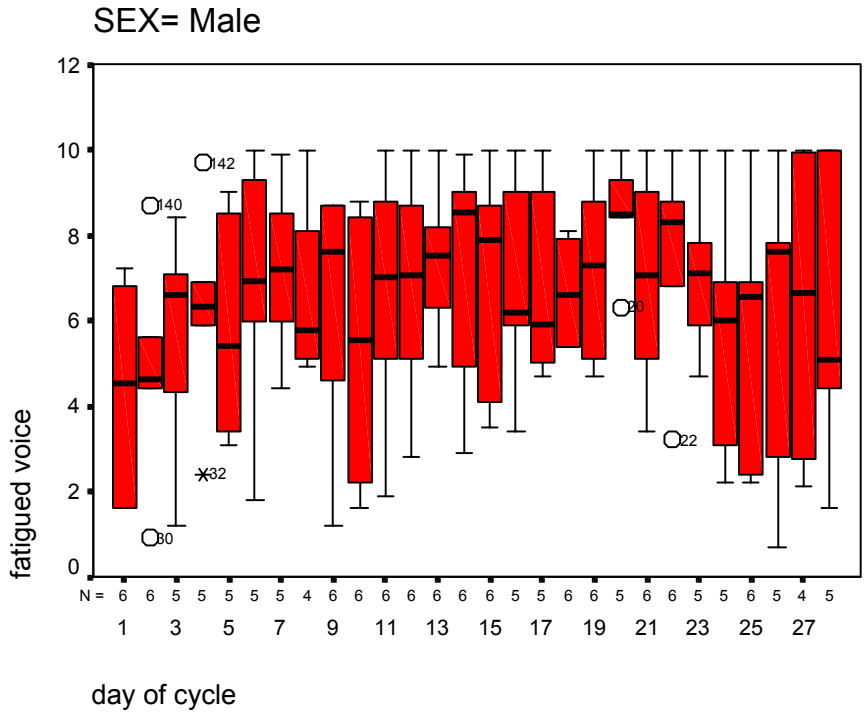
Perception of voice quality for female singers were summarised as median values and the range for each day are shown as box plots in Appendix 4. For the females for most variables, median values tended to be slightly lower on days 1-3 than for the remainder of the cycle and for some variables there was a trend for values to rise through days 1-7 as shown, for example, for 'fatigue in Figure 1.

Figure 1: Box plots of 'fatigue' by day in females



The voice parameters for male singers summarised as median values and the range for each day are shown as box plots in Appendix 5. Although some males had lower values on days 1 and 2, the plots tended to be slightly flatter over the cycle days than for females or more random as shown for 'fatigue' in Figure 2.

Figure 2: Box plots of 'fatigue' by day in males

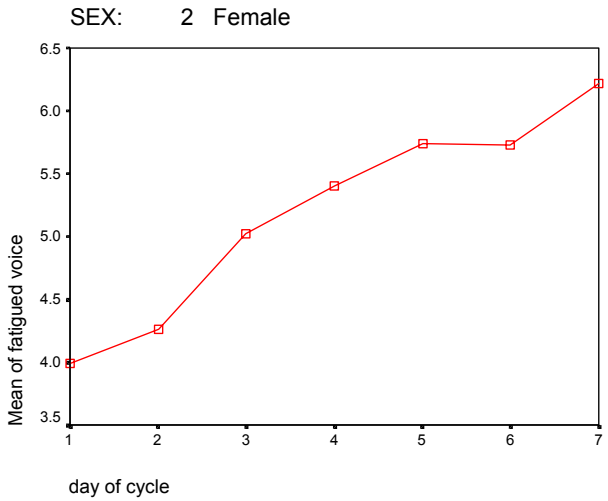


3.4.2 Trend for voice quality to improve over first 1-7 days of cycle in females

One-way ANOVA was used to generate a polynomial term to measure whether there was a linear trend for the voice quality parameters to improve over the first 7 days of the cycle for both males and females. The plots for females only over these days are shown in Appendix 10.

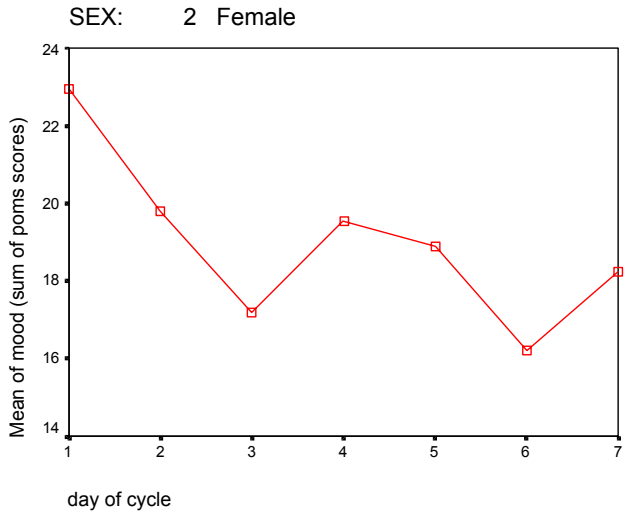
In males, there was a significant trend for fatigued voice to improve (P=0.01). In females, there was a significant trend for fatigued voice (P=0.004), effort (P=0.045), support (P=0.047), control (P=0.04) and sluggishness (P=0.02) to improve and a marginally significant trend for peak form (P=0.07) to improve. The means plot for 'fatigued voice' is shown in Figure 3.

Figure 3: Mean fatigued voice score from day 1-7 in females



Although mood improved somewhat in both males and females over days 1-7 as shown by reduced mood scores in both genders, the trend was not statistically significant (P=0.57 in males and P=0.1 in females). The plot for females is shown in Figure 4.

Figure 4: Mean total mood score over days 1-7 in females



3.4.3 Perceived voice quality by cycle

The mean values for voice quality for the first phase of the cycle (days 24-4) and the remainder of the cycle (days 5-23) are shown in Figure 5 for females and in Figure 6 for males. The figure for females indicates a tendency for all measurements to be approximately one point lower on average during days 24-4 of the cycle whereas for males mean values tend to be more alike during the two phases except for peak form. There were slightly larger differences between cycle phases for all voice parameters increasing during days 5-23 for females but not for males. Repeated measures analysis of variance showed a significant difference between voice scores ($P<0.001$) with a voice by gender interaction ($P=0.007$) but the differences between cycle phases was not significant ($P=0.13$).

Figure 5: Mean unadjusted voice quality in females during days 24-4 and days 5-23

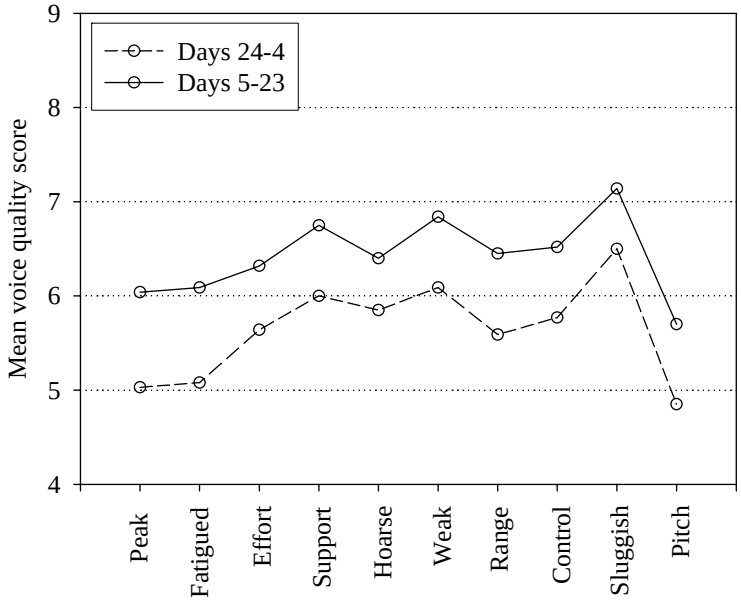


Figure 6: Mean unadjusted voice quality in males during days 24-4 and days 5-23

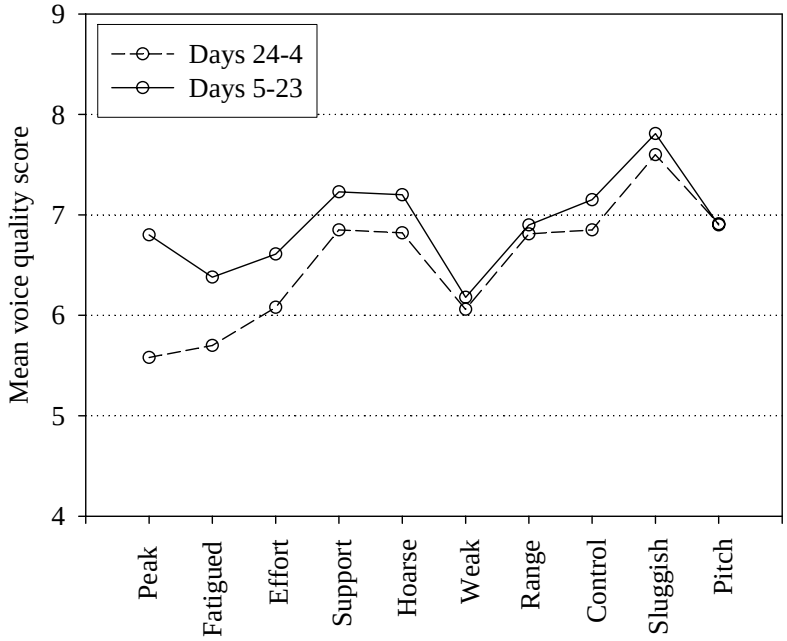


Figure 7 shows the mean score for mood and indicates that females had slightly lower mood during days 24-4 than for days 5-23, while for males there was no differences between the two phases.

Figure 7: Mean mood score by day in males and females

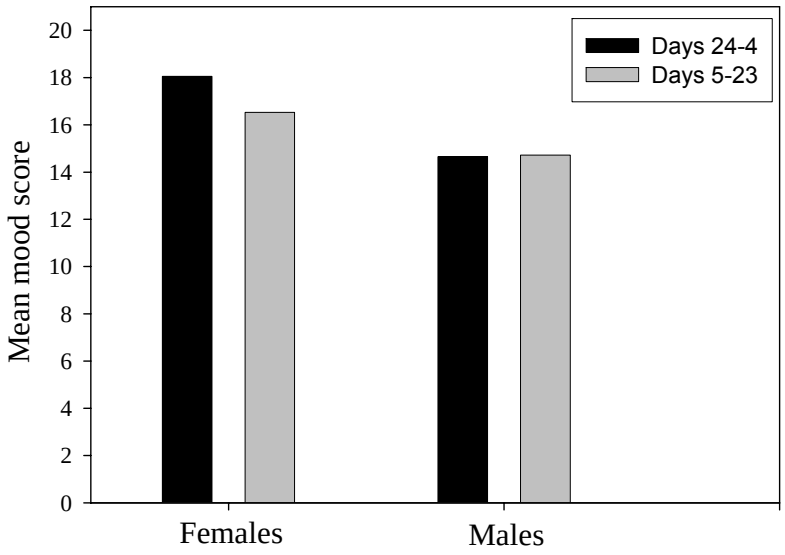


Table 3 shows the mean values of the voice quality and mood for selected days over the cycle in males and females. Females tended to score lower on all voice quality measurements, especially on days 1 and 4. For mood, female scores were on average 5-6 points higher than males on days 1 and 4 but similar on days 14 and 23.

Table 3: Mean values with standard deviations shown in brackets for voice quality measurements and mood on day 1, day 4, days 12-15 and day 23 of the cycle. *In the column for days 12-15, the highest mean value over the four days is shown, usually day 14 as shown in Table 5.

		Day 1	Day 4	Days 12-15*	Day 23
Peak form	**Females**	4.1 (2.5)	5.2 (2.6)	6.1 (2.9)	5.7 (2.4)
	Males	5.8 (1.8)	6.7 (1.7)	7.0 (1.4)	6.7 (1.0)
Fatigued	**Females**	4.1 (2.6)	5.2 (3.2)	6.9 (2.8)	6.7 (3.0)
	Males	4.4 (2.6)	6.1 (2.4)	7.3 (2.8)	6.8 (1.9)
Effort	**Females**	4.1 (2.8)	5.4 (3.0)	6.9 (2.6)	6.2 (2.8)
	Males	4.9 (2.6)	6.7 (2.6)	6.7 (2.0)	4.9 (2.4)
Support	**Females**	3.9 (2.8)	5.7 (3.1)	6.8 (2.4)	6.4 (3.2)
	Males	4.2 (3.4)	6.1 (2.5)	6.5 (3.4)	6.3 (2.1)
Hoarse	**Females**	5.3 (3.1)	5.8 (3.2)	7.5 (2.1)	7.3 (2.9)
	Males	7.7 (1.3)	7.0 (2.9)	7.6 (2.9)	7.3 (2.0)
Weak	**Females**	5.2 (3.1)	5.9 (3.2)	7.0 (2.9)	6.2 (3.2)
	Males	6.5 (2.5)	7.5 (1.5)	8.0 (1.4)	6.7 (2.1)
Range	**Females**	4.9 (3.5)	5.8 (3.8)	7.6 (2.1)	7.1 (3.1)
	Males	6.3 (3.4)	5.4 (2.2)	6.1 (3.7)	6.3 (3.2)
Control	**Females**	4.5 (3.2)	5.8 (3.4)	7.2 (2.9)	5.6 (3.6)
	Males	5.9 (2.5)	6.5 (2.8)	6.6 (3.2)	6.7 (2.8)
Sluggish	**Females**	4.6 (3.3)	6.2 (3.0)	7.1 (2.9)	5.7 (3.2)
	Males	6.2 (3.0)	6.6 (3.0)	7.3 (2.8)	7.1 (2.3)
Pitch	**Females**	6.3 (3.2)	6.7 (2.9)	7.1 (2.9)	6.6 (3.5)
	Males	7.2 (2.5)	7.7 (2.1)	7.6 (3.6)	8.3 (2.3)
Mood	**Females**	22.0 (12.7)	19.1 (9.7)	13.5 (7.2)	16.9 (8.9)
	Males	14.2 (7.9)	12.7 (5.4)	12.3 (5.9)	16.3 (7.2)

3.4.4 Gender and cycle effects on voice quality and mood

Table 4 shows the effects of gender and cycle (days 24-4 compared to day 5-23) on voice quality and mood as estimated using mixed model analyses. The mean scores for males tended to be higher than for females for all variables except range and mood, and the standard errors were also higher in males indicating a wider range used on each scale. There was a significant difference in peak form between males and females ($P<0.0001$) and a marginally significant difference in weak voice ($P=0.07$) and sluggish voice ($P=0.07$), with males scoring higher on all measurements. The difference in mood with males scoring lower than females did not reach statistical significance at $P=0.09$.

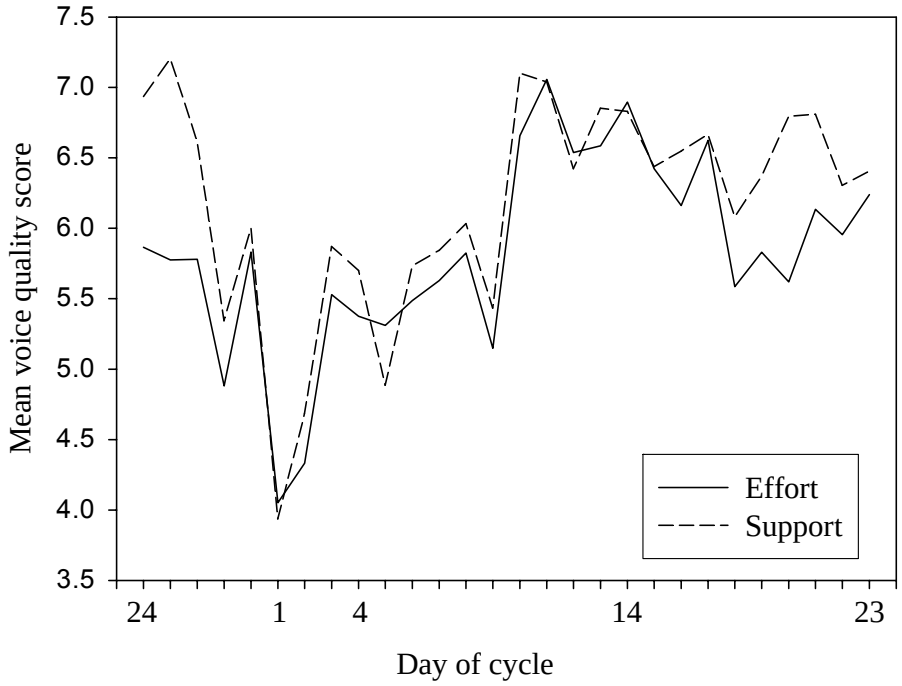
The estimated marginal mean values for cycle after adjusting for a gender influence are also shown in Table 4. The mean scores for voice quality tended to be lower as indicated by the negative values for mean difference, and mood tended to be higher as indicated by a positive mean difference in cycle days 24-4, when compared with cycle days 5-23. There was a statistically significant difference for fatigued voice ($P=0.004$) and effort ($P=0.03$).

Table 4: Marginal mean values for voice quality and mood in males and females and for days 24-4 and days 5-23 of cycle estimated from mixed linear models for voice quality and mood measurements.

Voice quality measure	Gender effect				Cycle effect			
	Males	Females			Days 24-4	Days 5-23		
	Mean (SE)	Mean (SE)	Difference (95% CI)	P value	Mean (SE)	Mean(SE)	Difference (95% CI)	P value
Peak form	6.8 (0.3)	5.4 (0.2)	1.4 (0.7,2.1)	<0.0001	5.9 (0.2)	6.3 (0.2)	-0.3 (-0.8,0.2)	0.20
Fatigued	6.2 (0.4)	5.6 (0.2)	0.6 (-0.2,1.4)	0.15	5.5 (0.3)	6.4 (0.2)	-0.9 (-1.4,-0.3)	0.004
Effort	6.1 (0.4)	5.7 (0.2)	0.4 (-0.4,1.2)	0.34	5.6 (0.3)	6.2 (0.2)	-0.6 (-1.2,-0.1)	0.03
Support	6.3 (0.4)	6.1 (0.2)	0.2 (-0.7,1.2)	0.62	6.2 (0.3)	6.2 (0.2)	-0.1 (-0.7,0.5)	0.83
Hoarse	7.1 (0.4)	6.5 (0.2)	0.6 (-0.3,1.5)	0.21	6.6 (0.3)	7.0 (0.3)	-0.3 (-0.9,0.2)	0.26
Weak	7.0 (0.4)	6.2 (0.2)	0.8 (-0.1,1.6)	0.07	6.6 (0.3)	6.7 (0.2)	-0.1 (-0.7,0.5)	0.74
Range	6.1 (0.4)	6.5 (0.2)	-0.4 (-1.3,0.5)	0.34	6.2 (0.3)	6.4 (0.3)	-0.3 (-0.9,0.3)	0.38
Control	6.8 (0.4)	6.1 (0.2)	0.7 (-0.2,1.5)	0.13	6.3 (0.3)	6.6 (0.2)	-0.3 (-0.9,0.3)	0.25
Sluggish	7.0 (0.4)	6.2 (0.2)	0.8 (-0.1,1.6)	0.07	6.4 (0.3)	6.7 (0.2)	-0.3 (-0.9,0.3)	0.34
Flat	7.6 (0.4)	7.0 (0.2)	0.7 (-0.3,1.7)	0.17	7.3 (0.3)	7.3 (0.3)	-0.1 (-0.7,0.5)	0.85
Mood	14.9 (1.0)	16.9 (0.6)	-2.0 (-4.3,0.3)	0.09	16.6 (0.8)	15.3 (0.7)	1.3 (-0.5,3.0)	0.16

Mean voice quality scores by day for effort and support are shown in Figure 8. For both measurements, the lowest point occurs at day 1, and there is a trend for voice quality to improve over the next few days followed by a peak at days 12-14.

Figure 8: Relation between effort and support and day of cycle in females



The F values and P values for the repeated measures deviation contrasts are shown in Table 5. Mean values for voice quality measurements were lower on day 1 of the cycle for females with significant differences for all measurements except hoarse or weak voice, range and flat voice. In addition, the mean mood score was higher (i.e. worse) on day 1 (P=0.05). In addition, mean values for all voice quality measurements except support were significantly higher in the centre of the cycle, usually at day 14 but at day 12 for hoarse or flat voice and at day 15 for range. Mean mood score was significantly lower (i.e. better) at day 12 (P=0.001). Day 1 was the lowest point in the cycle and therefore the trend from days 1 was tested. Table 5 also shows the trend test over days 1-4 for both males and

females. There was a significant trend for voice quality measurements to improve over days 1-4 in females for peak form, effort, support and sluggish but there were no trends for voice quality to improve over these days in males.

Table 5: F and P value statistics from general linear repeated measures models to identify lowest and highest days of cycle in females only and for trends over days 1-4 of cycle in both males and females

Voice quality	Day 1* Females		Days 12-15* Females			Days 1-4 trend** Females		Days 1-4 trend** Males	
	F value	P value	Day	F value	P value	F value	P value	F value	P value
Peak form	4.7	0.06	14	6.8	0.03	5.2	0.03	3.9	0.11
Fatigued	7.5	0.02	14	25.5	0.001	2.0	0.17	3.9	0.11
Effort	9.7	0.01	14	12.7	0.01	4.4	0.05	0.3	0.64
Support	19.7	0.001	14	2.5	0.15	4.5	0.05	2.2	0.20
Hoarse	2.5	0.15	12	11.7	0.01	1.2	0.29	0.1	0.75
Weak	1.7	0.23	14	8.3	0.02	1.6	0.22	1.6	0.30
Range	2.4	0.15	15	6.1	0.03	1.1	0.30	0.7	0.43
Control	4.2	0.07	14	6.0	0.04	1.7	0.21	0.1	0.83
Sluggish	8.0	0.02	14	6.7	0.03	5.1	0.04	0.1	0.88
Flat	1.6	0.23	12	9.4	0.01	0.1	0.72	0.4	0.56
Mood	4.9	0.05	12	16.7	0.001	1.9	0.18	0.3	0.64

* Deviation contrast with remainder of cycle
** Polynomial linear contrast

3.4.5 Effect of contraceptive pill

Table 6 shows the effects of taking a contraceptive pill and cycle in females. The negative mean differences for all voice quality measurements except peak form indicate that singers who were not taking a contraceptive pill tended to rate lower on the voice quality scores. They also rated almost two points higher on mood. The difference in mean values was significant for hoarse voice (P=0.003) and marginally significant for fatigued (P=0.07). The table also shows the estimated mean values for cycle in females only after adjusting for the influence of contraceptive pill use. After adjusting for the effect of taking a contraceptive pill, the mean values for all voice measurements again tended to be lower and mood tended to be worse in cycle days 24-4 than in days 5-23 with significant differences for fatigued voice (P=0.02) and a marginally significant difference for effort (P=0.06) and mood (P=0.07).

Table 6: Marginal mean values for voice quality measurements and mood by contraceptive pill use and days 24-4 or days 5-23 of cycle estimated from mixed linear models for each measurement in females only.

Voice	Contraceptive pill effect				Cycle effect			
Quality	No	Yes			Days 24-4	Days 5-23		
Measure	Mean (SE)	Mean (SE)	Difference (95% CI)	P value	Mean (SE)	Mean(SE)	Difference (95% CI)	P value
Peak form	5.5 (0.3)	5.2 (0.3)	0.3 (-0.4,1.1)	0.37	5.1 (0.3)	5.6 (0.2)	-0.4 (-1.0,0.1)	0.14
Fatigued	5.3 (0.3)	6.1 (0.3)	-0.8 (-1.6,0.1)	0.07	5.3 (0.3)	6.1 (0.2)	-0.8 (-1.5,-0.1)	0.02
Effort	5.5 (0.3)	6.0 (0.3)	-0.5 (-1.3,0.3)	0.20	5.4 (0.3)	6.0 (0.2)	-0.6 (-1.3,0.1)	0.06
Support	5.9 (0.3)	6.3 (0.3)	-0.5 (-1.3,0.7)	0.49	6.1 (0.3)	6.1 (0.3)	0.1 (-0.7,0.7)	0.98
Hoarse	5.9 (0.3)	7.3 (0.3)	-1.3 (-2.2,-0.5)	0.003	6.4 (0.3)	6.8 (0.2)	-0.4 (-1.0,0.3)	0.24
Weak	6.1 (0.3)	6.5 (0.3)	-0.4 (-1.2,0.4)	0.31	6.2 (0.3)	6.4 (0.2)	-0.2 (-0.9,0.5)	0.57
Range	6.2 (0.3)	6.9 (0.3)	-0.8 (-1.6,0.1)	0.10	6.4 (0.3)	6.7 (0.2)	-0.4 (-1.1,0.3)	0.28
Control	5.8 (0.3)	6.4 (0.3)	-0.6 (-1.5,0.2)	0.15	5.9 (0.3)	6.3 (0.2)	-0.4 (-1.1,0.3)	0.24
Sluggish	6.1 (0.3)	6.2 (0.3)	-0.1 (-0.9,0.7)	0.85	6.0 (0.3)	6.4 (0.2)	-0.4 (-1.0,0.3)	0.30
Flat	6.8 (0.3)	7.1 (0.3)	-0.3 (-1.2,0.6)	0.49	7.0 (0.3)	7.0 (0.3)	-0.1 (-0.7,0.7)	0.87
Mood	17.8 (0.7)	16.0 (0.8)	1.8 (-0.4,4.0)	0.10	17.8 (0.9)	15.9 (0.6)	1.9 (-0.1,3.9)	0.07

3.4.6 Relation between voice quality and mood

All significant correlations are negative indicating reduced voice quality with more negative mood experiences. The correlations with total mood score are more consistent with most voice quality measurements related or marginally related to mood on days 1, 3 and 18 with some correlations remaining over the other days.

Total mood score is more normally distributed than the individual scores and therefore parametric correlation coefficients and regression are appropriate. The plots of each sing variable for day 1 against the total mood score for females are shown in Appendix 9. Each figure in the appendix shows the scatter plot, the regression equation and the R square value. The plot for 'Voice feeling sluggish' is shown in Figure 9 below – the R square value of 0.45 indicates that 45% of the variation in voice feeling sluggish is explained by mood. The amount of variation explained by mood in the other voice quality parameters was as follows: peak 20%, fatigue 17%, effort 7%, support 25%, hoarse 20%, weak 22%, range 22%, control 24% and pitch 34%.

Figure 9: Relation between feeling the voice is sluggish and total mood score

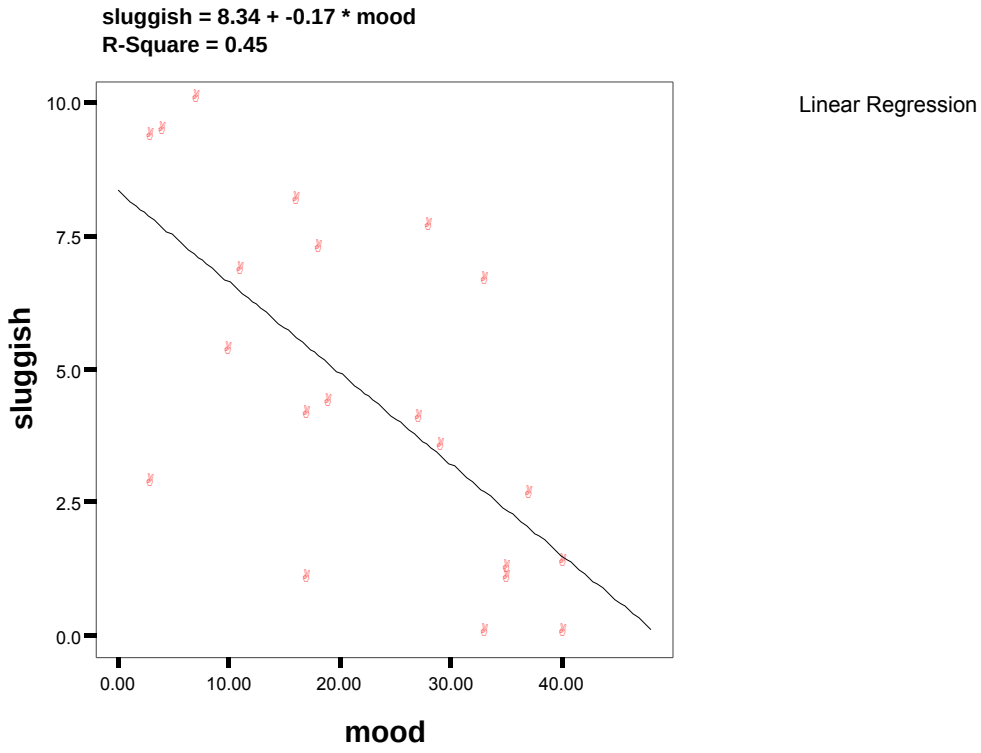


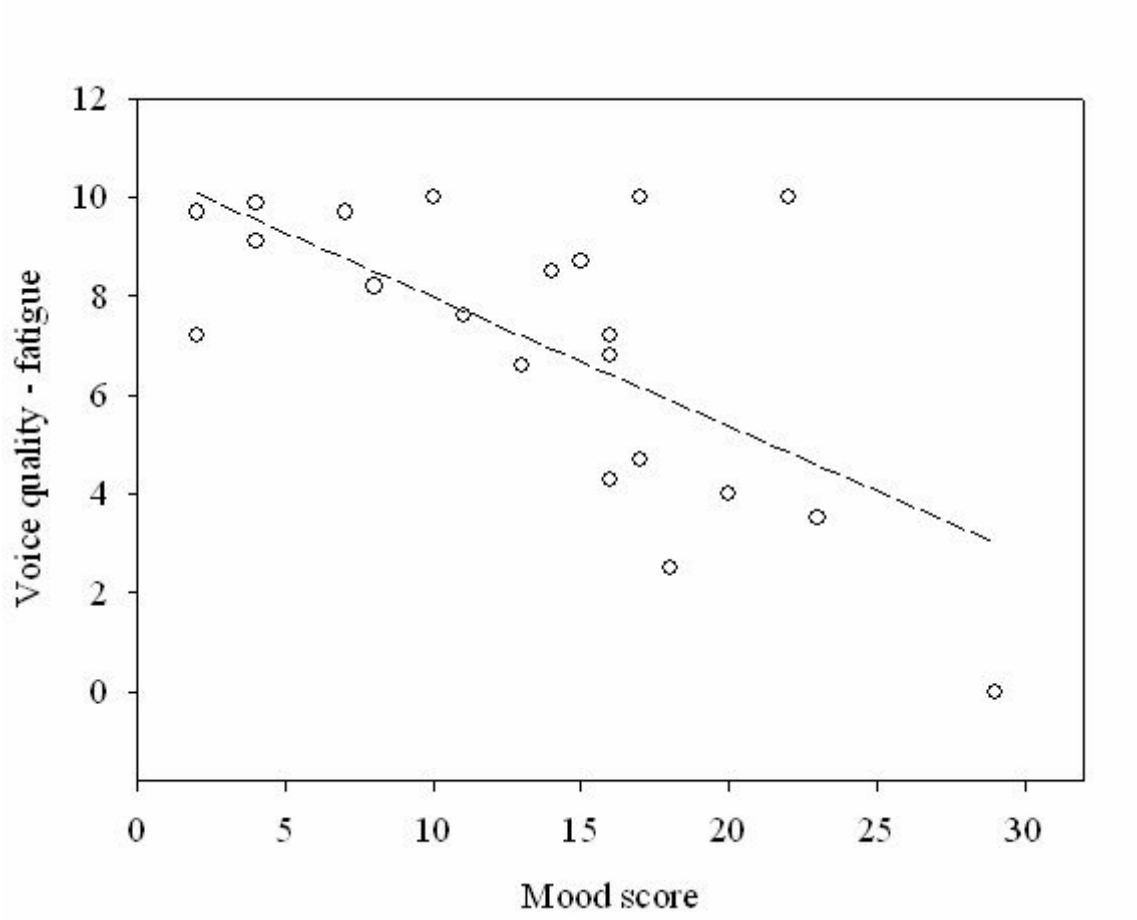
Table 7 shows that there was a negative correlation between voice quality and mood for all measurements on days 1, 4, 14 and 23 indicating poor mood with reduced voice quality. Correlations greater than 0.43, which indicate that approximately 40% of the variation in mood was explained by voice quality, were statistically significant. Most of the significant associations occurred on days 1 and 14.

Table 7: Correlation between voice quality measurements and mood on days 1, 4, 14 and 23 in female singers. The table shows Pearson's r-value with the P value in brackets

	Day 1	Day 4	Day 14	Day 23
Peak form	-0.45 (0.04)	-0.28 (0.22)	-0.43 (0.05)	-0.20 (0.41)
Fatigued voice	-0.41 (0.07)	-0.28 (0.21)	-0.53 (0.01)	-0.47 (0.04)
Effort	-0.27 (0.24)	-0.51 (0.02)	-0.42 (0.06)	-0.29 (0.22)
Support	-0.50 (0.02)	-0.24 (0.29	-0.37 (0.10)	-0.14 (0.55)
Hoarse	-0.45 (0.04)	-0.39 (0.08)	-0.49 (0.02)	-0.37 (0.11)
Weak	-0.47 (0.03)	-0.29 (0.21)	-0.51 (0.02)	-0.32 (0.16)
Range	-0.33 (0.14)	-0.34 (0.14)	-0.33 (0.15)	-0.24 (0.31)
Control	-0.49 (0.03)	-0.48 (0.03)	-0.50 (0.02)	-0.33 (0.16)
Sluggish	-0.67 (0.001)	-0.40 (0.07)	-0.49 (0.03)	-0.23 (0.33)
Pitch	-0.58 (0.01)	-0.20 (0.38)	-0.66 (0.001)	-0.19 (0.41)

The negative association between fatigue and mood at day 14 in females is shown in Figure 10 with voice quality decreasing as mood score increases, i.e. mood deteriorates.

Figure 10: Association between fatigue and total mood score in females at day 14



3.4.7 Relation between voice quality and feelings

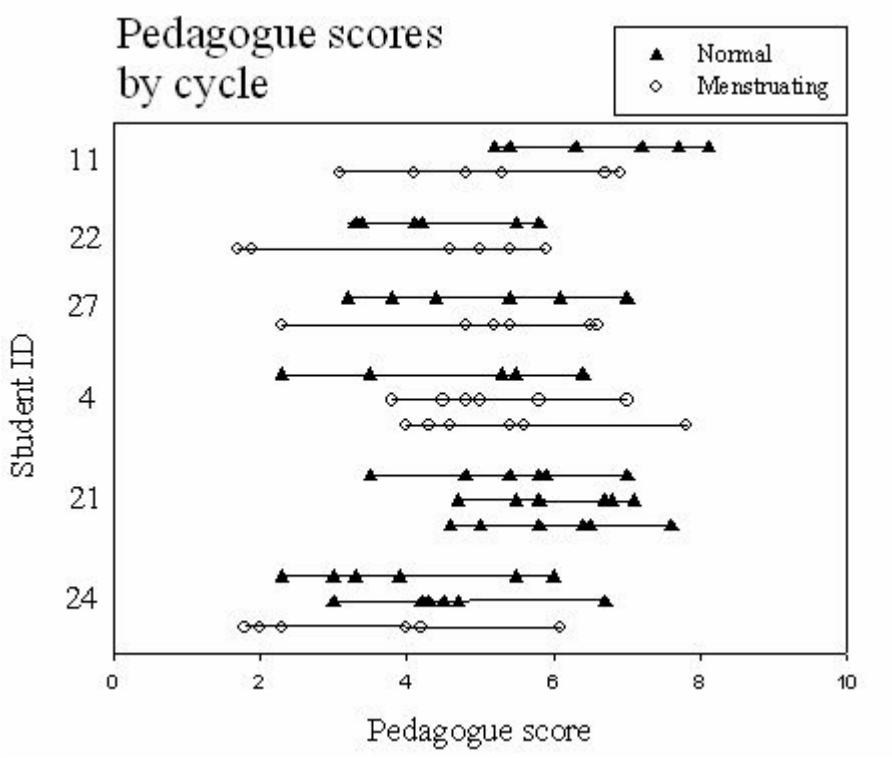
Non-parametric Kendall correlations were used to measure the relation between daily feelings (VAS scores) and voice quality in females on Days, 1, 3, 7, 14 and 18 of the cycle as shown in Appendix 6. In each table, only the singers with complete data for the day are included. To increase the validity of comparing correlations over the cycle, the analyses were undertaken up to day 18 to include the one singer who only completed 18 cycle days.

In general, there were some correlations between voice quality parameters and VAS scores each day. For some correlations, there are marginal P values of 0.05-0.1 when the correlation (r-value) is moderate at above 0.30. However, some associations, for example with cravings and headaches, were in the direction opposite to expected, that is voice quality improved as daily feelings decreased. This occurred when most singers recorded zero for the VAS scores and the correlation was therefore significantly influenced by the few singers with a non-zero rating.

3.4.8 Perceptual analysis of six female singers

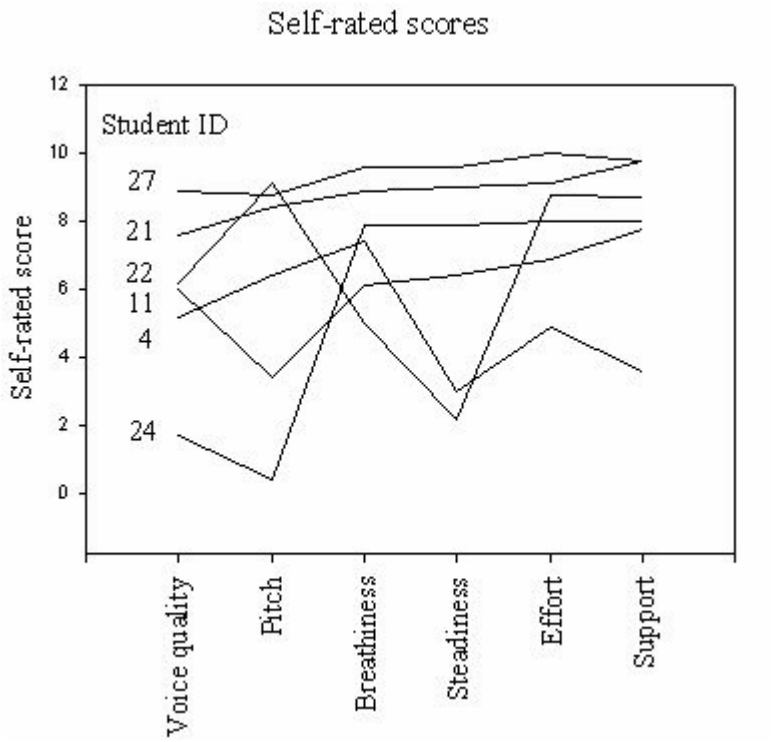
Figure 11 shows the pedagogue scores for each student during normal or menstruating phases. Variations in pedagogue scores were wide with the smallest range of 4.7-7.1 for singer ID 21 and the largest range of 1.7-5.9 for singer ID 22. There was no consistent change in direction of scores during menstruating and non-menstruating phases with scores tending to decrease for four singers and increase for one singer. For the singer who provided data only during the non-menstruating phase, the scores were equally variable.

Figure 11: Pedagogue scores for each student



Five of the six singers who were selected on the basis of the worst self-reported vocal symptoms during menstruation correctly identified their performance during menstruation when presented blind with both their recordings (one during menstruation and one not). Figure 12, below, shows the self-rated scores for each singer. Two singers (ID 21 and 27) rated themselves consistently and highly but for the other four singers the ratings across voice quality were inconsistent and variable.

Figure 12: Self-rated scores for each singer



Perceptual analysis of six female singers demonstrated a wide variation in pedagogue scoring during both normal and menstruating phases, with no consistent change. However, the students, who were selected based on the worst self-reported vocal symptoms during menstruation, correctly identified their performance during menstruation when presented blind with both their recordings.

3.4.9 Measurement of agreement

Mood and voice quality variables for the 19 singers who completed both phase I and phase II were compared. The difference for each day in phase I and II and the mean of the phase I and phase II measurements for the same day were computed and then plotted to assess agreement.

The mean-vs-differences plots for total mood score and the voice quality parameters to measure agreement between two cycles are shown in Appendix 12.

For all variables, the R square value and the mean and the intercept of the regression through the plot is close to zero indicating no systematic bias for the same days during two consecutive cycles. However, the scatter is not clustered around the zero line of no difference indicating wide variation in scores between the same day over two cycles. For mood, the plot widens as mood scores increase indicating less agreement at higher mood scores than at lower mood scores.

CHAPTER 4

DISCUSSION

This study is of considerable importance to the singing community, representing a detailed longitudinal study of the effects of the fluctuations of hormones over the menstrual cycle on the female classical singing voice. Singing is a demanding profession, requiring all body systems to function optimally. Singers are generally described as vocal athletes whose career and livelihood depends on the optimal functioning of their instrument (i.e. the whole body). This study makes a unique contribution to the management and pedagogy of female singers in the western classical tradition. Specifically designed for advanced singers, it represents one of only a very few studies that used technically challenging musical tasks and repeated measures longitudinal design to investigate the research questions of interest..

This study examined the effect of the menstrual cycle on the western female classical singing voice. Participants were singing students studying at the Sydney Conservatorium of Music, The University of Sydney. Twenty-one young western female students and six young male singing students kept diaries of their perceived vocal quality and mood state every day for one month (male) or two months (female). Results indicated that some singers were not affected during their cycle, while others reported a range of problems from mild to severe symptoms and perceived reductions in their vocal quality particularly during the first seven days of the cycle. The six females who reported being most severely affected by their hormone cycle were asked to record specific vocal tasks at specific times in the menstrual cycle, firstly during day 1 of the menstrual cycle and again at mid-cycle,

between days 10-14. Both expert vocal pedagogues and the six selected singers completed perceptual assessments. While five of the six singers correctly identified their song sample made during menstruation, expert listeners were unable to reliably identify the 'menstrual' sample.

Although male singers were included in the study as a control group to ascertain to what extent mood and vocal quality fluctuated from day to day without the influence of the female hormones, we were surprised to observe the degree to which the male singers fluctuated over the 28 days of their diary recordings. These fluctuations were less pronounced than for the females and showed no recognisable points of reference to calendar days. Personal communications with Professor Alfred Steinbeck MD BS (Syd) PhD (Lond) FRCP (Lond) FRACP, Specialist Endocrinologist, University of New South Wales, Sydney, and Clinical Associate Professor Katharine Steinbeck MB BS PhD FRACP, Staff Specialist in Endocrinology and Adolescent Medicine, Royal Prince Alfred Hospital, Sydney, confirmed that cyclical changes in males are known to occur on a diurnal basis (24-hourly) with hormone levels highest in the morning and falling towards midnight. A study by Ankarberg and Norjavaara (1999) in healthy girls before and during puberty, up to two years post-menarche, demonstrated that the same diurnal variation of testosterone occurs in females. Apparently, studies attempting to show that males have cyclical changes in a broader sense (monthly) similar to the female cycle have been unsuccessful previously and neither professor knew of any current research that demonstrated such a cycle.

Women are known to suffer from premenstrual symptomatology to varying degrees as ascertained from a large body of literature (Abitbol, de Brux, Millot, Masson, Mimoun,

Pau & Abitbol, 1989). A diagnosis of premenstrual syndrome is only established if symptoms resolve for at least those days between the end of the menstrual period and ovulation, i.e. approximately days seven to fourteen of the cycle. Nader (1991) separated significant individual cyclical variation of symptomatology surrounding the menstrual cycle, with premenstrual symptoms varying from mild to severe. About 30-40% women experience some form of pre-menstrual symptoms, and 10% of women experience severe symptoms. Nader (1991) classified the signs and symptoms of the syndrome into somatic (body states), affective (mood states), pain and behavioural states and other symptoms, such as food cravings, insomnia and fatigue. The participants recorded a daily diary related to the menstrual cycle, with physical symptoms based on those most commonly described in the literature (Nader, 1991; Wicklund, 1966).

4.1 Body states

The females were asked to record whether they were using hormonal contraception and other symptoms such as inter-current illness, unrelated physical symptoms, e.g. body pain, and alcohol intake were also recorded, as such factors could influence voice production and quality.

The effects of the cycle were assessed in a number of ways. We were interested in the variations over the first seven days of the cycle, assessed from the first day of bleeding. A second set of analyses comparing two parts of the cycle were also undertaken. The cycle was divided into the premenstrual and menstrual phase (days 24–4) when symptoms tend to be at their maximum and these days were compared to the remainder of the cycle (days 5–23).

In female participants, the degree of severity of symptoms varied widely, in agreement with Sommer (1978), and was not always consistent between the two cycles recorded by the same participant. After adjusting for the effect of taking a contraceptive pill, the mean values for all voice measurements again tended to be lower and mood tended to be worse (higher mood scores) in cycle days 24-4 than in days 5-23, with significant differences for fatigued voice and a marginally significant difference for effort and mood.

The effect of the contraceptive pill on the female cycle showed that those taking the medication rated their voice quality higher than those without medication, but their mood was lower than those not on the pill. This supports the research by Ledger and Davidson (in Comins, 2002) that the contraceptive pill has a stabilising effect on the voice and benefits female singers. In contrast to the perceived improvement in voice quality through the stable supply of extrinsic hormones to the body, there also appears to be more depression of mood because of the pill. Female singers report reluctance to use the contraceptive pill because of perceived changes that medication may have on their instrument, although there has been no scientific evidence to support this (Comins, 2002).

Despite the observation by Boulet and Oddens (1996) that combined oral contraception (oestrogen & progesterone) has a negative effect in only 5% of women, the use of various combinations of oral contraception in western classical female singers remains a large untapped source of further study. More recently, Amir et al (2003 & 2004) demonstrated that low-dose monophasic contraceptive pill does not show an adverse effect on the voice, while their 2003 study suggested that voice stability is associated with the smaller hormonal fluctuations induced by the contraceptive pill. However, singers who were not taking a contraceptive pill tended to rate lower on all voice quality scores, except peak

form, but they also rated almost two points higher on mood on cycle days 24-4. This result demonstrated that there is a negative association between vocal fatigue and mood, with voice quality (fatigue) decreasing as mood deteriorates.

With regard to the effort required to produce the voice and physical support of the voice measured against vocal quality, data showed that after a distinct low at day 1, voice quality improved to a peak at days 12-14 and was maintained almost through to the next premenstrual phase. Data also supported the anecdotal evidence from singers that their support and effort reduces the mean voice quality through the cycle days, i.e. their voice is not functioning as well initially, but tends to improve through the remainder of the cycle. These observations substantiate female subjective reports that they feel at their worst on or around the first day of the menses.

The variation in reaction to premenstrual symptoms is due in part to the fluctuations of oestrogen and progesterone concentrations during the menstrual cycle resulting in variable symptoms and, in part, by the way in which individuals cope psychologically with the physiological changes at that time of month. However, not all women experience the premenstrual syndrome, and when evident it is highly variable in symptomatology (Chae et al, 2001). Some singers are affected by the changes and some are not (Isenberger, Brown & Rothman, 1985). Some women manifest the effects more obviously in relation to the fine motor tasks that they require to maintain their reputation, notably singers in major opera houses and concert performers in recital and oratorio. These findings may also be applied to other fields of vocal endeavour, such as music theatre and contemporary vocalists.

4.2 Voice states

Voice quality is integral to a successful career in the professional singer and Rubin (2001) stated that nothing is static about the larynx or the vocal tract. With respect to singers, "laryngopathia premenstrualis" is caused by physiological, anatomical and psychological alterations because of endocrine changes (Sataloff et al, 1993). Premenstrual symptoms have been described in the literature for over forty years (Smith-Frable, 1962) and studied in various ways with diverse groups of people (Amir & Biron-Shental, 2004). Scientific confirmation of the aetiology has been debated (Davis & Davis, 1993; Nader, 1991). Abitbol et al (in Emerich et al, 1996) state that menstruation affects voice through changes in oestrogen levels throughout the cycle, which cause laryngeal water retention, oedema of interstitial tissues and venous dilatation.

Abramson et al (in Emerich et al, 1996) state that altered metabolic activity by oestrogen sensitive cells could have an effect on the quality of the voice, since vocal fold hormonal receptor sites are sensitive to oestrogen, progesterone and thyroid hormone. More recently these hormone receptors have been demonstrated in the human vocal folds (Altman et al, 2003) (Newman et al, 2000) and should lead to more defined clinical reasons for the variations of the singing voice. Through the various physiological feed back pathways and the neuro-endocrine system, mood and body states of the singer will influence the level of hormone production, in turn triggering the receptor sites in the vocal folds.

While some cyclical variation was observed in both sexes, the results for the male singers were more random than those observed in females. There was a trend for the voice quality parameters to improve over the first seven days of the cycle for both males and females,

showing a similar pattern of improvement; however, the male pattern commenced on a random day 1, as opposed to the physiological day 1 in the female cycle. While this may suggest that recording symptoms in a diary format arouses the awareness of the observer to their own symptomatology, another potential source of research, it also agrees with Bradley (1980) who observed that singers are very aware of their bodies throughout performances and that this enables them to control the unwanted effects of physiological changes.

Women consistently rated their voice lower than the men, which was plotted as mean unadjusted voice quality. The males manifested virtually no difference between the two cycle phases except for peak form and fatigued voice, while the females showed some difference in the cycle phases for nearly all recorded symptoms.

The different effects of gender and cycle on voice quality and mood showed that males scored higher than females for all qualities except range and mood, while also using a greater range of scores to record their symptoms. Male singers rated peak form significantly higher than female singers while there was only a marginal difference between men and women in rating of weak voice and sluggish voice. Over the cycle, fatigued voice improved significantly in both males and females but the women also improved in their effort, support, control and sluggishness, and to a lesser extent peak form.

It was also demonstrated that there is a distinct relationship between perceived voice quality and mood. Perceived voice quality between the first phase of the cycle (days 24-4) and the remainder of the cycle (days 5-23) indicated a tendency in females for all

measurements to be lower, on average, during days 24-4 of the cycle, whereas for males mean values tend to be more alike during the two phases, except for peak form. In fact, mood had a stronger effect on the voice than the contraceptive pill, an interesting and somewhat unexpected finding.

Results supported the hypothesis that the voice is perceived to be affected by the menstrual cycle and its inherent physiological changes. However, the effects were no uniform across all singers, a finding also observed by Brown et al (1985), who used trained singers, some of whom were taking the contraceptive pill. Their assessment included singing tasks such as chromatic scales and phrases where the voices revealed the most difficulty in phonation.

4.3 Mood states

This research demonstrated that there was wide variation in scores of mood and voice quality between the same days over two cycles. Mood varied more obviously than voice quality, with worse moods (higher scores) showing greater variation in vocal quality. Mood improved somewhat in both males and females over days 1-7 as shown by reduced mood scores in both genders, although the trend was not statistically significant. The overall mood score was not significantly different between males and females, although males consistently rated their mood as better than females.

In females, most ratings tended to be slightly lower on days 1-3 than for the remainder of the cycle and for some ratings there was a trend for values to rise through days 1-7. Poor mood was directly associated with perceived reduced voice quality for all days throughout the cycle and was significantly greater on days 1 and 14. Similarly, there was a negative

association between fatigue and mood at day 14, the peak in hormone secretion around ovulation. The effect of the menses, withdrawal of hormones, is well documented; however, the mid-cycle peak of hormones also apparently affects the voice detrimentally in association with body and mood states; another potential source of further research.

However, singers' awareness of vocal distress and low mood is not necessarily transmitted to their audience. Consequently, singers' education should include information that their perceptions regarding their vocal quality may not adversely affect perceptual quality.

4.4 Temperature

Temperature chart recordings throughout the two cycles showed that there was no apparent relationship between temperature and day of cycle in this study. There was a wide variation in temperature in the females involved in the study with some showing marked fluctuations, while others recorded virtually no change. Physiology texts such as Rhoades and Pflanzer (1992) state that after ovulation body temperature quickly rises approximately 1^0C and remains at this normal level until the onset of the next cycle. However, the same text states that the magnitude of the oscillations in body temperature associated with the menstrual cycle varies with the individual and that ovulation can occur in the absence of a detectable change in body temperature.

There is potential for measurement error in students unused to taking and recording their temperatures for experimental purposes.. However, each singer was provided with a high quality, digitally recording thermometer, so the more likely explanation for the lack of association between temperature and day of cycle is that the measures of central tendency

that were used to assess this association may have obscured particular associations within individuals between these two factors.

These explanations notwithstanding, the findings are generally at odds with the use of temperature charting in clinical medicine (such as used by the Family Planning Association clinics in Australia), which is used to help ascertain the date of ovulation. This study demonstrated approximately equal numbers of participants who recorded a temperature rise and those that did not record any rise. Similarly, females taking oral contraception recorded temperature quite variably in this study, considering that the effect of a consistent dose of ingested oestrogen would tend to reduce the potential temperature rise that is associated with the oestrogen peak of the mid-cycle. Of those most affected by their cyclical symptoms, four were not taking the pill and two were using oral contraception, yet only one in each subgroup recorded an obvious temperature rise. Future research will document more precisely the hormone content of the pill taken and how the various groups of hormones may effect the menstrual cycle, including temperature changes.

4.5 Singer analysis

Five of the six singers who were selected on the basis of the worst self-reported vocal symptoms during menstruation correctly identified their performance during menstruation when presented blind with both their recordings (one on the first day of menstruation and one at approximately mid-cycle). Analysis of their diary data also showed that there was a wide variation during both normal and menstruating phases, but with no consistent changes observed.

Lacina (in Chae et al, 2001) reported that many female singers had difficulty with intricate phonation control before each menstruation. Lacina also reported (1968) that the changes to the voice appear proportional to the presenting severity of the premenstrual symptoms, with which this research is in agreement. Sataloff (2002) also stated that singers are trained to discern subtle differences in the supernormal to near-perfect range in which the professional performer's body must operate.

4.6 Pedagogue analysis

Perceptual analysis of the six female singers demonstrated a wide variation in perceptual ratings and there was no consistent change in direction of those scores during menstruating and non-menstruating phases. Essentially, the pedagogues were unable to distinguish clearly between the two phases of the cycle.. No comparative data was noted in the literature reviewed, and the perceptual effect on independent, blinded listeners is a fruitful area of new research in singing.

4.7 Future directions

There were some limitations of the research, as multiple observations had to be made on many days, involving data collection over two non-contiguous months. Twice daily input of information (discipline) required dedication of all the participants, which can both contribute to observer error / bias and potential 'fudging' of results, i.e. using the same observations to fill in the second results for the day. .

Blood samples would no doubt give more accurate indications of actual hormonal fluctuations during the female cycle (maybe the male cycle also) and could be used in further research. However, this is an invasive and expensive procedure, especially with the periodicity required to ascertain hormone status at different times of cycle.

Future studies could possibly include blood sampling of participants for female hormone levels (oestrogen & progesterone), as well as the potential effects of insulin or sugar levels (diabetes effect) and thyroid hormone on the voice. As far back as 1971, Brodnitz stated that 14.1% of voice disorders could be traced to some endocrine cause, whilst 15% of disorders are caused by hormone-related drugs. Currently, Lã and Davidson (2005) are undertaking a systematic investigation on the effects of a third generation oral contraceptive pill (OCP) on the female operatic singing voice at the Music Department of the University of the University of Sheffield in England.

Deeper knowledge of hormonal effects would require greater willingness / commitment of the participants and more strictly controlled studies. This would certainly add to the specific body of knowledge of singers and potentially to those who may be compromised by a medically treatable illness. In the broader sphere, this may assist all categories of voice users who rely on phonation as the medium of their profession.

CONCLUSION

This study indicated that the female hormonal cycle had a perceptual effect on the voice of the young female western classical singer for the singers who reported being affected by menstrual symptoms. Not everyone reported symptoms and there was wide variation in symptomatology. However, the results indicated that a percentage of singers were severely affected. These singers find the demands of co-ordinating their body more challenging, vocalization takes more effort and at these times singing was less aurally and artistically rewarding. However, well-recognised singing teachers generally could not identify loss of vocal quality during menses in those singers.

The study demonstrated that self-awareness by the artist is much more sensitive and critical than any perception of a highly trained observer, implying that audience satisfaction is not necessarily as difficult to achieve as self-satisfaction.

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APPENDICES

Appendix 1

Documents involving ethics, participant recruitment and feedback

The University of Sydney

1. Human Research Ethics Committee
http://www.usyd.edu.au/ethics/human
Manager:
Mrs Gail Briody
Telephone: (02) 9351 4811
(02) 9351 4474
Facsimile: (02) 9351 6706
Email: gbriody@mail.usyd.edu.au
Rooms L4.14 & L4.13 Main Quadrangle A14

1. Human Secretariat
Telephone: (02) 9036 9309
(02) 9036 9308
Facsimile: (02) 9036 9310
Email: r.todd@reschols.usyd.edu.au
m.williams@reschols.usyd.edu.au

19 August 2003

Associate Professor D Kenny
School of Behavioural & Community Health Sciences
Cumberland Campus
C42

Dear Professor Kenny

Thank you for your correspondence dated 16 July 2003 addressing comments made to you by the Committee. After considering the additional information, the Executive Sub-committee at its meeting on 14 August 2003 approved your protocol on the study below. Please note that subject to annual monitoring returns, the approved protocol is valid for five years.

Title:	***The effect of premenstrual sumptoms on vocal quality in young female professional singers***
Ref No:	***6922***
Approval Period:	***August 2003 – August 2004***
Authorised Personnel:	***Associate Professor Dianna Kenny***
	Ms Maree Ryan
	Associate Professor Pamela Davis

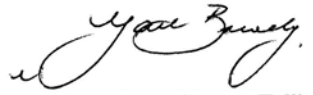
The additional information will be filed with your application.

In order to comply with the *National Statement on Ethical Conduct in Research Involving Humans,* and in line with the Human Research Ethics Committee requirements the Chief Investigator's responsibility is to ensure that:

1. The individual researcher's protocol complies with the final and Committee approved protocol.
2. Modifications to the protocol cannot proceed until such approval is obtained in writing.
3. The confidentiality and anonymity of all research subjects is maintained at all times, except as required by law.
4. All research subjects are provided with a Participant Information Sheet and Consent Form, unless otherwise agreed by the Committee.
5. The Participant Information Sheet and Consent Form are to be on University of Sydney letterhead and include the full title of the research project and telephone contacts for the researchers, unless otherwise agreed by the Committee.
6. The following statement must appear on the bottom of the Participant Information Sheet. ***Any person with concerns or complaints about the conduct of a research study can contact the Manager of Ethics Administration, University of Sydney, on (02) 9351 4811.***

7. The standard University policy concerning storage of data and tapes should be followed. While temporary storage of data or tapes at the researcher's home or an off-campus site is acceptable during the active transcription phase of the project, permanent storage should be at a secure, University controlled site for a minimum of five years.
8. A progress report should be provided by the end of each year. Failure to do so will lead to withdrawal of the approval of the research protocol and re-application to the Committee must occur before recommencing.
9. A report and a copy of any published material should be provided at the completion of the Project.

Yours sincerely



Associate Professor Stewart Kellie
Chairman, Human Research Ethics Committee

Encl.
Advertisement
Participant Information Sheet (female)
Participant Information Sheet (male)
Participant Information Sheet (pedagogue)

cc: Ms Maree Ryan, Sydney Conservatorium of Music, Bldg C41

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

A/Professor Dianna Kenny
Australian Centre for Applied Research in Music Performance

ATTENTION: SINGING STUDENTS

Singing students of the Conservatorium are invited to participate in a research study on the effects of the hormonal cycle on the voice. Male students are also required to act as control subjects (for comparative purposes). Students who agree to participate will be briefed at a convenient time & venue at the Conservatorium.

Maree Ryan
A/Prof Dianna Kenny

Please contact Maree Ryan

at the Sydney Conservatorium of Music by telephone 9351 1259 or by email mryan@greenway.usyd.edu.au

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

CONSENT FORM

I, ... , (please print)

give consent to my participation in the research project

RESEARCH STUDY INTO THE EFFECTS OF THE HORMONAL CYCLE ON THE HUMAN VOICE

In giving my consent I acknowledge that:

1. The procedures required for the project have been explained to me, and any questions I have about the project have been answered to my satisfaction;
2. I have read the Subject Information Statement and have been given the opportunity to discuss the information and my involvement in the project with family and /or friends.
3. I am aware of any risks or inconveniences associated with the project;
4. I understand that I can withdraw from the study at any time, without affecting my relationships with the researcher(s) now or in the future.
5. I understand that my involvement is strictly confidential and no information about me will be used in any way, which reveals my identity.

Signed: ..... **Date**: .....

Name: ..... (please print)

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

A/Professor Dianna Kenny
Australian Centre for Applied Research in Music Performances

SUBJECT INFORMATION SHEET (Female)

RESEARCH STUDY INTO EFFECTS OF THE HORMONAL CYCLE ON THE HUMAN VOICE

You are invited to take part in a research project into the effects of hormonal fluctuation on the singing voice. This research study is to be known as the "Effect of Premenstrual Symptoms on Singers".

The aim is to investigate the variability of the singing voice due to the effect of certain conditions relevant to professional singers. Any adverse effect on the voice that changes quality, ease of production and range can cause anxiety in a singer and have an adverse effect on confidence and ultimately career.

The study is being conducted by Ms Maree Ryan, full time lecturer in voice at the Sydney Conservatorium of Music, under the supervision of Associate Professor Dianna Kenny from the Australian Centre for Applied Research in Music Performance. It forms the basis of a Masters Degree by Research and meets the ethics requirements of The University of Sydney into research with human subjects.

If you agree to participate in this study, you will be asked to fill in a daily diary as part of a self-evaluating questionnaire, for the time span of two (2) separate months. You will also need to take your temperature sublingually (under the tongue) by digital thermometer every morning in those same months and fill in a daily temperature chart to show that there are definitive changes in the basal body temperature of female subjects. These procedures should not take longer than a few minutes each day. At a later date, a smaller number of volunteers will be required for audiotape recording, of no longer than 30 minutes on two (2) separate occasions, to ascertain the levels of perceived changes when hormone levels in the body change. These perceived changes will be assessed by independent experts/pedagogues. There are no risks involved in this research which will be carried out at the Sydney Conservatorium of Music in a staff singing studio.

All collected data from the study will be strictly confidential and only Maree Ryan and Associate Professor Dianna Kenny will have direct access to information about the participants. A report of the study may be submitted for publication but individual participants will not be able to be identified from such a report. Only an allocated number will identify each subject and information will be stored in a locked area within the University premises until it is destroyed at the completion of the mandatory storage period of seven (7) years.

Participation in this study is entirely voluntary and withdrawal will not jeopardize your future academic progress in any way.

When you have read this information Maree Ryan will be happy to discuss it with you further and answer any questions that you may have about the study. If you would like to know more at any stage, please feel free to contact Maree Ryan, Lecturer in Voice, Sydney Conservatorium of Music, by telephone on (02) 9351 1259 or by email at mryan@greenway.usyd.edu.au or Associate Professor Dianna Kenny by telephone on (02) 9351 1386 or by email at d.kenny@fhs.usyd.edu.au

This information sheet is for you to keep.

Any person with concerns or complaints about the conduct of this research can contact the Manager for Ethics Administration at The University of Sydney on (02) 9351 4811.

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

A/Professor Dianna Kenny
Australian Centre for Applied Research in Music Performance

SUBJECT INFORMATION SHEET (Male)

RESEARCH STUDY INTO EFFECTS OF THE HORMONAL CYCLE ON THE HUMAN VOICE

You are invited to take part in a research project into the effects of hormonal fluctuation on the singing voice. As a male subject you will be used in the control group. This research study is to be known as the "Effect of Premenstrual Symptoms on Singers".

The aim is to investigate the variability of the singing voice due to the effect of certain conditions relevant to professional singers. Any adverse effect on the voice that changes quality, ease of production and range can cause anxiety in a singer and have an adverse effect on confidence and ultimately career.

The study is being conducted by Ms Maree Ryan, full time lecturer in voice at the Sydney Conservatorium of Music, under the supervision of Associate Professor Dianna Kenny from the Australian Centre for Applied Research in Music Performance. It forms the basis of a Masters Degree by Research and meets the ethics requirements of The University of Sydney into research with human subjects.

If you agree to participate in this study, you will be asked to fill in a daily diary as part of a self-evaluating questionnaire, for the time span of two (2) separate months. You will also need to take your temperature sublingually (under the tongue) by digital thermometer every morning in those same months and fill in a daily temperature chart to show that there are no significant changes in the basal body temperature of male subjects. These procedures should not take longer than a few minutes each day. At a later date, a smaller number of female volunteers will be required for audiotape recording, to ascertain the levels of perceived changes when hormone levels in the body change. These perceived changes will be assessed by independent experts/pedagogues. There are no risks involved in this research which will be carried out at the Sydney Conservatorium of Music in a staff singing studio.

All collected data from the study will be strictly confidential and only Maree Ryan and Associate Professor Dianna Kenny will have direct access to information about the participants. A report of the study may be submitted for publication but individual participants will not be able to be identified from such a report. Only an allocated number will identify each subject and information will be stored in a locked area within the University premises until it is destroyed at the completion of the mandatory storage period of seven (7) years.

Participation in this study is entirely voluntary and withdrawal will not jeopardize your future academic progress in any way.

When you have read this information Maree Ryan will be happy to discuss it with you further and answer any questions that you may have about the study. If you would like to know more at any stage, please feel free to contact Maree Ryan, Lecturer in Voice, Sydney Conservatorium of Music, by telephone on (02) 9351 1259 or by email at mryan@greenway.usyd.edu.au or Associate Professor Dianna Kenny by telephone on (02) 9351 1386 or by email at d.kenny@fhs.usyd.edu.au

This information sheet is for you to keep.

Any person with concerns or complaints about the conduct of this research can contact the Manager for Ethics Administration at The University of Sydney on (02) 9351 4811.

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

AUSTRALIAN CENTRE FOR APPLIED RESEARCH IN MUSIC PERFORMANCE

RESEARCH STUDY

Hormonal influences on the female singing voice

STRUCTURED DIARY FOR SINGERS

Please record your temperature each day upon rising for every day of your cycle on the temperature chart provided (see chart for detailed instructions)

Please complete each diary page in this booklet at the same time each day, preferably towards the END OF THE WORKING DAY. There is one page for each day over the FOUR-week period

Any concerns or questions, please phone
Maree Ryan 02 9351 1259
Dianna Kenny 02 9351 9644

DATE: _____ ID:_____ Male □ Female □

Below is a list of feelings that people have.
For each feeling, cross ONE number for the answer that best describes HOW YOU ARE FEELING **RIGHT NOW**.

The numbers refer to these phrases
0 = Not at all, 1 = A little, 2 = Moderately, 3 = Quite a lot, 4 = Very

Relaxed	(0)	(1)	(2)	(3)	(4)
Discouraged	(0)	(1)	(2)	(3)	(4)
Annoyed / Irritable	(0)	(1)	(2)	(3)	(4)
Sad/depressed	(0)	(1)	(2)	(3)	(4)
Unable to Concentrate	(0)	(1)	(2)	(3)	(4)
Energetic	(0)	(1)	(2)	(3)	(4)
Forgetful /confused	(0)	(1)	(2)	(3)	(4)
Tense/anxious	(0)	(1)	(2)	(3)	(4)
Exhausted	(0)	(1)	(2)	(3)	(4)
Cheerful	(0)	(1)	(2)	(3)	(4)
Angry	(0)	(1)	(2)	(3)	(4)
Fatigued	(0)	(1)	(2)	(3)	(4)
Happy	(0)	(1)	(2)	(3)	(4)

For how many years have you been studying singing?
_____ years
What is your voice type?_____
How old are you?_____
Are you pregnant? YES □ NO □
Are your menstrual cycles regular?
YES □ NO □
What is your usual cycle length?_____ days
Do you currently take the oral contraceptive pill?
YES □ NO □

Thinking about your singing **today**, to what extent do you agree or disagree with the following:

	Strongly agree	Strongly disagree
My voice felt in peak form	_____	
My voice felt fatigued	_____	
It took a lot of effort to sing	_____	
My ability to support my sound was affected	_____	
My voice seemed hoarse or husky	_____	
My voice felt muffled, weak or breathy	_____	
I could not extend to the top of my range	_____	
I was not able to control my voice as easily	_____	
My voice felt "sluggish"	_____	
My voice sounded flat in pitch	_____	

TODAY, DID YOU:

		not at all severe	very severe
experience cramps?	NO___YES___	_____	
feel fatigued?	NO___YES___	_____	
feel nauseous?	NO___YES___	_____	
feel bloated? (eg breasts?)	NO___YES___	_____	
experience food cravings? (change in appetite)	NO___YES___	_____	
have headaches?	NO___YES___	_____	
feel dizzy?	NO___YES___	_____	
have difficulty sleeping last night?	NO___YES___	_____	

ID number .....

DAILY TEMPERATURE CHART

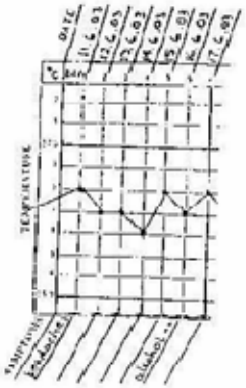
Cycle begins (date) ..... (day 1)

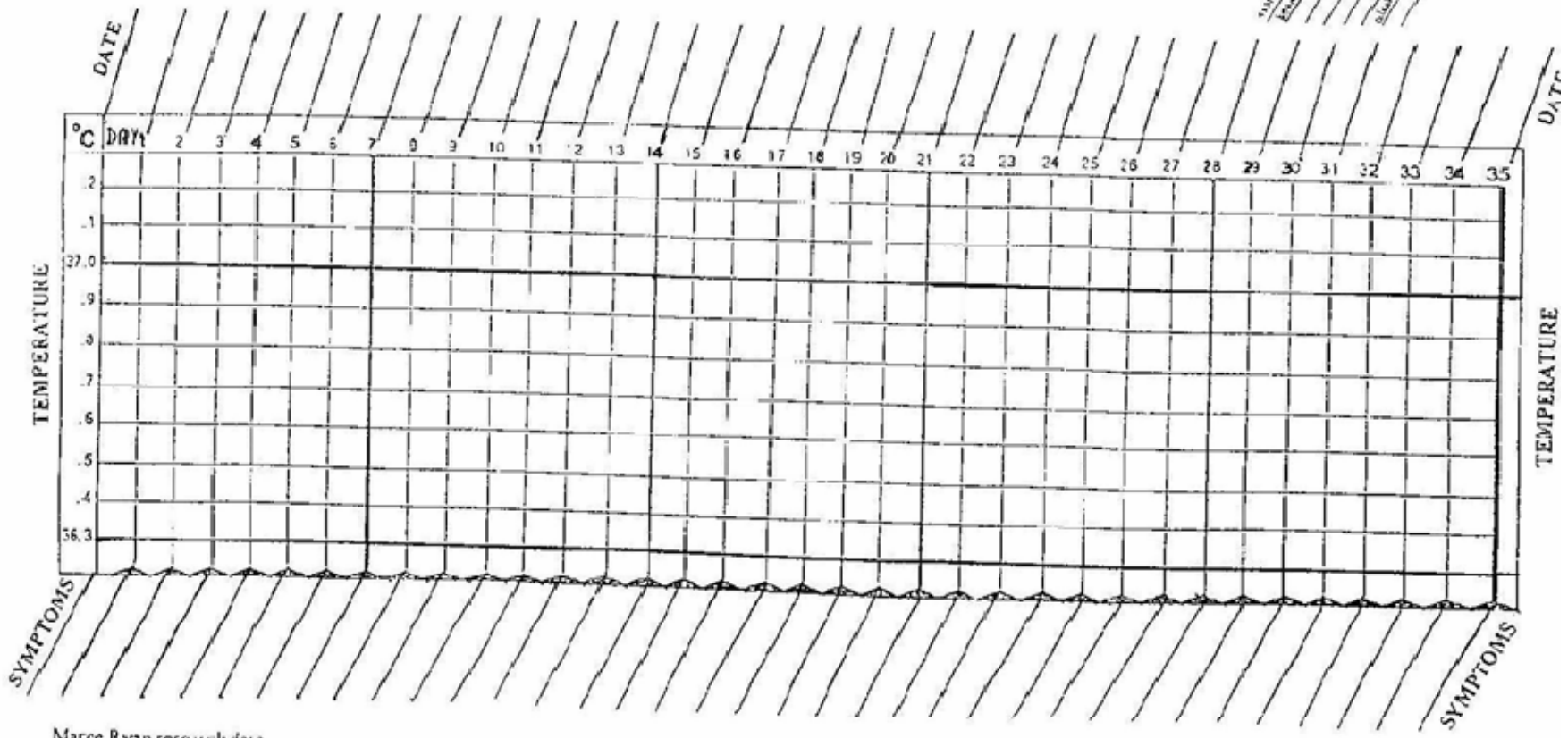
USING THE CHART

Day 1 of your period is counted as day 1 of your cycle. The cycle ends on the day before your next period begins, eg. bleeding that starts on the first of July with another bleed starting on the 30th of July, is a 29 day cycle.
On day 1 of bleeding, write the date at the top of the chart and also above the space for day 1.
Continue in this way writing the date above each day.
A new chart needs to be started at the beginning (day 1) of each menstrual cycle.

HOW TO RECORD ORAL TEMPERATURE (degrees centigrade)

Take the temperature on waking, at the same time each morning and record it on the chart.
Any unusual circumstances such as illness and alcohol consumption should be noted in the space under the chart.
An example of a completed chart is given in the top right corner.





Marce Ryan research data

1 June, 2003

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

AUSTRALIAN CENTRE FOR APPLIED RESEARCH IN MUSIC PERFORMANCE

Maree Ryan
Lecturer in Voice

Sunday, 23 May 2004

Dear xxxx

I am writing to you to invite you to take part in a study at the Australian Centre for Applied Research in Music Performance, University of Sydney. The study is about the effect of hormonal changes on the sound qualities of the young female singer's voice.

You have been selected for this project as a singer who demonstrates vocal changes associated with your menstrual cycle. The objective is to investigate acoustical and perceptual analysis variances when the singer is at certain times in her cycle.

Enclosed are copies of the Information Sheet about the study and the Consent Sheet.

Please do not hesitate to contact me for further information on this project.
I look forward to speaking with you soon.

Yours sincerely

Maree Ryan

Australian Centre for Applied Research in Music Performance
The University of Sydney

RESEARCH STUDY INTO THE EFFECT OF HORMONAL CHANGES ON THE YOUNG FEMALE SINGER

CONSENT SHEET

Project Title: **The Effect of Hormonal Changes on the Young Female Singer**

Investigators: Ms Maree Ryan
Associate Professor Dianna Kenny

1. I acknowledge that I have read the appended information sheet, which explains the nature, objective and the possible risks of the investigation, and the statement has been explained to me to my satisfaction. Before signing this document I have been given the opportunity to ask questions relating to any possible physical harm I may suffer as a result of my participation and I have received satisfactory answers. I have also been informed that I may not receive any benefits from participating in this study. I have been offered a debriefing session after the research has been completed.

2. My decision whether or not to participate will not prejudice my future relations with Australian Centre for Applied Research in Music Performance or any of the investigators listed above. If I decide to participate, I am free to withdraw my consent and to discontinue participation at any time without prejudice.

3. I agree that research data gathered from the results of the study may be published provided my name is not used.

_____ _____
DATE Signature of Subject

4. I have fully explained to the subject _____ the nature and purpose of the program and the procedures to be employed and such risks as are involved in their performance.

_____ _____
DATE Signature of Responsible Investigator

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

AUSTRALIAN CENTRE FOR APPLIED RESEARCH IN MUSIC PERFORMANCE

PERCEPTUAL ANALYSIS OF SINGING

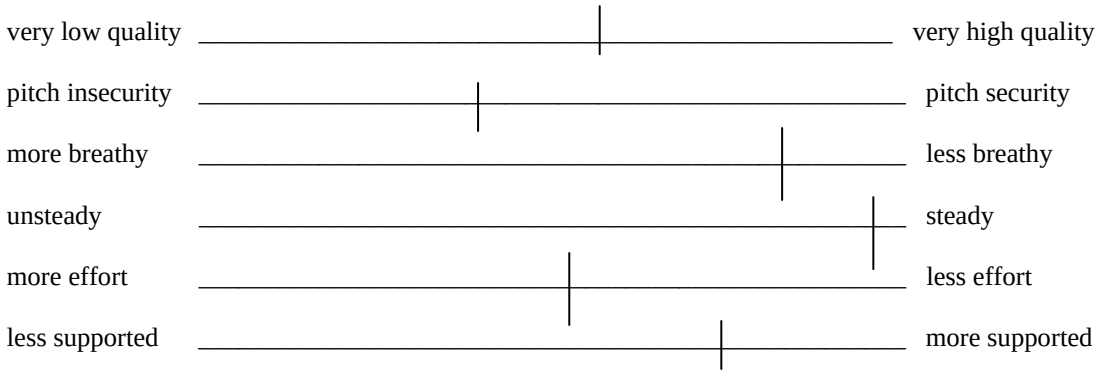
There are two recordings of your singing, each of twenty (20) seconds duration.

Listen to each recording and indicate by circling either 'Recording 1' or 'Recording 2' below, which one is better in overall quality. If you think the two recordings are of equal quality, please circle the word 'Equal'.

Recording 1 Recording 2 Equal

Then rate the recording you have chosen, for the following characteristics, by placing a vertical line on the scale below:

Example:



Recording chosen:

very low quality _____ very high quality

pitch security _____ pitch insecurity

more breathy _____ less breathy

unsteady _____ steady

more effort _____ less effort

less supported _____ more supported

Australian Centre for Applied Research in Music Performance
The University of Sydney

RESEARCH STUDY INTO THE EFFECT OF HORMONAL CHANGES ON THE VOCAL QUALITY OF YOUNG FEMALE SINGERS

SINGER SUBJECT FEEDBACK SHEET

Below are a number of statements about your singing voice quality. Please rate your agreement or disagreement with each statement by placing a horizontal mark on the scale below.

For example ……

I felt happy with my singing today

I felt happy with my singing today	Strongly disagree ——— Strongly agree

The mark to the right of the centre of the line indicates that this singer was agreed (but not strongly) that she felt happy with her singing voice today

The rating scales begin on the next page.

Excerpt 1: scales

Please rate how you perceived your voice during this singing sample on the following items:

My voice felt in peak form	Strongly disagree — Strongly agree
My voice felt fatigued	Strongly disagree — Strongly agree
It took a lot of effort to sing	Strongly disagree — Strongly agree
My ability to support my sound was affected	Strongly disagree — Strongly agree
My voice seemed hoarse or husky	Strongly disagree — Strongly agree
My voice felt muffled, weak or breathy	Strongly disagree — Strongly agree
I could extend to the top of my range	Strongly disagree — Strongly agree
I was able to control my voice easily	Strongly disagree — Strongly agree
My voice felt "sluggish"	Strongly disagree — Strongly agree
My voice sounded flat in pitch	Strongly disagree — Strongly agree

Excerpt 2: "O mio babbino caro"

Please rate how you perceived your voice during this singing sample on the following items:

My voice felt in peak form	Strongly disagree	Strongly agree
My voice felt fatigued	Strongly disagree	Strongly agree
It took a lot of effort to sing	Strongly disagree	Strongly agree
My ability to support my sound was affected	Strongly disagree	Strongly agree
My voice seemed hoarse or husky	Strongly disagree	Strongly agree
My voice felt muffled, weak or breathy	Strongly disagree	Strongly agree
I could extend to the top of my range	Strongly disagree	Strongly agree
I was able to control my voice easily	Strongly disagree	Strongly agree
My voice felt "sluggish"	Strongly disagree	Strongly agree
My voice sounded flat in pitch	Strongly disagree	Strongly agree

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

A/Professor Dianna Kenny
Australian Centre for Applied Research in Music Performance

SUBJECT INFORMATION SHEET (Pedagogue)

RESEARCH STUDY INTO EFFECTS OF THE HORMONAL CYCLE ON THE HUMAN VOICE

You are invited to take part in a research project into the effects of hormonal fluctuation on the singing voice. Both female (subjects) and male (controls) students will be recruited for this research study to be known as the "Effect of Premenstrual Symptoms on Singers".

The aim is to investigate the variability of the singing voice due to the effect of certain conditions relevant to professional singers. Any adverse effect on the voice that changes quality, ease of production and range can cause anxiety in a singer and have an adverse effect on confidence and ultimately career.

The study is being conducted by Ms Maree Ryan, full time lecturer in voice at the Sydney Conservatorium of Music, under the supervision of Associate Professor Dianna Kenny from the Australian Centre for Applied Research in Music Performance. It forms the basis of a Masters Degree by Research and meets the ethics requirements of The University of Sydney into research with human subjects.

If you agree to participate in this study, you will be asked to listen to tape-recorded vocal excerpts from the female (subjects) students during different phases of their menstrual cycle to ascertain if you can perceive any differences in their voices on those occasions. Each singer will present two (2) separate recordings and you will not be told from which part of the cycle each recording is taken. There are no risks involved in this research which will be carried out at the Sydney Conservatorium of Music in a staff singing studio.

All collected data from the study will be strictly confidential and only Maree Ryan and Associate Professor Dianna Kenny will have direct access to information about the participants. A report of the study may be submitted for publication but individual participants will not be able to be identified from such a report. Only an allocated number will identify each subject and each pedagogue and information will be stored in a locked area within the University premises until it is destroyed at the completion of the mandatory storage period of seven (7) years.

Participation in this study is entirely voluntary and there is no remuneration involved.

When you have read this information Maree Ryan will be happy to discuss it with you further and answer any questions that you may have about the study. If you would like to know more at any stage, please feel free to contact Maree Ryan, Lecturer in Voice, Sydney Conservatorium of Music, by telephone on (02) 9351 1259 or by email at mryan@greenway.usyd.edu.au or Associate Professor Dianna Kenny by telephone on (02) 9351 1386 or by email at d.kenny@fhs.usyd.edu.au

This information sheet is for you to keep.

Any person with concerns or complaints about the conduct of this research can contact the Manager for Ethics Administration at The University of Sydney on (02) 9351 4811.

The University of Sydney

SYDNEY CONSERVATORIUM OF MUSIC

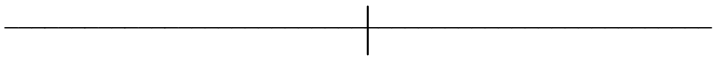
AUSTRALIAN CENTRE FOR APPLIED RESEARCH IN MUSIC PERFORMANCE

PERCEPTUAL ANALYSIS OF SINGING

There are fifteen (15) singing samples in the CD, each of twenty (20) seconds duration. The excerpts are presented in random order. We would like you to

1. rate each sample for overall quality of voice, by placing a vertical line on the scale below;
2. on the line beneath, explain how you would describe the sound, e.g. Breathy, unsteady. etc:

Sample example:



Very low quality Very high quality

Breathy, unsteady, etc.

……...

Sample 1: _____

Very low quality Very high quality

……...

Sample 2: _____

Very low quality Very high quality

……...

Sample 3: _____

Very low quality Very high quality

……...

Sample 4: _____

Very low quality Very high quality

……...

Sample 5: _____

Very low quality Very high quality

……...

Sample 6: _____

Very low quality Very high quality

……...

Sample 7: _____

Very low quality Very high quality

……...

Sample 8: _____

Very low quality Very high quality

……...

Sample 9: _____

Very low quality Very high quality

……...

Sample 10: _____

Very low quality Very high quality

……...

Sample 11: _____

Very low quality Very high quality

……...

Sample 12: _____

Very low quality Very high quality

……...

Sample 13: _____

Very low quality Very high quality

……...

Sample 14: _____

Very low quality Very high quality

……...

Sample 15: _____

Very low quality Very high quality

……...

Appendix 2

Voice quality by regular cycle or using an oral contraceptive

T-Test

Group Statistics

	Regular cylces	N	Mean	Std. Deviation	Std. Error Mean
Peak_form_r	no	4	2.5750	3.21286	1.60643
	yes	17	4.4765	2.26896	.55030
fatigued voice	no	4	2.500	2.9833	1.4916
	yes	17	4.500	2.4650	.5979
effort	no	4	2.900	4.1992	2.0996
	yes	17	4.324	2.4954	.6052
support	no	4	3.250	4.0087	2.0044
	yes	17	4.100	2.5547	.6196
hoarse	no	4	3.350	3.4337	1.7168
	yes	17	5.753	2.9971	.7269
weak	no	4	4.625	3.6473	1.8236
	yes	17	5.329	3.0805	.7471
range	no	4	4.175	4.4470	2.2235
	yes	17	5.124	3.3772	.8191
control	no	4	3.175	4.1740	2.0870
	yes	17	4.865	3.0000	.7276
sluggish	no	4	2.900	4.3650	2.1825
	yes	17	4.971	2.9624	.7185
pitch	no	4	4.350	5.0030	2.5015
	yes	17	6.788	2.5923	.6287

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Peak_form_r	Equal variances assumed	.472	.500	-1.401	19	.177	-1.9015	1.35727	-4.74227	.93933
	Equal variances not assumed			-1.120	3.736	.330	-1.9015	1.69807	-6.75056	2.94762
fatigued voice	Equal variances assumed	.067	.798	-1.409	19	.175	-2.000	1.4192	-4.9705	.9705
	Equal variances not assumed			-1.245	4.022	.281	-2.000	1.6070	-6.4522	2.4522
effort	Equal variances assumed	1.579	.224	-.904	19	.377	-1.424	1.5746	-4.7191	1.8720
	Equal variances not assumed			-.651	3.515	.555	-1.424	2.1851	-7.8354	4.9883
support	Equal variances assumed	.960	.340	-.540	19	.596	-.850	1.5751	-4.1466	2.4466
	Equal variances not assumed			-.405	3.595	.708	-.850	2.0980	-6.9433	5.2433
hoarse	Equal variances assumed	.041	.842	-1.408	19	.175	-2.403	1.7061	-5.9740	1.1681
	Equal variances not assumed			-1.289	4.147	.265	-2.403	1.8644	-7.5077	2.7018
weak	Equal variances assumed	.131	.722	-.399	19	.694	-.704	1.7654	-4.3994	2.9906
	Equal variances not assumed			-.357	4.070	.739	-.704	1.9707	-6.1391	4.7303
range	Equal variances assumed	.814	.378	-.478	19	.638	-.949	1.9825	-5.0980	3.2010
	Equal variances not assumed			-.400	3.856	.710	-.949	2.3696	-7.6254	5.7284
control	Equal variances assumed	.405	.532	-.946	19	.356	-1.690	1.7861	-5.4280	2.0486
	Equal variances not assumed			-.764	3.763	.490	-1.690	2.2102	-7.9816	4.6022
sluggish	Equal variances assumed	.714	.409	-1.155	19	.262	-2.071	1.7920	-5.8213	1.6802
	Equal variances not assumed			-.901	3.677	.423	-2.071	2.2977	-8.6770	4.5358
pitch	Equal variances assumed	7.732	.012	-1.415	19	.173	-2.438	1.7228	-6.0441	1.1677
	Equal variances not assumed			-.945	3.388	.407	-2.438	2.5793	-10.1392	5.2627

T-Test

Group Statistics

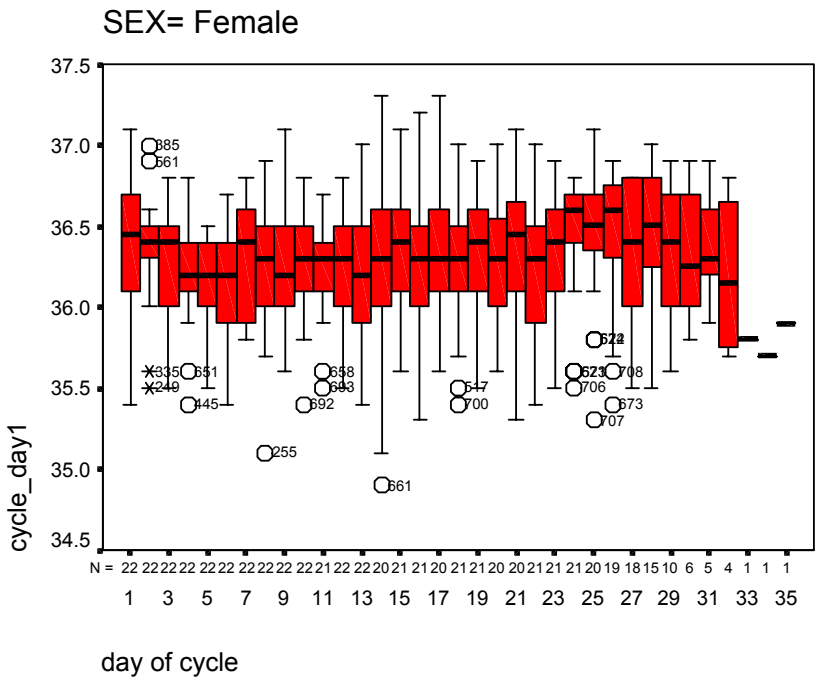
	Take oral contr pill	N	Mean	Std. Deviation	Std. Error Mean
Peak_form_r	No	12	3.5083	2.91687	.84203
	Yes	9	4.9222	1.62694	.54231
fatigued voice	No	12	3.375	3.0404	.8777
	Yes	9	5.111	1.5688	.5229
effort	No	12	3.592	3.2324	.9331
	Yes	9	4.667	2.1857	.7286
support	No	12	2.850	2.6273	.7584
	Yes	9	5.389	2.3950	.7983
hoarse	No	12	4.075	3.1915	.9213
	Yes	9	6.922	2.3467	.7822
weak	No	12	4.725	3.2589	.9408
	Yes	9	5.822	2.9651	.9884
range	No	12	3.708	3.5124	1.0140
	Yes	9	6.589	2.8799	.9600
control	No	12	3.517	3.4769	1.0037
	Yes	9	5.911	2.3197	.7732
sluggish	No	12	3.758	3.5426	1.0227
	Yes	9	5.667	2.6144	.8715
pitch	No	12	5.525	3.6262	1.0468
	Yes	9	7.389	2.2178	.7393

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Peak_form_r	Equal variances assumed	4.525	.047	-1.305	19	.208	-1.4139	1.08374	-3.68218	.85441
	Equal variances not assumed			-1.412	17.806	.175	-1.4139	1.00156	-3.51973	.69195
fatigued voice	Equal variances assumed	10.407	.004	-1.558	19	.136	-1.736	1.1145	-4.0688	.5966
	Equal variances not assumed			-1.699	17.213	.107	-1.736	1.0217	-3.8896	.4174
effort	Equal variances assumed	6.551	.019	-.859	19	.401	-1.075	1.2519	-3.6953	1.5453
	Equal variances not assumed			-.908	18.862	.375	-1.075	1.1839	-3.5541	1.4041
support	Equal variances assumed	.001	.980	-2.274	19	.035	-2.539	1.1166	-4.8759	-.2019
	Equal variances not assumed			-2.306	18.184	.033	-2.539	1.1012	-4.8507	-.2271
hoarse	Equal variances assumed	2.617	.122	-2.253	19	.036	-2.847	1.2639	-5.4926	-.2018
	Equal variances not assumed			-2.356	19.000	.029	-2.847	1.2086	-5.3768	-.3176
weak	Equal variances assumed	.563	.462	-.793	19	.438	-1.097	1.3840	-3.9939	1.7995
	Equal variances not assumed			-.804	18.198	.432	-1.097	1.3645	-3.9617	1.7673
range	Equal variances assumed	3.851	.065	-2.003	19	.060	-2.881	1.4380	-5.8903	.1292
	Equal variances not assumed			-2.063	18.795	.053	-2.881	1.3963	-5.8052	.0441
control	Equal variances assumed	5.622	.028	-1.784	19	.090	-2.394	1.3422	-5.2036	.4148
	Equal variances not assumed			-1.890	18.818	.074	-2.394	1.2670	-5.0481	.2592
sluggish	Equal variances assumed	1.609	.220	-1.359	19	.190	-1.908	1.4044	-4.8478	1.0311
	Equal variances not assumed			-1.420	19.000	.172	-1.908	1.3436	-4.7205	.9039
pitch	Equal variances assumed	3.536	.075	-1.358	19	.190	-1.864	1.3722	-4.7360	1.0082
	Equal variances not assumed			-1.454	18.411	.163	-1.864	1.2815	-4.5520	.8242

Appendix 3

Temperature and day of cycle



Temperature and oral contraception

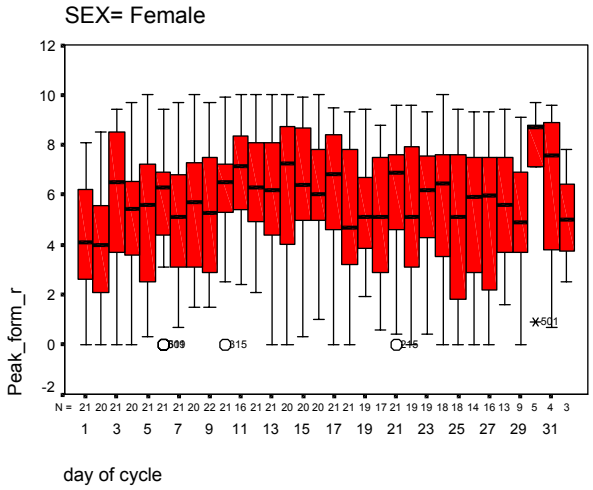
		Cycle 1			Cycle 2	
		Taking pill	**Temp rise**		**Taking pill**	**Temp rise**
ID No						
1		no	yes		no	yes
2 male						
3		no	yes		no	no
4	■	no	?		no	?
5						
6 male						
7		yes	no		yes	no
8		yes	yes		yes	yes
9						
10		no	yes		no	no
11	■	no	yes		no	yes
12		yes	yes		yes	yes
13		no	yes		no	yes
14 male						
15 male						
16		no	no		yes	no
17		yes	no			
18		no	no		no	no
19		no	no		no	no
20		?	yes		no	yes
21	■	no	yes		no	yes
22	■	no	?		yes	no
23						
24	■	yes	no		no	yes
25		yes	no			
26		yes	yes		yes	no
27	■	yes	yes		no	yes
28		no	yes		no	no
29		yes	yes		yes	?
30 male						
31 male						

■ most affected females

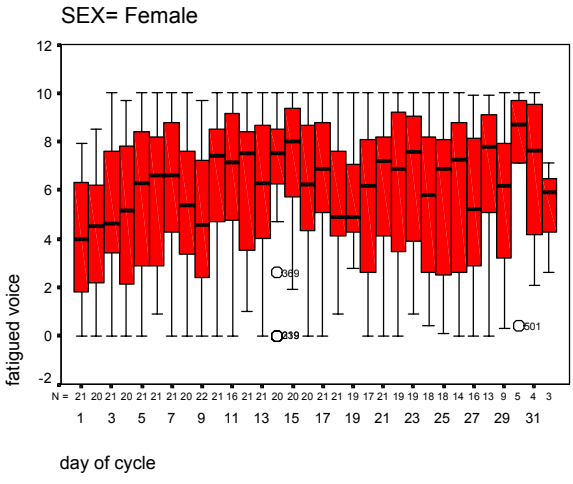
Appendix 4

Voice quality by day in females

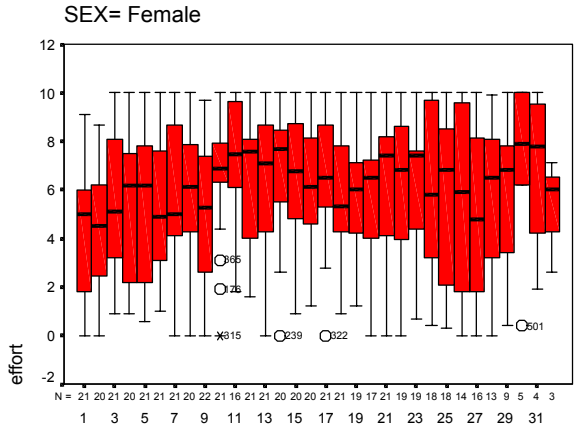
Peak_form_r



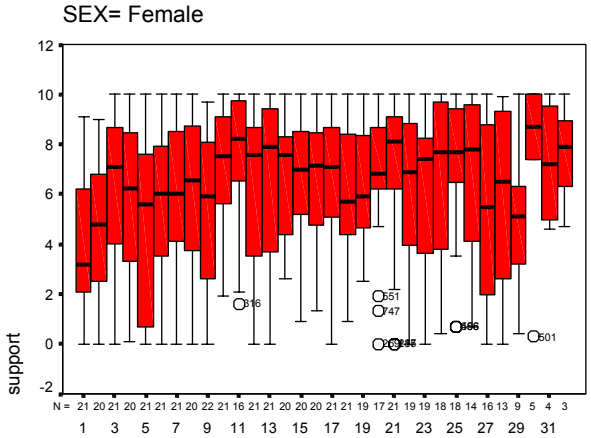
fatigued voice



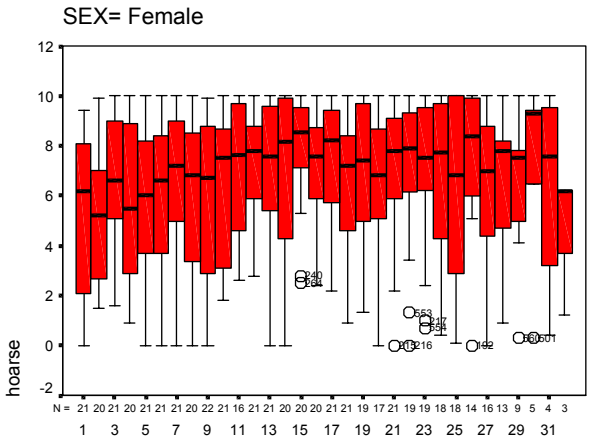
effort



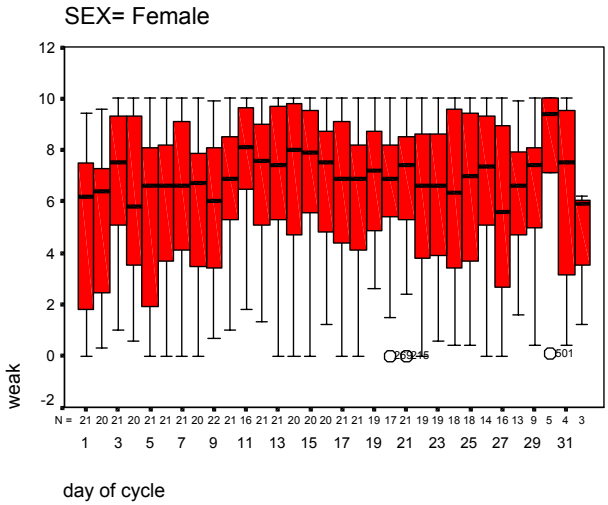
support



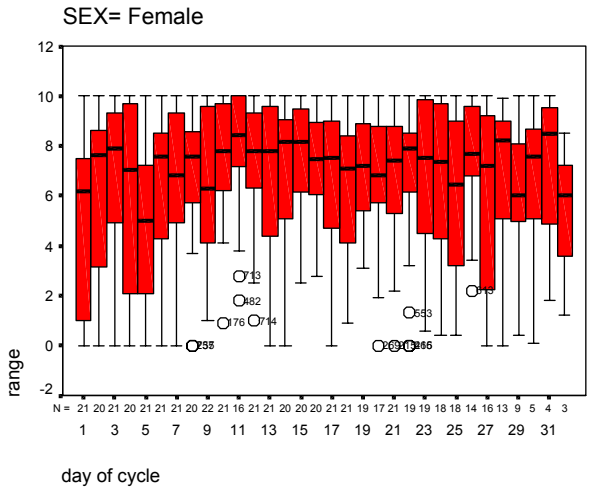
hoarse



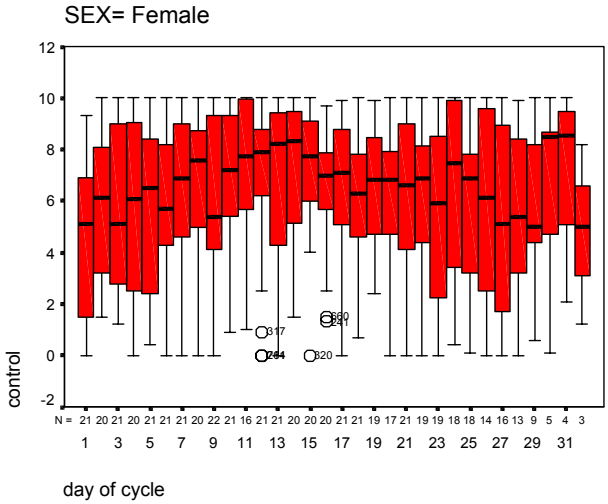
weak



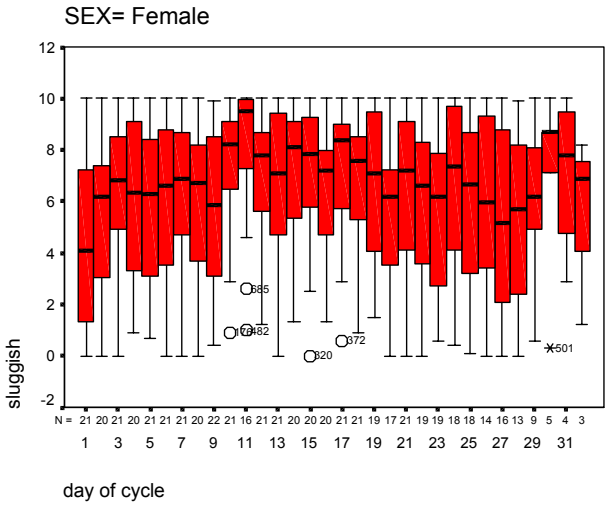
range



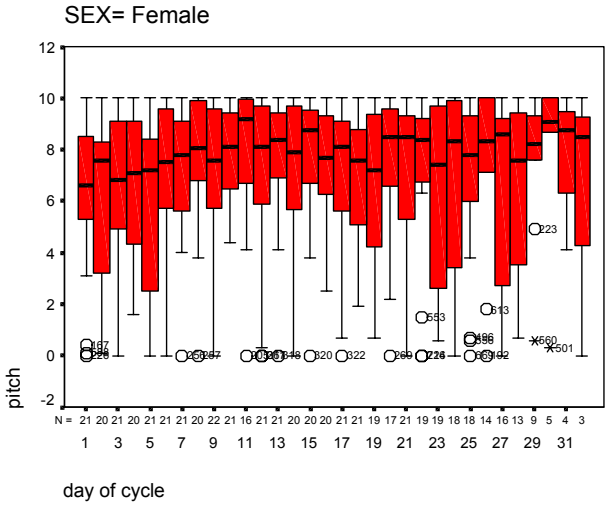
control



sluggish



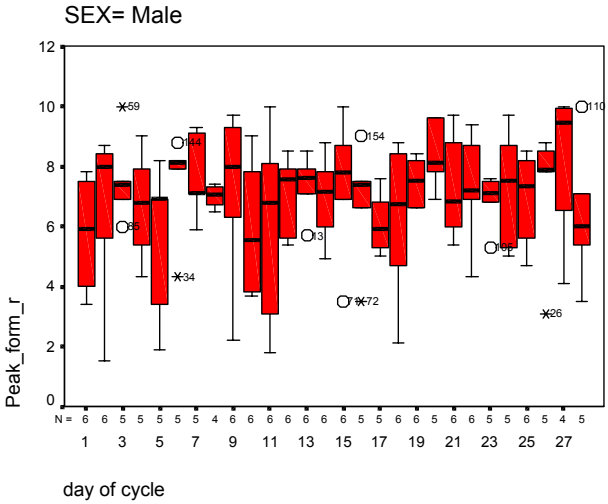
pitch



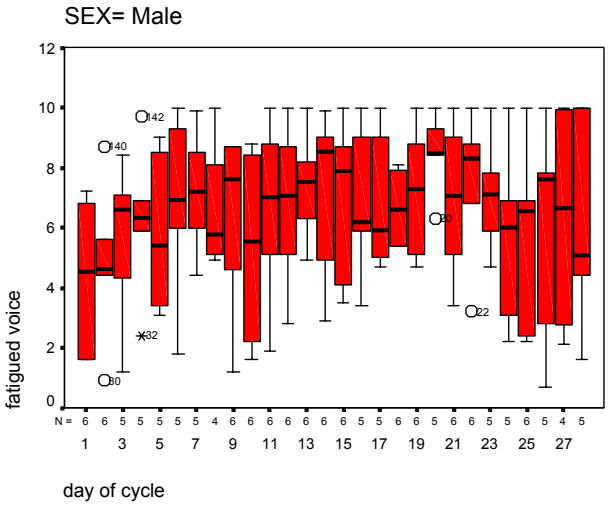
Appendix 5

Voice quality by day in males

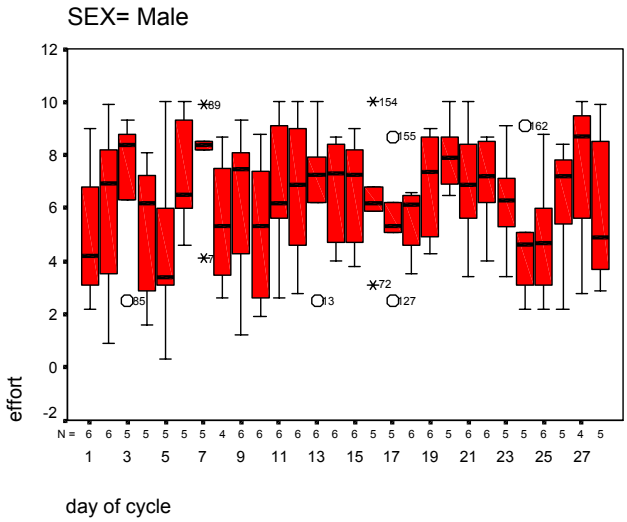
Peak form



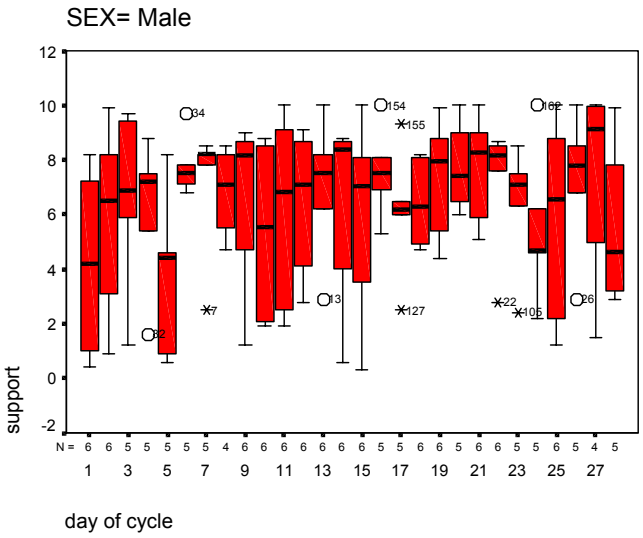
fatigued voice



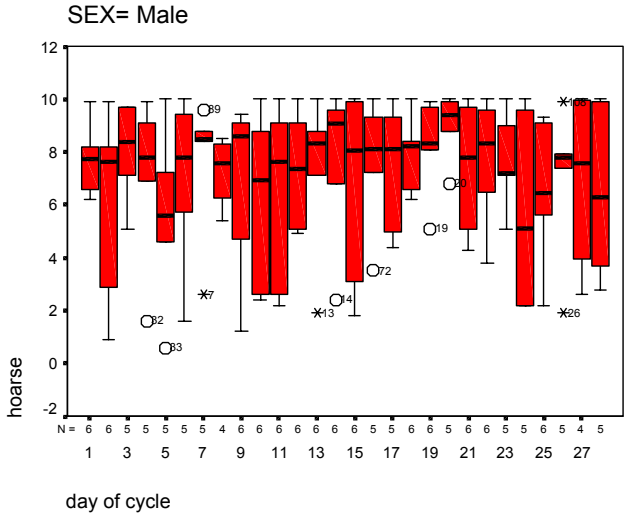
effort



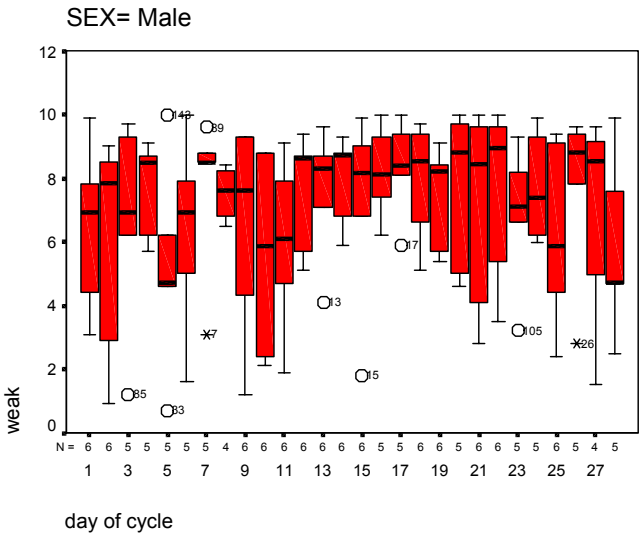
support



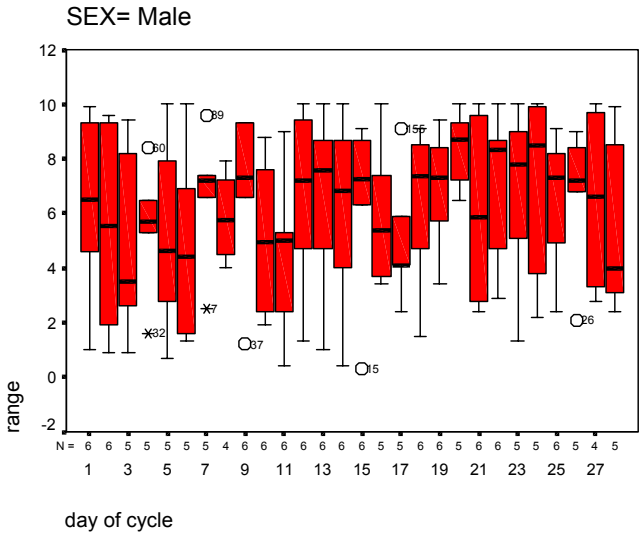
hoarse



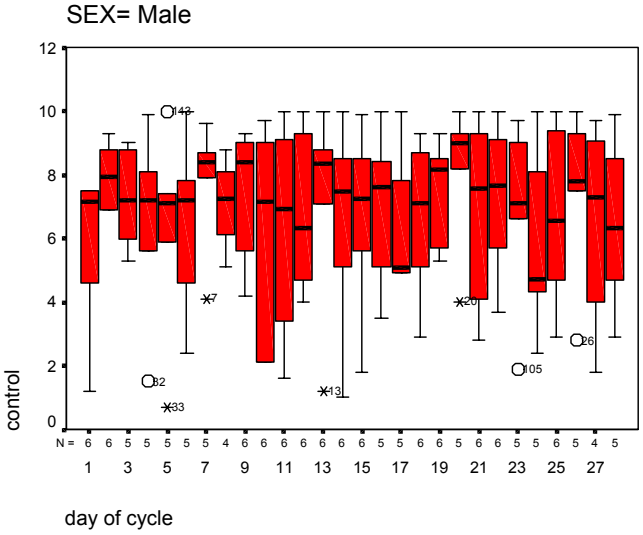
weak



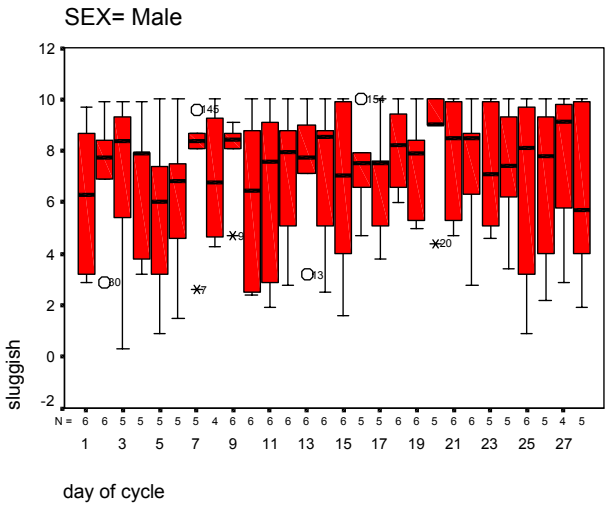
range



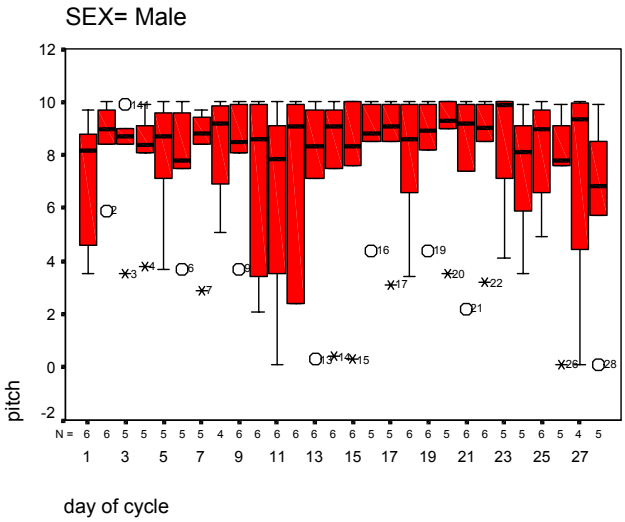
control



sluggish



pitch



Appendix 6

Kendall's correlation between VAS scores and voice quality by day in females

DAY 1		Cramps	Fatigue	Nauseous	Bloated	Cravings	Headaches	Dizzy	Sleeping
Peak form	Kendalls	-0.01	-0.07	-0.32	-0.33	-0.16	0.20	-0.32	-0.31
	Pvalue	0.97	0.72	0.09	0.08	0.40	0.28	0.09	0.10
fatigued voice	Kendalls	-0.02	-0.13	-0.25	-0.16	0.01	0.23	-0.32	-0.19
	Pvalue	0.93	0.47	0.18	0.39	0.97	0.22	0.09	0.30
effort	Kendalls	-0.08	-0.12	-0.10	-0.34	0.00	0.16	-0.20	-0.33
	Pvalue	0.68	0.51	0.60	0.07	1.00	0.39	0.29	0.08
support	Kendalls	-0.23	-0.31	-0.20	-0.48	-0.06	0.16	-0.31	-0.25
	Pvalue	0.22	0.09	0.28	0.01	0.75	0.39	0.10	0.18
hoarse	Kendalls	-0.17	-0.33	-0.14	-0.19	0.08	0.15	-0.26	-0.11
	Pvalue	0.36	0.08	0.46	0.32	0.67	0.43	0.17	0.55
weak	Kendalls	-0.08	-0.26	0.06	-0.23	0.07	0.16	-0.01	-0.25
	Pvalue	0.68	0.17	0.74	0.23	0.70	0.41	0.94	0.18
range	Kendalls	0.03	-0.10	0.02	-0.29	0.05	0.40	0.09	-0.11
	Pvalue	0.87	0.59	0.91	0.13	0.80	0.03	0.62	0.54
control	Kendalls	-0.02	-0.15	-0.20	-0.35	-0.07	0.43	-0.13	-0.19
	Pvalue	0.90	0.44	0.30	0.06	0.72	0.02	0.50	0.30
sluggish	Kendalls	-0.47	-0.25	-0.17	-0.31	0.15	0.12	-0.01	-0.35
	Pvalue	0.01	0.19	0.37	0.10	0.42	0.51	0.97	0.06
pitch	Kendalls	-0.41	0.11	-0.15	-0.16	0.01	-0.22	-0.01	0.05
	Pvalue	0.03	0.55	0.41	0.39	0.97	0.25	0.94	0.80

DAY 3		Cramps	Fatigue	Nauseous	Bloated	Cravings	Headaches	Dizzy	Sleeping
Peak form	Kendalls	0.12	-0.52	-0.06	-0.13	-0.04	-0.09	0.01	-0.21
	Pvalue	0.53	0.01	0.74	0.48	0.82	0.63	0.96	0.26
fatigued voice	Kendalls	0.25	-0.26	-0.13	0.21	0.09	-0.17	0.03	-0.11
	Pvalue	0.19	0.17	0.51	0.27	0.63	0.37	0.89	0.57
effort	Kendalls	0.15	-0.28	-0.22	0.33	0.19	-0.01	-0.01	-0.09
	Pvalue	0.43	0.13	0.25	0.08	0.31	0.97	0.96	0.63
support	Kendalls	-0.08	-0.20	-0.23	0.15	0.01	-0.11	-0.11	-0.11
	Pvalue	0.65	0.29	0.21	0.44	0.94	0.58	0.56	0.58
hoarse	Kendalls	0.08	0.20	0.12	0.31	0.28	0.21	0.22	0.15
	Pvalue	0.68	0.28	0.51	0.09	0.14	0.26	0.24	0.43
weak	Kendalls	0.08	-0.03	-0.28	0.14	0.08	-0.09	0.03	-0.13
	Pvalue	0.68	0.88	0.14	0.46	0.68	0.63	0.86	0.48
range	Kendalls	-0.15	-0.06	-0.03	0.25	0.12	0.12	0.15	-0.10
	Pvalue	0.43	0.75	0.87	0.20	0.52	0.52	0.44	0.60
control	Kendalls	0.04	-0.25	-0.16	0.34	0.19	0.06	0.02	-0.08
	Pvalue	0.82	0.19	0.41	0.07	0.31	0.77	0.93	0.65
sluggish	Kendalls	0.08	-0.29	-0.25	0.21	0.06	0.01	-0.08	-0.18
	Pvalue	0.68	0.12	0.19	0.26	0.74	0.94	0.65	0.35
pitch	Kendalls	0.07	-0.18	0.09	0.42	0.30	0.18	0.08	0.06
	Pvalue	0.71	0.35	0.62	0.03	0.11	0.35	0.69	0.77

DAY 7		Cramps	Fatigue	Nauseous	Bloated	Cravings	Headaches	Dizzy	Sleeping
Peak form	Kendalls	-0.28	-0.14	-0.23	-0.03	0.41	-0.43	-0.39	-0.23
	Pvalue	0.13	0.46	0.22	0.89	0.03	0.02	0.04	0.23
fatigued voice	Kendalls	-0.38	-0.07	-0.22	-0.17	0.08	-0.44	-0.16	-0.40
	Pvalue	0.04	0.72	0.25	0.37	0.68	0.02	0.40	0.04
effort	Kendalls	-0.34	-0.03	-0.17	-0.21	0.37	-0.25	-0.10	-0.35
	Pvalue	0.07	0.89	0.36	0.26	0.05	0.19	0.59	0.06
support	Kendalls	-0.33	-0.03	-0.14	-0.17	0.43	-0.31	-0.12	-0.36
	Pvalue	0.08	0.89	0.46	0.37	0.02	0.10	0.51	0.06
hoarse	Kendalls	-0.36	0.01	-0.19	-0.23	0.30	-0.47	-0.25	-0.41
	Pvalue	0.06	0.94	0.32	0.23	0.11	0.01	0.19	0.03
weak	Kendalls	-0.32	-0.07	-0.12	-0.19	0.23	-0.39	-0.16	-0.29
	Pvalue	0.09	0.70	0.51	0.30	0.23	0.04	0.40	0.12
range	Kendalls	-0.36	-0.05	-0.19	-0.15	0.48	-0.04	-0.03	-0.32
	Pvalue	0.05	0.78	0.32	0.42	0.01	0.82	0.86	0.09
control	Kendalls	-0.36	-0.14	-0.19	-0.07	0.42	-0.09	0.02	-0.20
	Pvalue	0.06	0.46	0.32	0.72	0.03	0.62	0.90	0.29
sluggish	Kendalls	-0.37	-0.01	-0.20	-0.18	0.44	-0.16	-0.19	-0.18
	Pvalue	0.05	0.97	0.28	0.35	0.02	0.39	0.31	0.35
pitch	Kendalls	-0.43	0.10	-0.28	-0.08	0.29	-0.49	-0.30	-0.09
	Pvalue	0.02	0.59	0.14	0.69	0.13	0.01	0.12	0.64

DAY 14		Cramps	Fatigue	Nauseous	Bloated	Cravings	Headaches	Dizzy	Sleeping
Peak form	Kendalls	.	-0.16	-0.15	.	-0.02	-0.37	-0.31	-0.22
	Pvalue	.	0.40	0.43	.	0.93	0.06	0.11	0.26
fatigued voice	Kendalls	.	-0.07	0.13	.	0.05	-0.27	-0.12	-0.20
	Pvalue	.	0.73	0.49	.	0.79	0.16	0.53	0.31
effort	Kendalls	.	-0.16	0.12	.	-0.03	-0.20	-0.15	-0.11
	Pvalue	.	0.42	0.54	.	0.86	0.31	0.45	0.56
support	Kendalls	.	-0.17	0.12	.	-0.17	-0.19	-0.04	-0.16
	Pvalue	.	0.38	0.54	.	0.38	0.33	0.85	0.42
hoarse	Kendalls	.	-0.13	0.02	.	0.08	-0.33	-0.22	-0.18
	Pvalue	.	0.52	0.93	.	0.66	0.09	0.25	0.37
weak	Kendalls	.	-0.11	0.03	.	0.15	-0.33	-0.21	-0.17
	Pvalue	.	0.57	0.86	.	0.43	0.10	0.28	0.39
range	Kendalls	.	-0.23	0.03	.	-0.22	-0.19	-0.21	0.01
	Pvalue	.	0.24	0.86	.	0.26	0.34	0.28	0.96
control	Kendalls	.	-0.15	-0.02	.	0.15	-0.31	-0.23	-0.12
	Pvalue	.	0.45	0.93	.	0.43	0.11	0.23	0.52
sluggish	Kendalls	.	-0.21	0.05	.	-0.05	-0.24	-0.20	-0.07
	Pvalue	.	0.27	0.79	.	0.79	0.22	0.31	0.71
pitch	Kendalls	.	-0.15	0.02	.	-0.13	-0.28	-0.15	-0.18
	Pvalue	.	0.45	0.93	.	0.49	0.15	0.45	0.37

DAY 18		Cramps	Fatigue	Nauseous	Bloated	Cravings	Headaches	Dizzy	Sleeping
Peak form	Kendalls	0.07	-0.04	-0.19	-0.19	-0.09	0.00	0.01	0.12
	Pvalue	0.72	0.85	0.31	0.30	0.65	1.00	0.96	0.51
fatigued voice	Kendalls	0.06	-0.18	-0.18	-0.20	-0.11	0.03	0.04	-0.16
	Pvalue	0.76	0.35	0.34	0.28	0.55	0.87	0.84	0.40
effort	Kendalls	0.00	-0.32	-0.20	-0.04	-0.02	0.02	0.02	-0.15
	Pvalue	1.00	0.09	0.28	0.82	0.92	0.93	0.92	0.44
support	Kendalls	-0.08	-0.23	-0.24	-0.13	-0.08	-0.05	-0.01	0.01
	Pvalue	0.65	0.22	0.21	0.50	0.65	0.80	0.96	0.95
hoarse	Kendalls	-0.18	-0.45	-0.29	-0.07	-0.15	-0.12	-0.07	-0.21
	Pvalue	0.34	0.02	0.12	0.72	0.42	0.51	0.72	0.25
weak	Kendalls	-0.11	-0.24	-0.25	-0.02	-0.09	-0.09	-0.02	-0.20
	Pvalue	0.55	0.20	0.19	0.93	0.61	0.62	0.92	0.28
range	Kendalls	-0.08	-0.51	-0.22	-0.03	-0.11	-0.06	0.00	-0.19
	Pvalue	0.69	0.01	0.23	0.86	0.55	0.74	1.00	0.31
control	Kendalls	-0.04	-0.40	-0.25	-0.03	-0.08	-0.06	-0.02	0.02
	Pvalue	0.84	0.03	0.19	0.86	0.69	0.74	0.92	0.90
sluggish	Kendalls	-0.18	-0.17	-0.33	0.16	0.11	-0.14	-0.09	0.03
	Pvalue	0.34	0.37	0.08	0.39	0.55	0.46	0.61	0.86
pitch	Kendalls	-0.17	-0.32	-0.32	0.03	0.02	-0.12	-0.09	-0.16
	Pvalue	0.36	0.09	0.09	0.86	0.92	0.51	0.65	0.40

Appendix 7

Kendall's correlation between mood and voice quality by day in females – part 1

DAY 1		Relaxed	Discouraged	Annoyed	Sad	Concentrate	Energetic	Forgetful	Tense
Peak form	Kendalls	-0.23	-0.31	-0.44	-0.28	-0.34	-0.17	-0.35	-0.35
	Pvalue	0.18	0.08	0.01	0.10	0.06	0.34	0.05	0.04
fatigued voice	Kendalls	-0.14	-0.41	-0.36	-0.27	-0.34	-0.04	-0.39	-0.33
	Pvalue	0.42	0.02	0.04	0.12	0.06	0.82	0.03	0.06
effort	Kendalls	-0.13	-0.24	-0.12	-0.03	-0.30	-0.03	-0.39	-0.31
	Pvalue	0.45	0.17	0.50	0.85	0.09	0.87	0.03	0.07
support	Kendalls	-0.26	-0.42	-0.27	-0.26	-0.39	-0.24	-0.44	-0.32
	Pvalue	0.13	0.02	0.12	0.13	0.03	0.17	0.01	0.06
hoarse	Kendalls	-0.26	-0.39	-0.26	-0.30	-0.36	-0.10	-0.33	-0.09
	Pvalue	0.13	0.03	0.13	0.08	0.04	0.59	0.06	0.59
weak	Kendalls	-0.18	-0.38	-0.28	-0.30	-0.33	-0.10	-0.36	-0.22
	Pvalue	0.30	0.03	0.11	0.08	0.06	0.59	0.04	0.20
range	Kendalls	-0.13	-0.28	-0.29	-0.18	-0.15	0.02	-0.19	-0.09
	Pvalue	0.45	0.10	0.10	0.31	0.41	0.92	0.28	0.61
control	Kendalls	-0.25	-0.39	-0.39	-0.29	-0.23	-0.06	-0.25	-0.27
	Pvalue	0.15	0.02	0.03	0.09	0.20	0.72	0.16	0.12
sluggish	Kendalls	-0.49	-0.55	-0.48	-0.35	-0.44	-0.35	-0.46	-0.36
	Pvalue	0.00	0.00	0.01	0.04	0.01	0.04	0.01	0.04
pitch	Kendalls	-0.43	-0.49	-0.44	-0.35	-0.35	-0.45	-0.34	-0.21
	Pvalue	0.01	0.00	0.01	0.04	0.05	0.01	0.05	0.22

DAY 3		Relaxed	Discouraged	Annoyed	Sad	Concentrate	Energetic	Forgetful	Tense
Peak form	Kendalls	-0.28	-0.12	0.07	-0.22	-0.12	-0.29	-0.33	-0.11
	Pvalue	0.11	0.50	0.72	0.22	0.49	0.10	0.07	0.54
fatigued voice	Kendalls	-0.56	-0.23	-0.27	-0.56	-0.10	-0.09	-0.22	-0.39
	Pvalue	0.00	0.19	0.14	0.00	0.57	0.59	0.23	0.02
effort	Kendalls	-0.43	-0.39	-0.41	-0.48	-0.19	0.02	-0.26	-0.37
	Pvalue	0.01	0.03	0.02	0.01	0.28	0.90	0.14	0.03
support	Kendalls	-0.46	-0.60	-0.56	-0.47	-0.33	0.11	-0.34	-0.38
	Pvalue	0.01	0.00	0.00	0.01	0.06	0.53	0.06	0.03
hoarse	Kendalls	-0.36	-0.42	-0.34	-0.32	-0.11	-0.03	-0.27	-0.19
	Pvalue	0.04	0.02	0.05	0.07	0.53	0.85	0.13	0.28
weak	Kendalls	-0.63	-0.56	-0.62	-0.54	-0.23	0.10	-0.31	-0.56
	Pvalue	0.00	0.00	0.00	0.00	0.18	0.55	0.09	0.00
range	Kendalls	-0.44	-0.63	-0.50	-0.54	-0.26	0.00	-0.44	-0.43
	Pvalue	0.01	0.00	0.01	0.00	0.14	1.00	0.01	0.01
control	Kendalls	-0.44	-0.47	-0.46	-0.57	-0.28	-0.03	-0.32	-0.41
	Pvalue	0.01	0.01	0.01	0.00	0.11	0.88	0.08	0.02
sluggish	Kendalls	-0.44	-0.36	-0.46	-0.48	-0.19	-0.05	-0.29	-0.46
	Pvalue	0.01	0.04	0.01	0.01	0.27	0.78	0.11	0.01
pitch	Kendalls	-0.33	-0.42	-0.28	-0.43	-0.06	0.04	-0.40	-0.25
	Pvalue	0.06	0.02	0.12	0.02	0.73	0.80	0.03	0.16

DAY 7		Relaxed	Discouraged	Annoyed	Sad	Concentrate	Energetic	Forgetful	Tense
Peak form	Kendalls	-0.31	-0.12	-0.14	0.02	-0.30	-0.35	-0.13	-0.24
	Pvalue	0.07	0.48	0.42	0.90	0.08	0.05	0.46	0.17
fatigued voice	Kendalls	0.20	-0.07	0.00	0.06	-0.14	-0.04	0.02	-0.04
	Pvalue	0.24	0.70	1.00	0.72	0.44	0.82	0.92	0.82
effort	Kendalls	-0.09	-0.28	-0.40	-0.17	-0.35	-0.14	-0.37	-0.42
	Pvalue	0.59	0.10	0.02	0.33	0.05	0.43	0.04	0.02
support	Kendalls	-0.11	-0.28	-0.35	-0.07	-0.34	-0.16	-0.35	-0.36
	Pvalue	0.51	0.10	0.05	0.67	0.05	0.36	0.06	0.04
hoarse	Kendalls	-0.07	-0.25	-0.20	-0.11	-0.32	-0.23	-0.23	-0.21
	Pvalue	0.68	0.15	0.26	0.54	0.07	0.20	0.20	0.23
weak	Kendalls	-0.06	-0.26	-0.34	-0.04	-0.35	-0.14	-0.34	-0.25
	Pvalue	0.71	0.13	0.06	0.82	0.05	0.43	0.06	0.16
range	Kendalls	-0.08	-0.40	-0.46	-0.29	-0.31	-0.08	-0.35	-0.44
	Pvalue	0.64	0.02	0.01	0.09	0.08	0.65	0.06	0.01
control	Kendalls	-0.03	-0.33	-0.53	-0.11	-0.30	0.13	-0.42	-0.48
	Pvalue	0.85	0.06	0.00	0.54	0.08	0.47	0.02	0.01
sluggish	Kendalls	-0.14	-0.31	-0.44	-0.02	-0.15	-0.02	-0.43	-0.42
	Pvalue	0.43	0.07	0.01	0.90	0.40	0.92	0.02	0.02
pitch	Kendalls	-0.00	-0.07	-0.11	-0.16	-0.30	0.04	-0.12	-0.20
	Pvalue	1.00	0.70	0.55	0.36	0.09	0.84	0.52	0.26

DAY 14		Relaxed	Discouraged	Annoyed	Sad	Concentrate	Energetic	Forgetful	Tense
Peak form	Kendalls	-0.32	-0.42	-0.12	-0.29	0.04	-0.24	0.02	-0.18
	Pvalue	0.08	0.03	0.51	0.12	0.82	0.18	0.91	0.33
fatigued voice	Kendalls	-0.27	-0.39	-0.26	-0.50	-0.06	-0.24	-0.15	-0.37
	Pvalue	0.14	0.04	0.16	0.01	0.77	0.17	0.42	0.04
effort	Kendalls	-0.13	-0.35	-0.12	-0.28	-0.07	-0.19	0.08	-0.24
	Pvalue	0.46	0.07	0.54	0.14	0.71	0.27	0.67	0.19
support	Kendalls	-0.11	-0.28	-0.24	-0.36	-0.11	-0.09	-0.05	-0.18
	Pvalue	0.55	0.14	0.21	0.06	0.58	0.61	0.79	0.33
hoarse	Kendalls	-0.27	-0.26	-0.02	-0.31	-0.22	-0.18	-0.05	-0.35
	Pvalue	0.13	0.16	0.93	0.09	0.24	0.30	0.79	0.05
weak	Kendalls	-0.20	-0.27	-0.08	-0.41	-0.06	-0.24	-0.02	-0.33
	Pvalue	0.26	0.15	0.70	0.03	0.74	0.17	0.91	0.07
range	Kendalls	-0.06	-0.15	-0.43	-0.40	-0.06	-0.05	-0.07	-0.20
	Pvalue	0.73	0.42	0.02	0.03	0.74	0.79	0.73	0.26
control	Kendalls	-0.09	-0.28	-0.22	-0.49	-0.03	-0.30	-0.12	-0.43
	Pvalue	0.63	0.14	0.26	0.01	0.85	0.09	0.54	0.02
sluggish	Kendalls	-0.17	-0.40	-0.20	-0.37	-0.09	-0.24	-0.01	-0.31
	Pvalue	0.36	0.03	0.30	0.05	0.63	0.17	0.97	0.09
pitch	Kendalls	-0.24	-0.42	-0.48	-0.64	0.03	-0.28	-0.16	-0.36
	Pvalue	0.18	0.02	0.01	0.00	0.88	0.11	0.39	0.05

DAY 18		Relaxed	Discouraged	Annoyed	Sad	Concentrate	Energetic	Forgetful	Tense
Peak form	Kendalls	-0.51	-0.43	-0.27	-0.02	-0.02	-0.28	-0.40	-0.15
	Pvalue	0.00	0.02	0.13	0.91	0.89	0.11	0.03	0.41
fatigued voice	Kendalls	-0.43	-0.48	-0.20	-0.27	-0.19	-0.43	-0.43	-0.28
	Pvalue	0.02	0.01	0.26	0.14	0.30	0.01	0.02	0.12
effort	Kendalls	-0.36	-0.42	-0.43	-0.35	-0.27	-0.27	-0.42	-0.28
	Pvalue	0.05	0.02	0.02	0.06	0.14	0.12	0.02	0.13
support	Kendalls	-0.35	-0.41	-0.42	-0.41	-0.42	-0.18	-0.51	-0.12
	Pvalue	0.05	0.02	0.02	0.03	0.02	0.31	0.00	0.50
hoarse	Kendalls	-0.25	-0.27	-0.26	-0.40	-0.26	-0.39	-0.31	-0.20
	Pvalue	0.16	0.13	0.15	0.04	0.16	0.03	0.09	0.28
weak	Kendalls	-0.27	-0.41	-0.28	-0.52	-0.47	-0.32	-0.45	-0.14
	Pvalue	0.13	0.02	0.12	0.01	0.01	0.07	0.01	0.43
range	Kendalls	-0.21	-0.06	-0.19	-0.11	-0.32	-0.30	-0.22	-0.06
	Pvalue	0.23	0.76	0.29	0.55	0.08	0.09	0.22	0.76
control	Kendalls	-0.28	-0.32	-0.36	-0.23	-0.43	-0.17	-0.55	-0.30
	Pvalue	0.11	0.08	0.04	0.23	0.02	0.34	0.00	0.10
sluggish	Kendalls	-0.32	-0.45	-0.43	-0.32	-0.32	0.01	-0.36	-0.17
	Pvalue	0.07	0.01	0.02	0.09	0.08	0.95	0.05	0.36
pitch	Kendalls	-0.41	-0.29	-0.28	-0.11	-0.09	-0.25	-0.17	-0.04
	Pvalue	0.02	0.12	0.13	0.57	0.61	0.15	0.35	0.81

Appendix 8

Kendall's correlation between mood and voice quality by day in females – part 2

DAY 1		Exhausted	Cheerful	Angry	Fatigued	Happy	Total mood
Peak form	Kendalls	-0.40	-0.10	-0.17	-0.47	-0.18	-0.34
	Pvalue	0.02	0.56	0.35	0.01	0.30	0.03
fatigued voice	Kendalls	-0.37	-0.14	-0.13	-0.48	-0.16	-0.31
	Pvalue	0.03	0.40	0.49	0.00	0.34	0.05
effort	Kendalls	-0.37	0.06	-0.11	-0.33	0.08	-0.19
	Pvalue	0.03	0.75	0.56	0.05	0.64	0.24
support	Kendalls	-0.44	-0.28	-0.14	-0.54	-0.21	-0.36
	Pvalue	0.01	0.11	0.44	0.00	0.22	0.02
hoarse	Kendalls	-0.34	-0.38	-0.21	-0.42	-0.35	-0.37
	Pvalue	0.04	0.03	0.26	0.01	0.04	0.02
weak	Kendalls	-0.40	-0.26	-0.21	-0.43	-0.33	-0.35
	Pvalue	0.02	0.14	0.25	0.01	0.05	0.03
range	Kendalls	-0.35	-0.26	-0.06	-0.40	-0.25	-0.25
	Pvalue	0.04	0.13	0.76	0.02	0.15	0.12
control	Kendalls	-0.41	-0.39	-0.14	-0.48	-0.28	-0.38
	Pvalue	0.02	0.02	0.46	0.00	0.10	0.02
sluggish	Kendalls	-0.38	-0.43	-0.30	-0.47	-0.42	-0.50
	Pvalue	0.02	0.01	0.10	0.01	0.01	0.00
pitch	Kendalls	-0.37	-0.52	-0.31	-0.47	-0.58	-0.49
	Pvalue	0.03	0.00	0.09	0.01	0.00	0.00

DAY 3		Exhausted	Cheerful	Angry	Fatigued	Happy	Total mood
Peak form	Kendalls	-0.31	-0.38	0.13	-0.60	-0.36	-0.32
	Pvalue	0.07	0.03	0.49	0.00	0.04	0.05
fatigued voice	Kendalls	-0.46	-0.46	-0.30	-0.28	-0.28	-0.40
	Pvalue	0.01	0.01	0.10	0.11	0.11	0.01
effort	Kendalls	-0.44	-0.36	-0.37	-0.22	-0.32	-0.41
	Pvalue	0.01	0.04	0.04	0.19	0.06	0.01
support	Kendalls	-0.35	-0.30	-0.56	-0.16	-0.26	-0.41
	Pvalue	0.04	0.08	0.00	0.35	0.13	0.01
hoarse	Kendalls	-0.27	-0.38	-0.32	-0.07	-0.25	-0.35
	Pvalue	0.11	0.03	0.08	0.69	0.15	0.03
weak	Kendalls	-0.23	-0.32	-0.58	-0.05	-0.21	-0.40
	Pvalue	0.18	0.06	0.00	0.76	0.22	0.01
range	Kendalls	-0.42	-0.37	-0.43	-0.22	-0.27	-0.48
	Pvalue	0.01	0.03	0.02	0.20	0.12	0.00
control	Kendalls	-0.46	-0.38	-0.41	-0.24	-0.27	-0.47
	Pvalue	0.01	0.03	0.03	0.16	0.11	0.00
sluggish	Kendalls	-0.43	-0.32	-0.45	-0.21	-0.26	-0.43
	Pvalue	0.01	0.06	0.01	0.21	0.13	0.01
pitch	Kendalls	-0.40	-0.29	-0.24	-0.19	-0.23	-0.32
	Pvalue	0.02	0.09	0.19	0.26	0.18	0.05

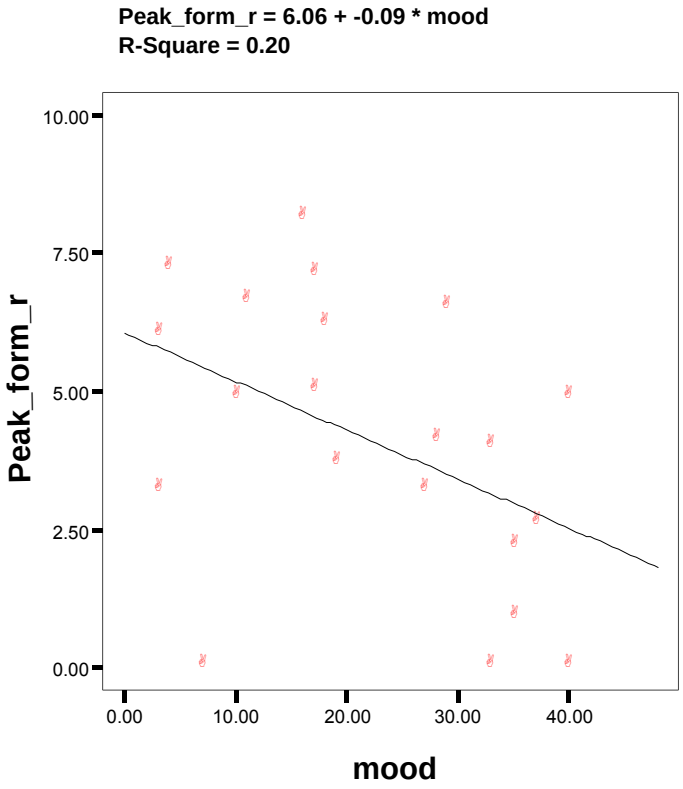
DAY 7		Exhausted	Cheerful	Angry	Fatigued	Happy	Total mood
Peak form	Kendalls	-0.06	-0.32	-0.13	-0.13	-0.31	-0.29
	Pvalue	0.71	0.06	0.46	0.47	0.07	0.07
fatigued voice	Kendalls	-0.14	-0.12	-0.05	-0.02	0.07	-0.08
	Pvalue	0.43	0.47	0.77	0.92	0.69	0.63
effort	Kendalls	-0.16	-0.16	-0.31	-0.13	-0.11	-0.27
	Pvalue	0.34	0.35	0.09	0.45	0.51	0.10
support	Kendalls	-0.07	-0.18	-0.35	-0.07	-0.09	-0.25
	Pvalue	0.68	0.29	0.05	0.70	0.60	0.12
hoarse	Kendalls	-0.18	-0.27	-0.31	-0.07	-0.08	-0.24
	Pvalue	0.30	0.12	0.09	0.68	0.64	0.13
weak	Kendalls	-0.17	-0.23	-0.29	-0.08	-0.02	-0.23
	Pvalue	0.31	0.19	0.11	0.66	0.90	0.15
range	Kendalls	-0.13	-0.09	-0.19	-0.19	-0.18	-0.31
	Pvalue	0.47	0.59	0.29	0.27	0.30	0.05
control	Kendalls	-0.03	-0.05	-0.22	-0.11	-0.12	-0.25
	Pvalue	0.85	0.78	0.24	0.53	0.47	0.11
sluggish	Kendalls	0.02	-0.15	-0.18	-0.13	-0.29	-0.27
	Pvalue	0.90	0.40	0.33	0.46	0.09	0.09
pitch	Kendalls	-0.07	-0.07	-0.14	0.04	0.01	-0.10
	Pvalue	0.68	0.68	0.46	0.80	0.95	0.52

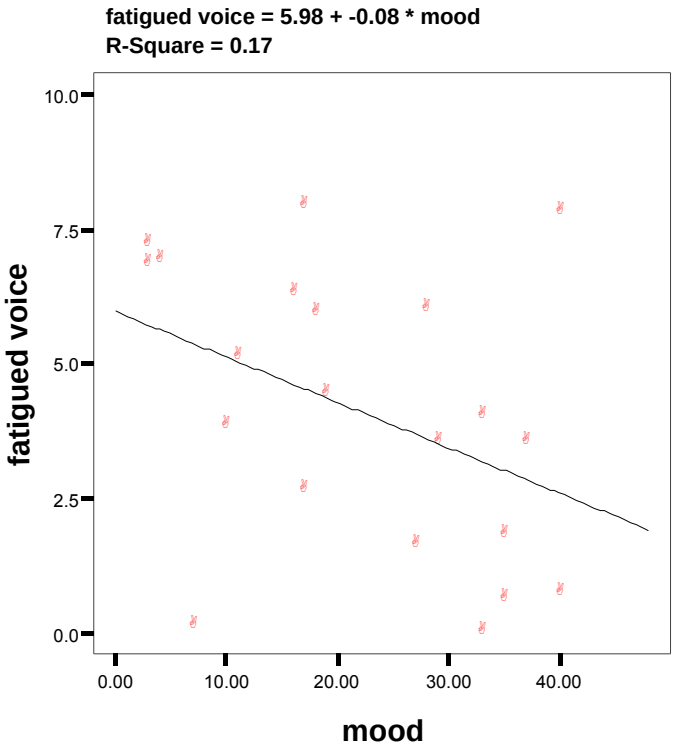
DAY 14		Exhausted	Cheerful	Angry	Fatigued	Happy	Total mood
Peak form	Kendalls	0.08	-0.48	-0.10	-0.01	-0.50	-0.28
	Pvalue	0.65	0.01	0.61	0.97	0.01	0.10
fatigued voice	Kendalls	-0.07	-0.39	-0.27	-0.23	-0.41	-0.42
	Pvalue	0.70	0.03	0.16	0.21	0.02	0.01
effort	Kendalls	0.05	-0.47	-0.15	-0.17	-0.37	-0.21
	Pvalue	0.78	0.01	0.45	0.34	0.04	0.20
support	Kendalls	-0.10	-0.44	-0.22	-0.14	-0.28	-0.20
	Pvalue	0.60	0.02	0.25	0.43	0.12	0.24
hoarse	Kendalls	-0.04	-0.53	-0.27	-0.21	-0.54	-0.31
	Pvalue	0.81	0.00	0.16	0.23	0.00	0.06
weak	Kendalls	0.07	-0.52	-0.25	-0.14	-0.47	-0.32
	Pvalue	0.70	0.00	0.21	0.43	0.01	0.06
range	Kendalls	-0.19	-0.22	-0.27	-0.32	-0.14	-0.24
	Pvalue	0.30	0.23	0.16	0.08	0.43	0.14
control	Kendalls	-0.08	-0.41	-0.21	-0.23	-0.38	-0.37
	Pvalue	0.65	0.02	0.28	0.20	0.03	0.02
sluggish	Kendalls	-0.08	-0.47	-0.16	-0.33	-0.38	-0.30
	Pvalue	0.65	0.01	0.41	0.07	0.04	0.07
pitch	Kendalls	-0.12	-0.46	-0.25	-0.25	-0.40	-0.47
	Pvalue	0.51	0.01	0.21	0.16	0.03	0.00

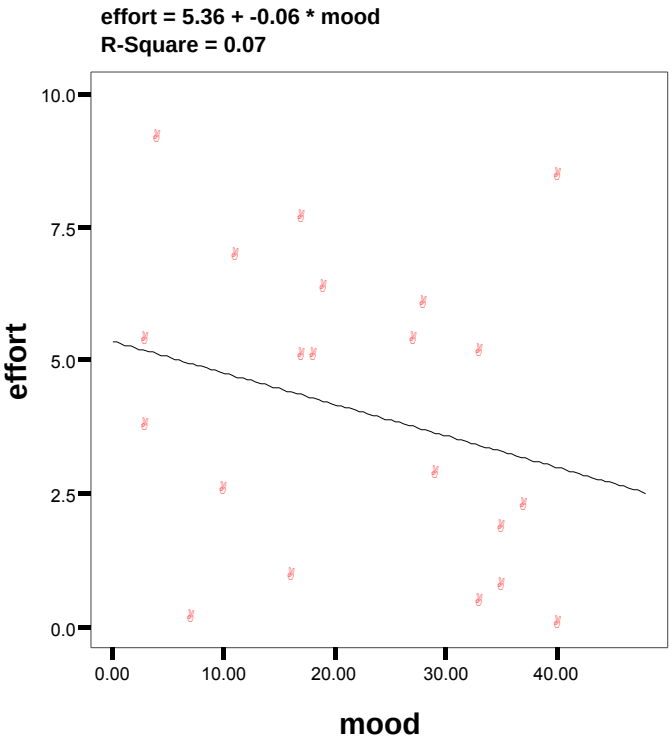
DAY 18		Exhausted	Cheerful	Angry	Fatigued	Happy	Total mood
Peak form	Kendalls	-0.03	-0.20	-0.34	-0.20	-0.10	-0.29
	Pvalue	0.85	0.25	0.06	0.24	0.55	0.08
fatigued voice	Kendalls	-0.26	-0.37	-0.25	-0.41	-0.38	-0.50
	Pvalue	0.13	0.03	0.18	0.02	0.03	0.00
effort	Kendalls	-0.29	-0.35	-0.30	-0.36	-0.33	-0.50
	Pvalue	0.09	0.05	0.10	0.04	0.05	0.00
support	Kendalls	-0.18	-0.36	-0.37	-0.26	-0.27	-0.46
	Pvalue	0.30	0.04	0.04	0.13	0.11	0.00
hoarse	Kendalls	-0.34	-0.40	-0.40	-0.20	-0.39	-0.48
	Pvalue	0.05	0.02	0.03	0.24	0.02	0.00
weak	Kendalls	-0.20	-0.49	-0.26	-0.30	-0.43	-0.56
	Pvalue	0.26	0.00	0.15	0.08	0.01	0.00
range	Kendalls	-0.41	-0.24	-0.26	-0.14	-0.17	-0.29
	Pvalue	0.02	0.16	0.15	0.43	0.33	0.07
control	Kendalls	-0.31	-0.33	-0.34	-0.14	-0.25	-0.45
	Pvalue	0.08	0.06	0.06	0.41	0.14	0.01
sluggish	Kendalls	0.01	-0.34	-0.19	-0.02	-0.24	-0.34
	Pvalue	0.95	0.05	0.29	0.90	0.16	0.04
pitch	Kendalls	-0.11	-0.23	-0.28	-0.05	-0.11	-0.25
	Pvalue	0.54	0.19	0.12	0.77	0.53	0.12

Appendix 9

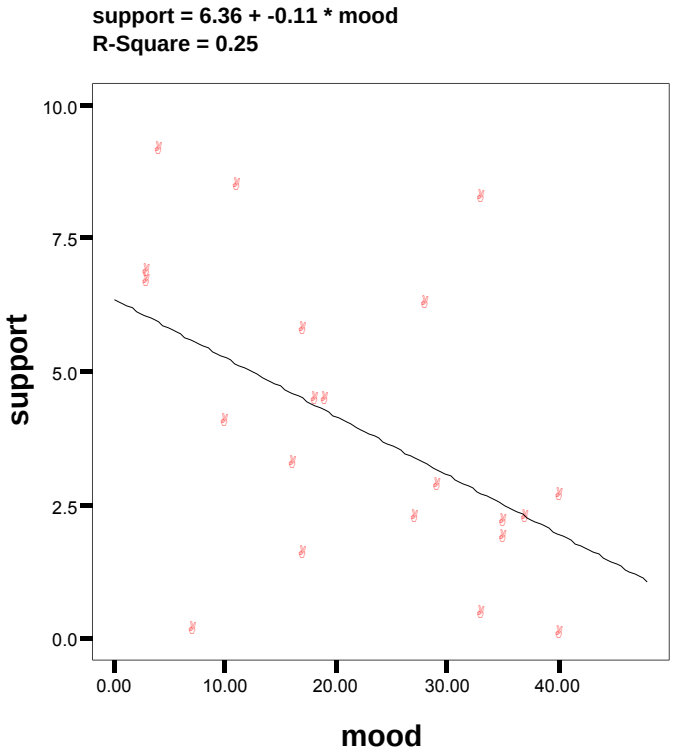
Relation between voice quality and total mood score in females



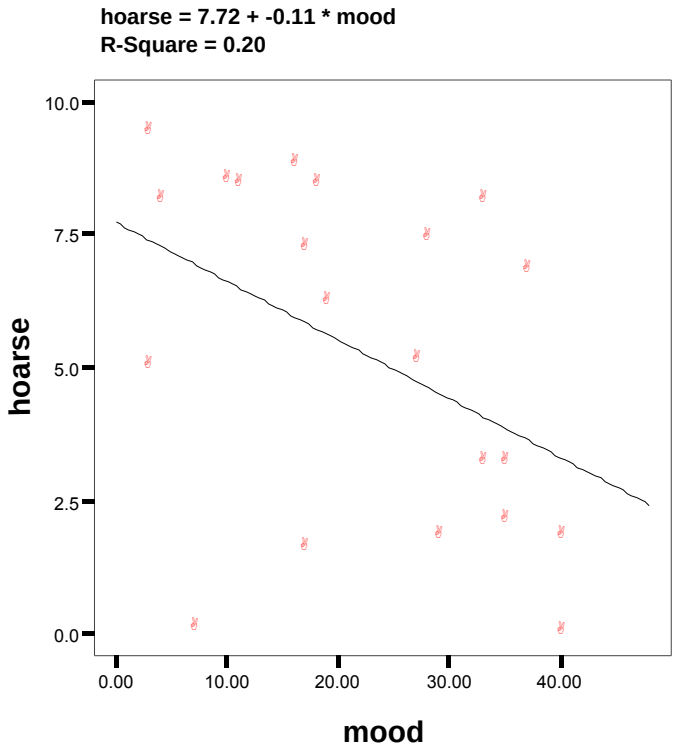


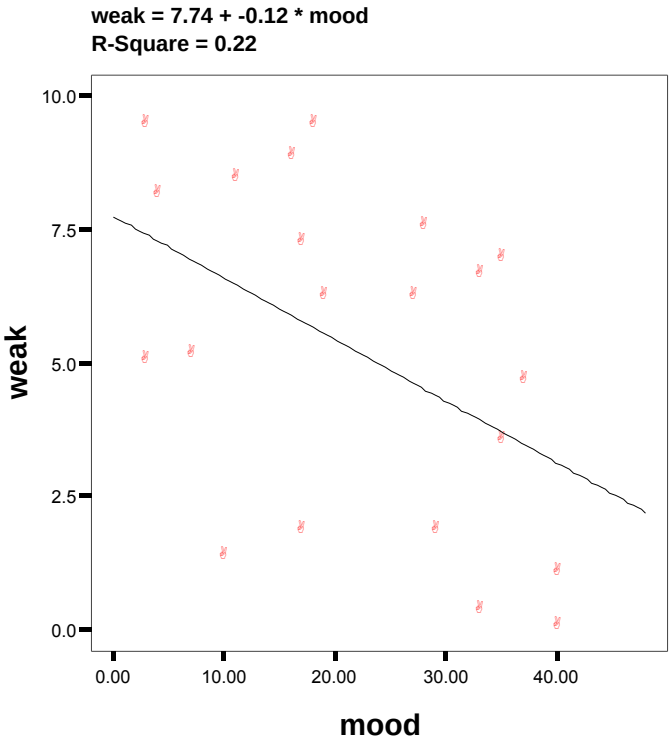


Linear Regression

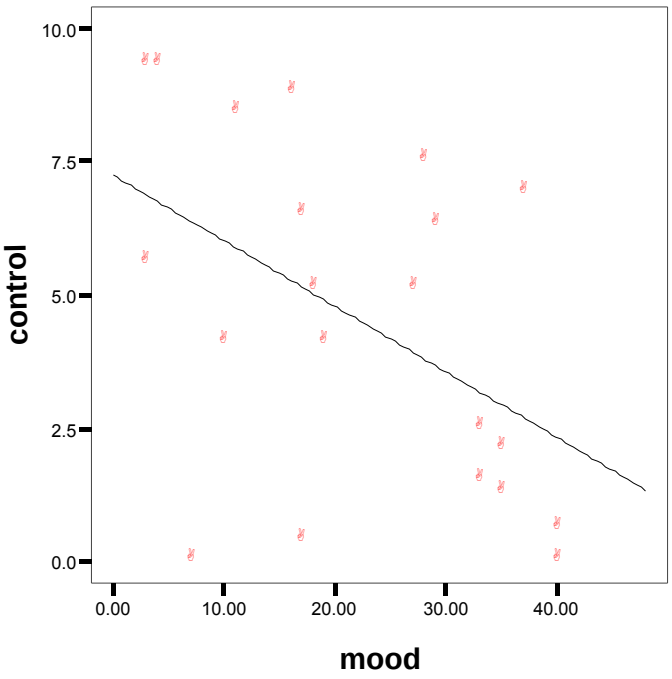


Linear Regression


hoarse = 7.72 + -0.11 * mood
R-Square = 0.20
Linear Regression
10.0
7.5
5.0
2.5
0.0
hoarse
0.00
10.00
20.00
30.00
40.00
mood

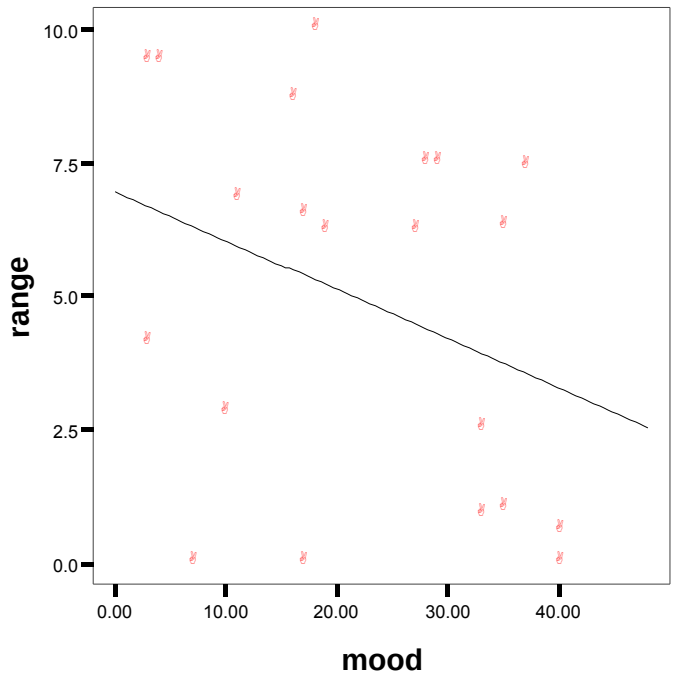

weak = 7.74 + -0.12 * mood
R-Square = 0.22
Linear Regression
10.0
7.5
5.0
2.5
0.0
weak
0.00
10.00
20.00
30.00
40.00
mood

control = 7.25 + -0.12 * mood
R-Square = 0.24

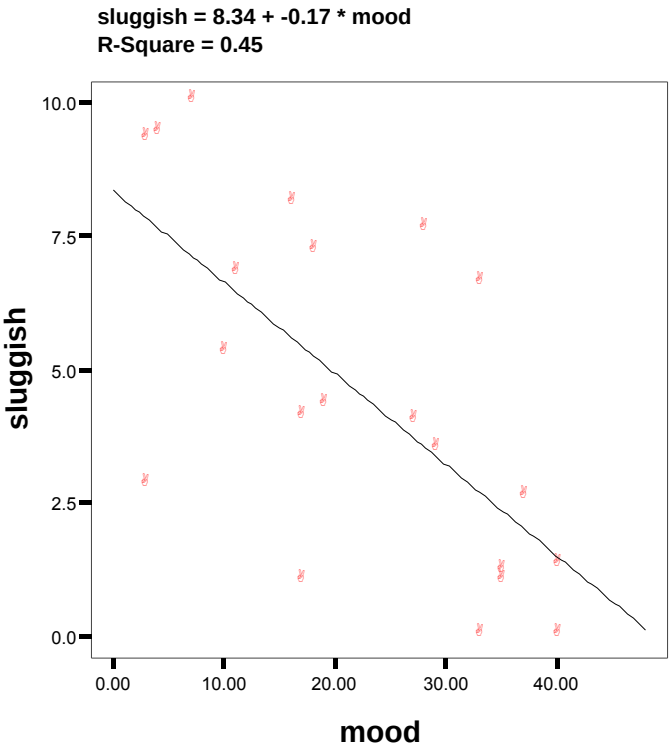


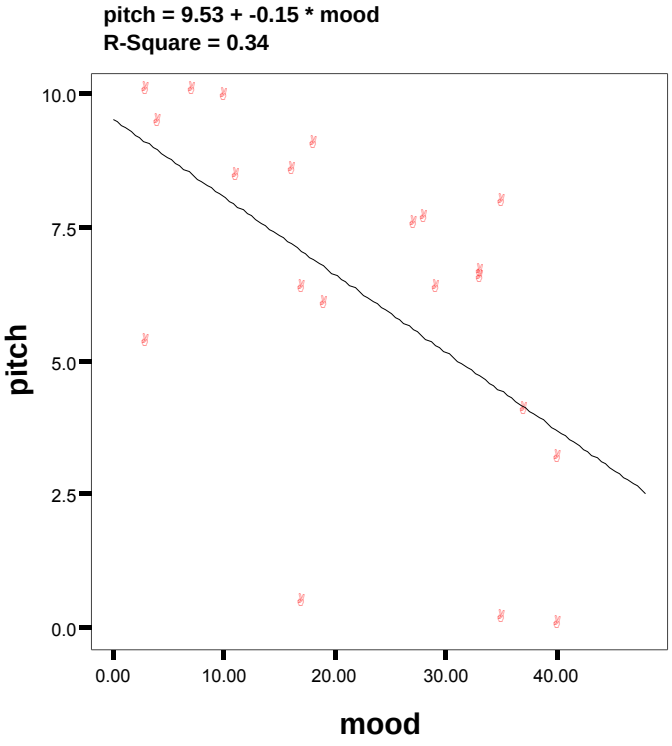
Linear Regression

range = 6.96 + -0.09 * mood
R-Square = 0.11



Linear Regression

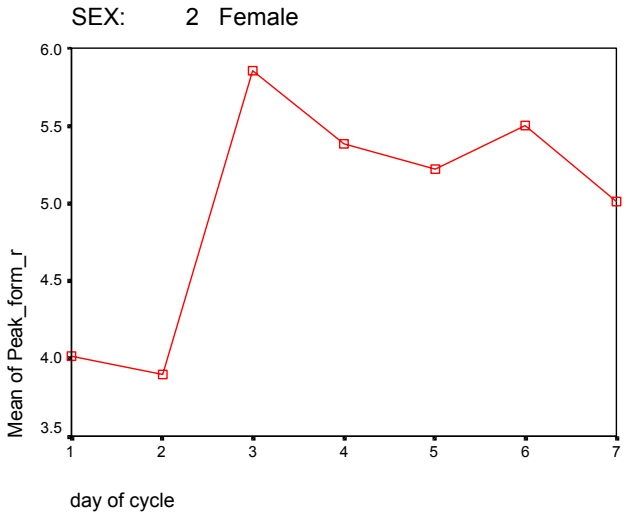

sluggish = 8.34 + -0.17 * mood
R-Square = 0.45
Linear Regression
sluggish
mood
10.0
7.5
5.0
2.5
0.0
0.00
10.00
20.00
30.00
40.00

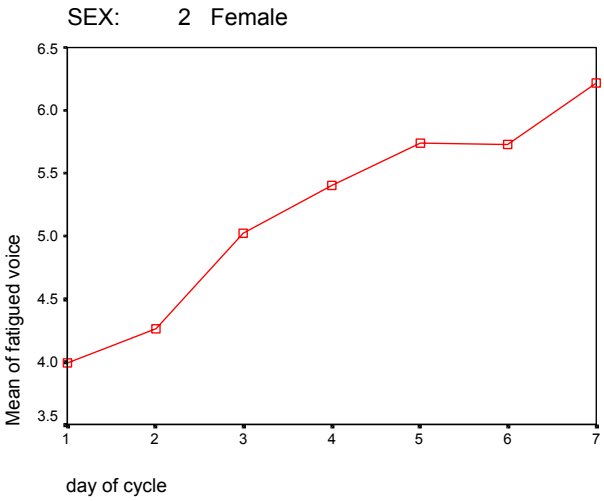

pitch = 9.53 + -0.15 * mood
R-Square = 0.34
Linear Regression
pitch
mood
10.0
7.5
5.0
2.5
0.0
0.00
10.00
20.00
30.00
40.00

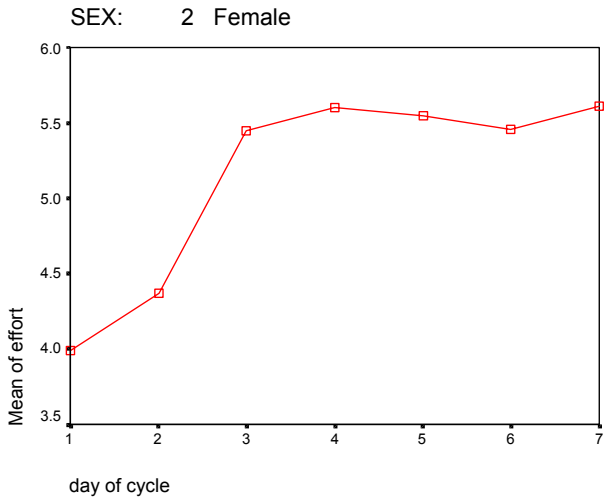
Appendix 10

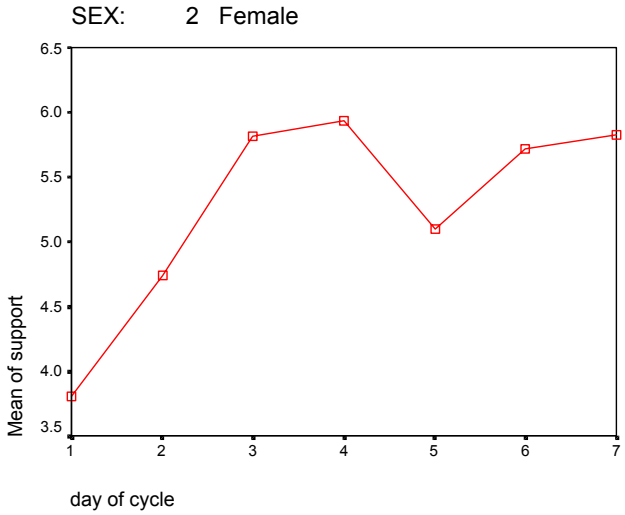
Plots of voice quality parameters in females over days 1-7 of the cycle

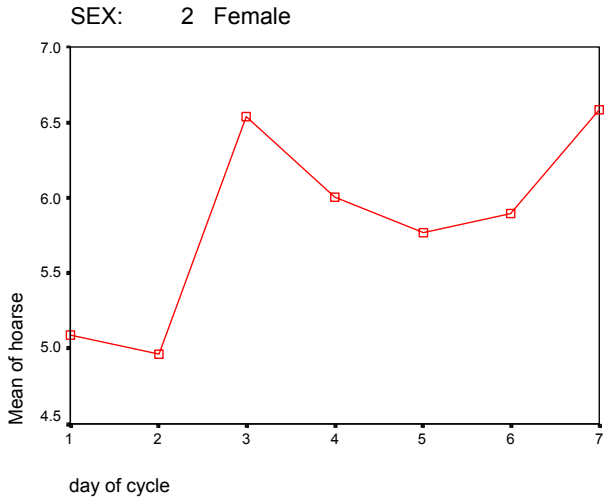
Means Plots



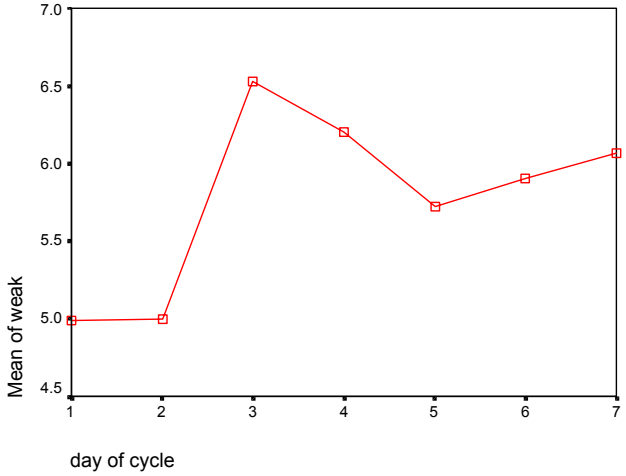



SEX: 2 Female
Mean of effort
6.0
5.5
5.0
4.5
4.0
3.5
1
2
3
4
5
6
7
day of cycle

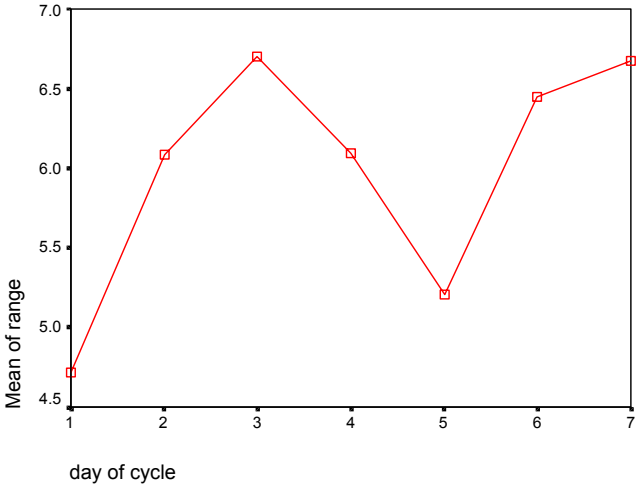

SEX: 2 Female
Mean of support
6.5
6.0
5.5
5.0
4.5
4.0
3.5
1
2
3
4
5
6
7
day of cycle


SEX: 2 Female
Mean of hoarse
7.0
6.5
6.0
5.5
5.0
4.5
1
2
3
4
5
6
7
day of cycle

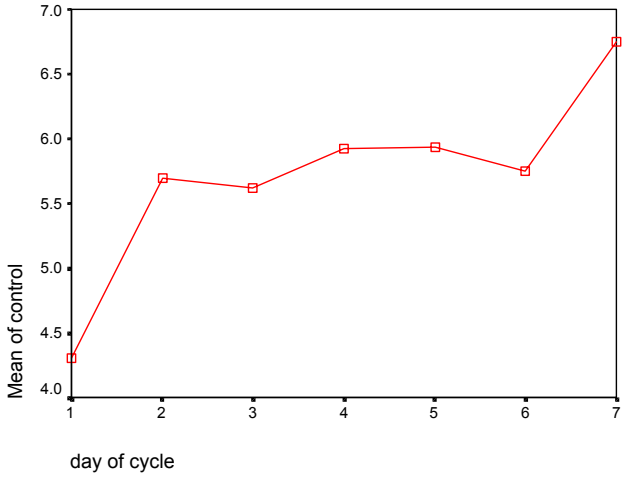
SEX: 2 Female



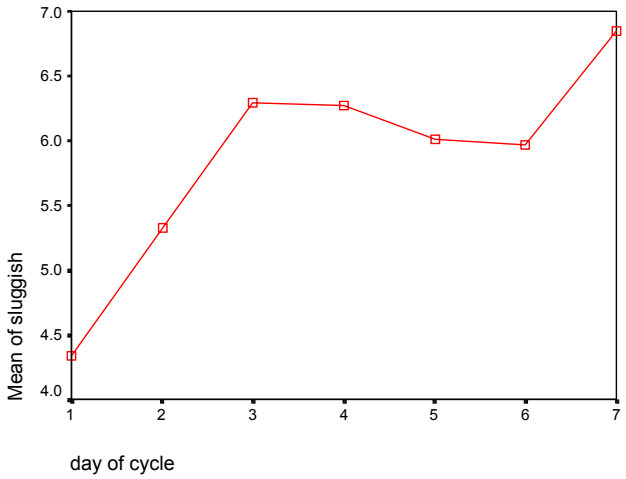
SEX: 2 Female



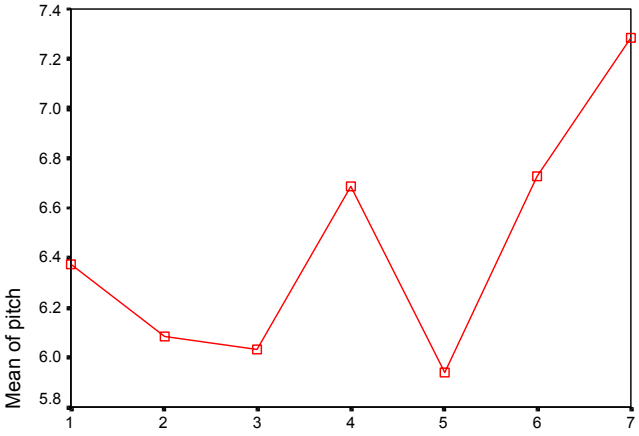
SEX: 2 Female



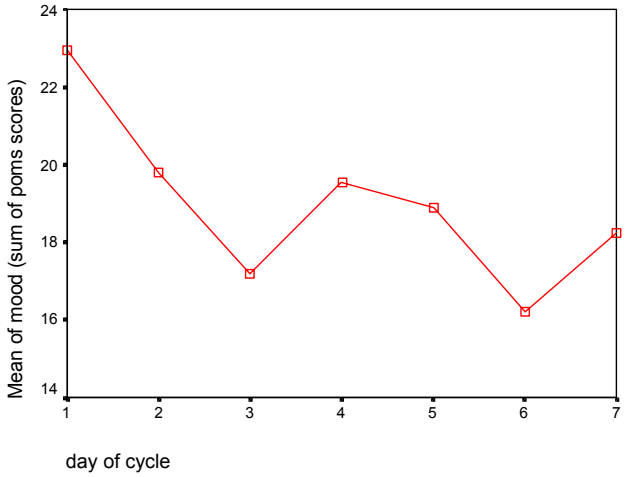
SEX: 2 Female



SEX: 2 Female



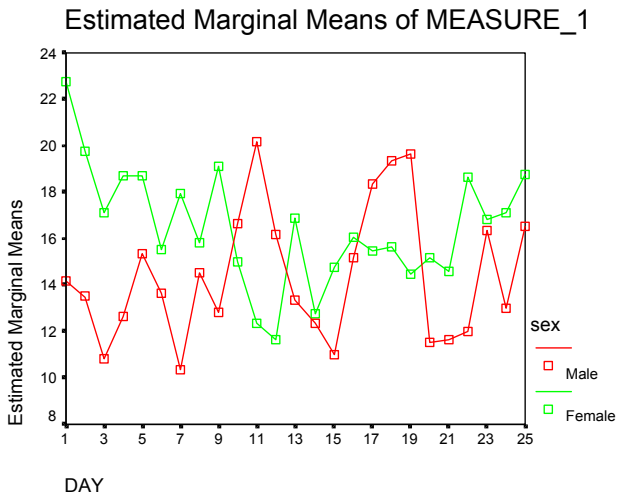
SEX: 2 Female



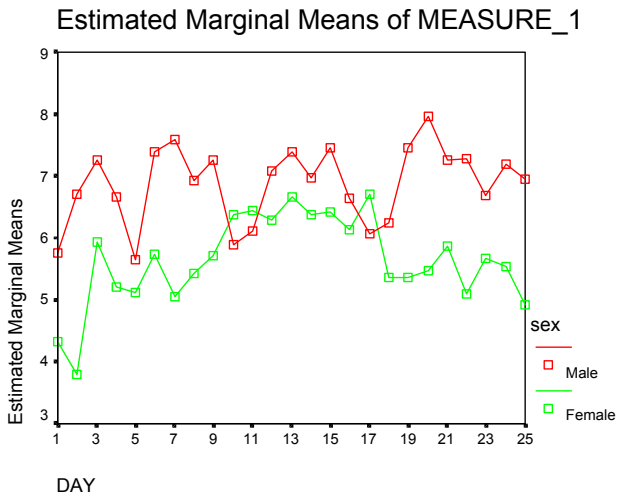
Appendix 11

Plots of mean voice quality over days 1-25 of cycle by gender

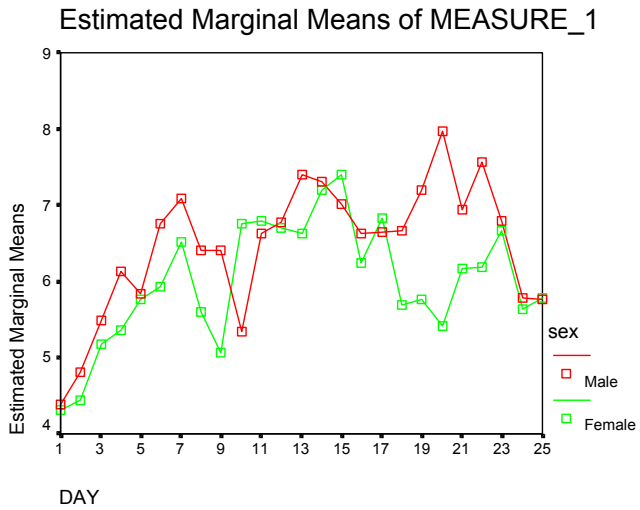
Mood



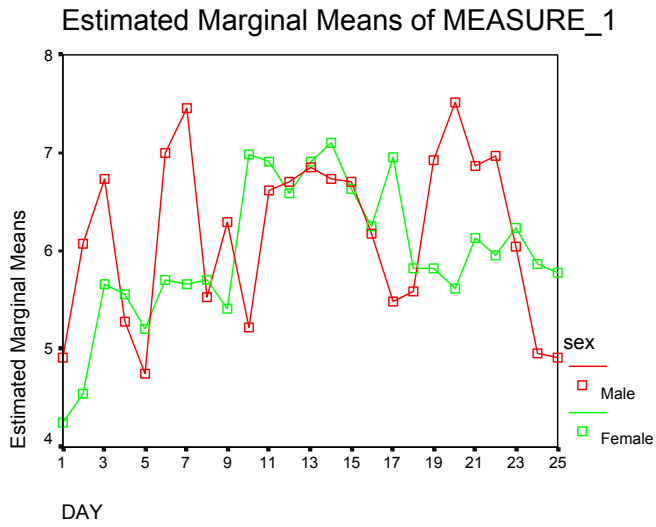
Peak form



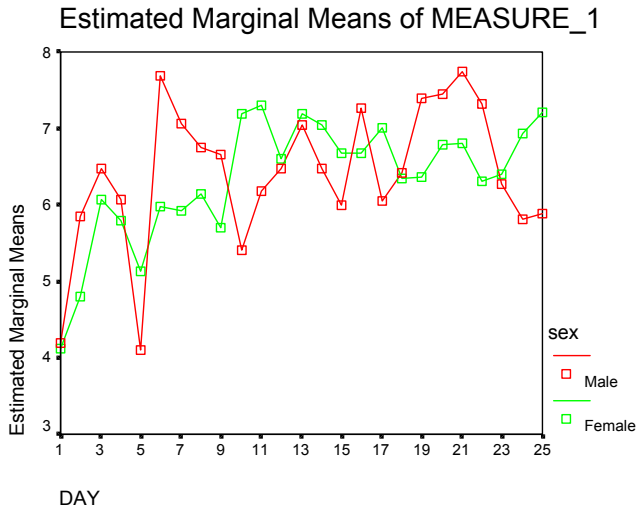
Fatigued



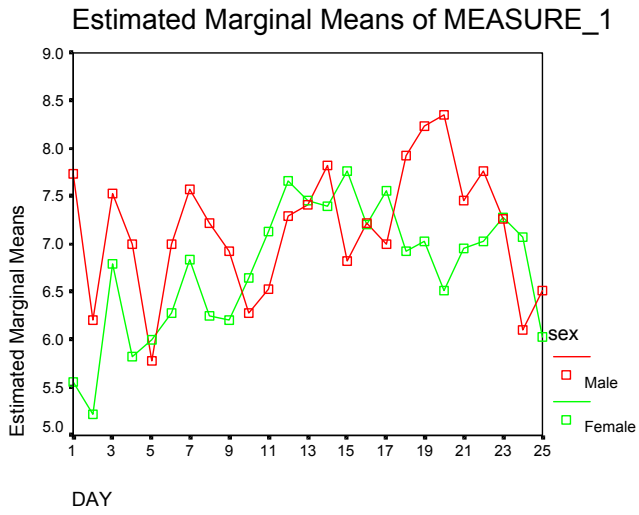
Effort



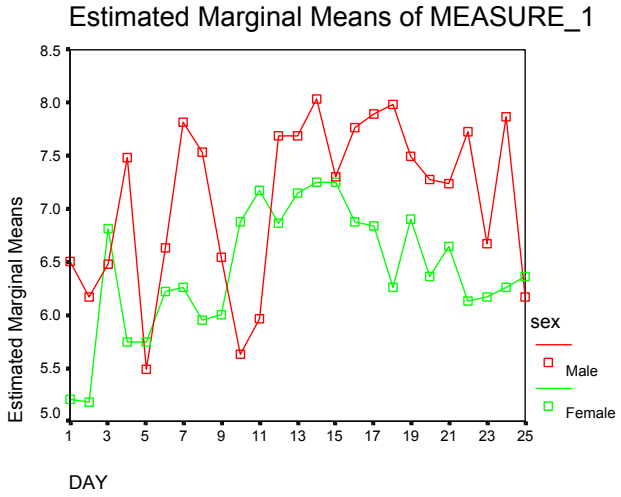
Support



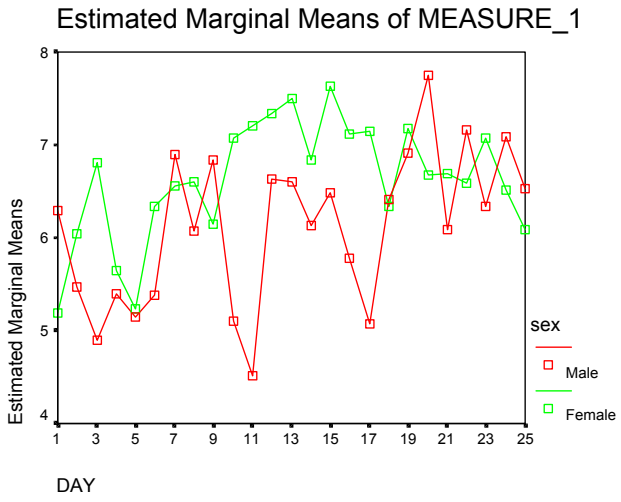
Hoarse



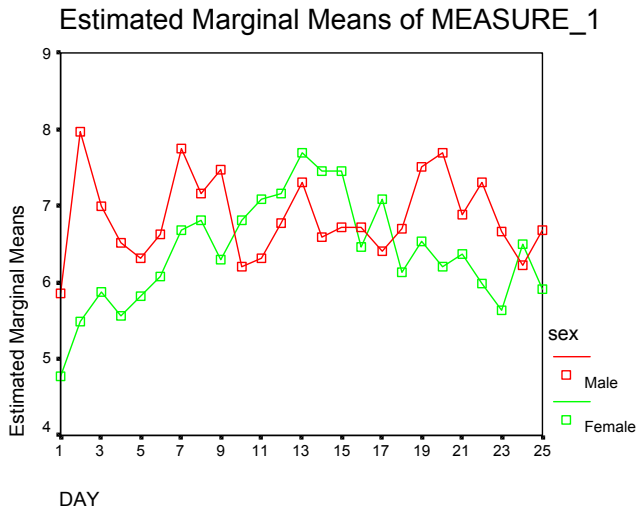
Weak



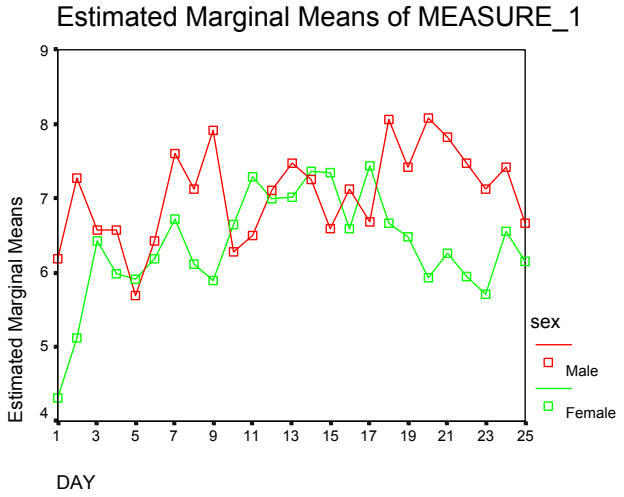
Range



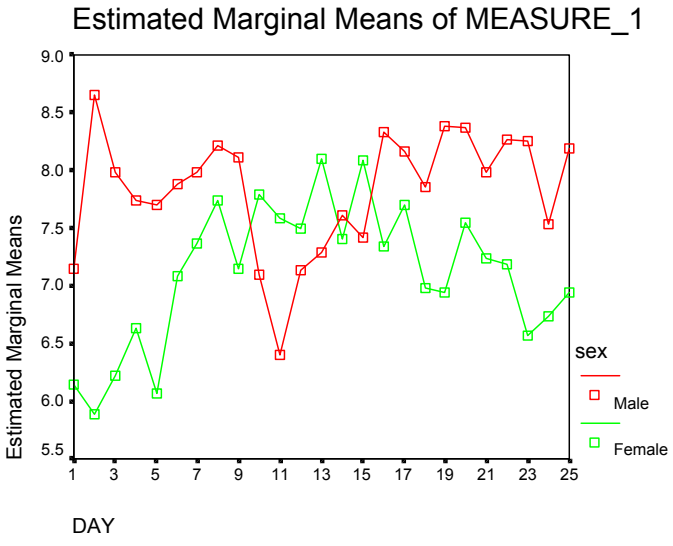
Control



Sluggish

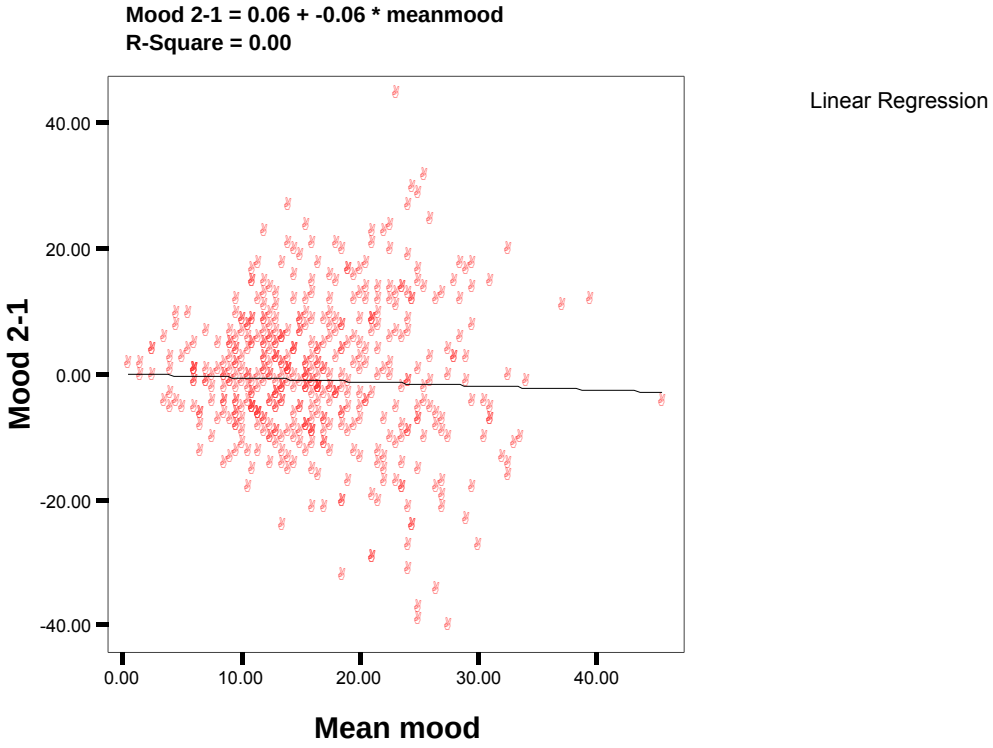


Pitch

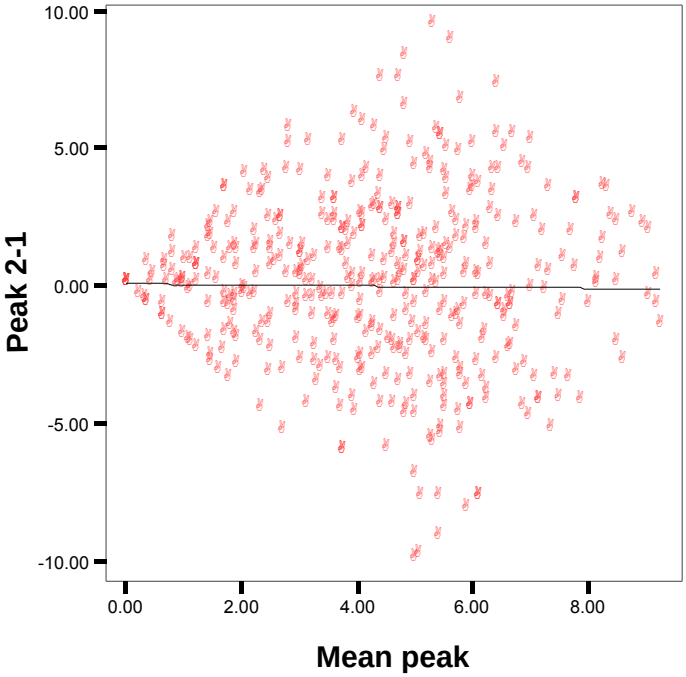


Appendix 12

Mean-vs- differences plots for mood and voice quality variables

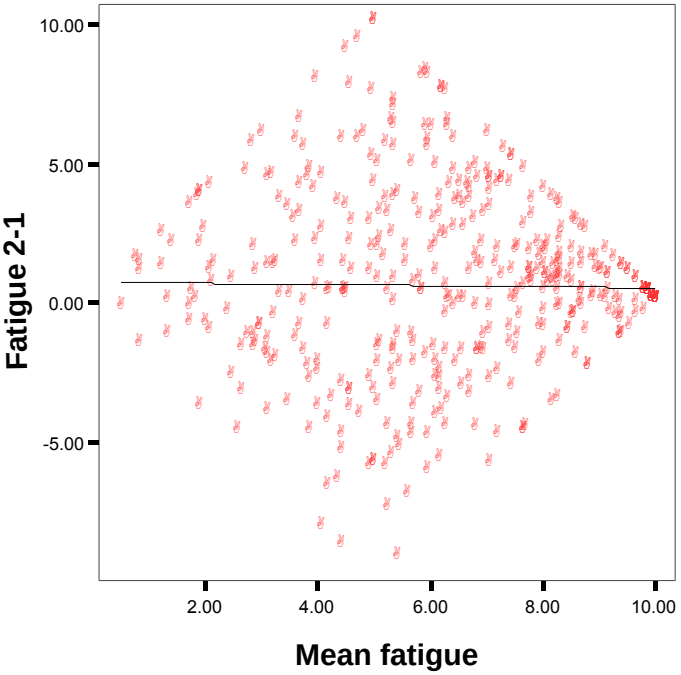


Peak 2-1 = 0.06 + -0.02 * mean_s1
R-Square = 0.00



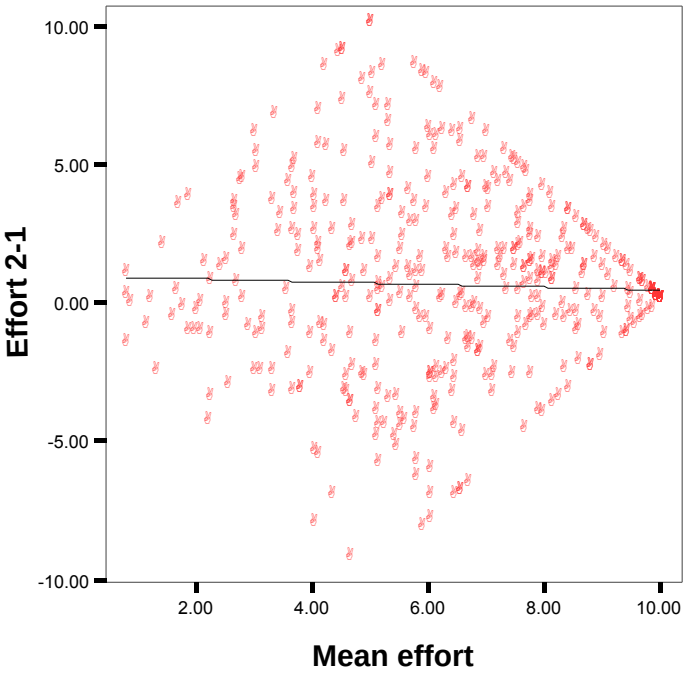
Linear Regression

Fatigue 2-1 = 0.74 + -0.02 * mean_s2
R-Square = 0.00



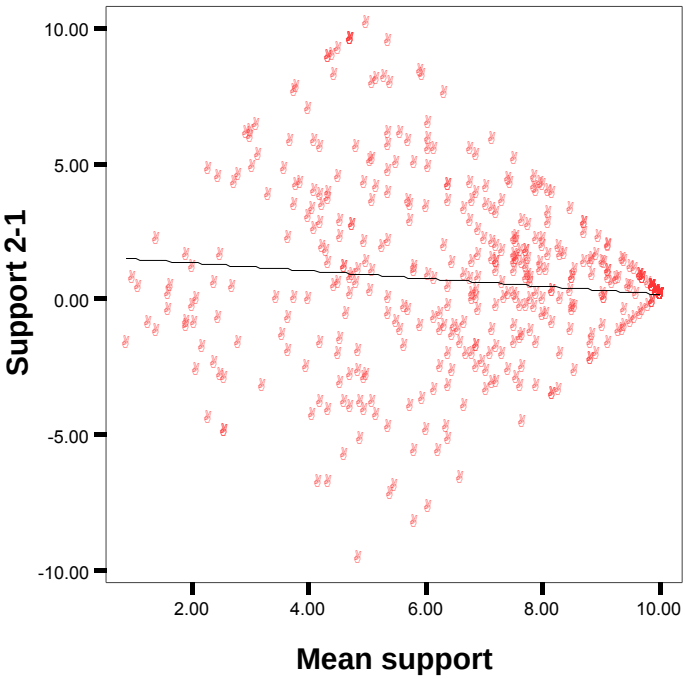
Linear Regression

Effort 2-1 = 0.97 + -0.05 * mean_s3
R-Square = 0.00



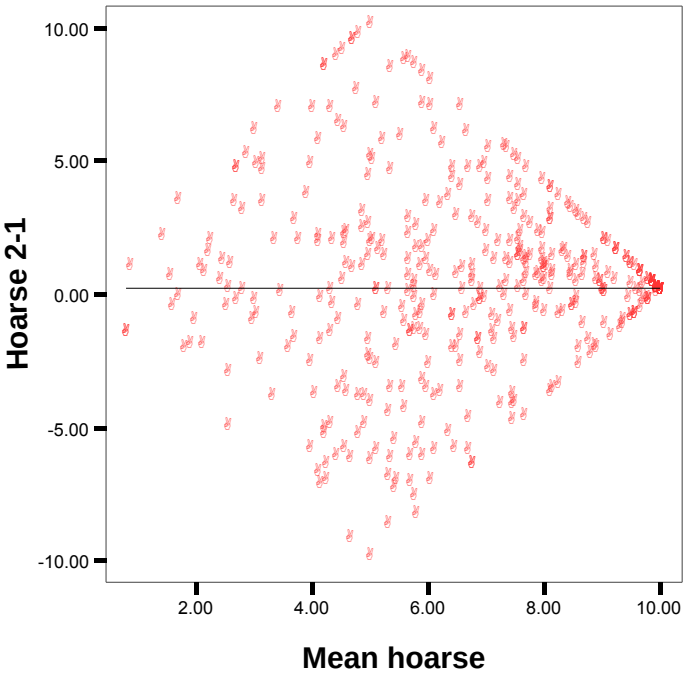
Linear Regression

Support 2-1 = 1.62 + -0.14 * mean_s4
R-Square = 0.01



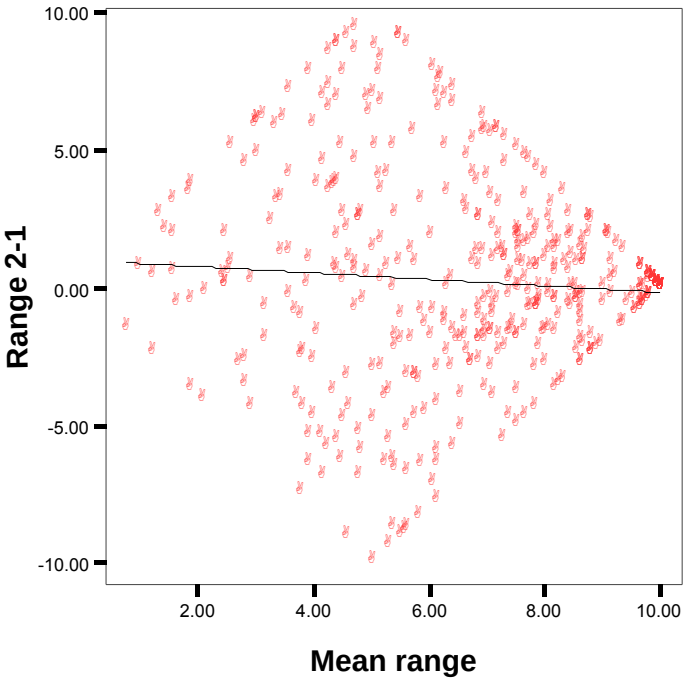
Linear Regression

Hoarse 2-1 = 0.25 + -0.00 * mean_s5
R-Square = 0.00



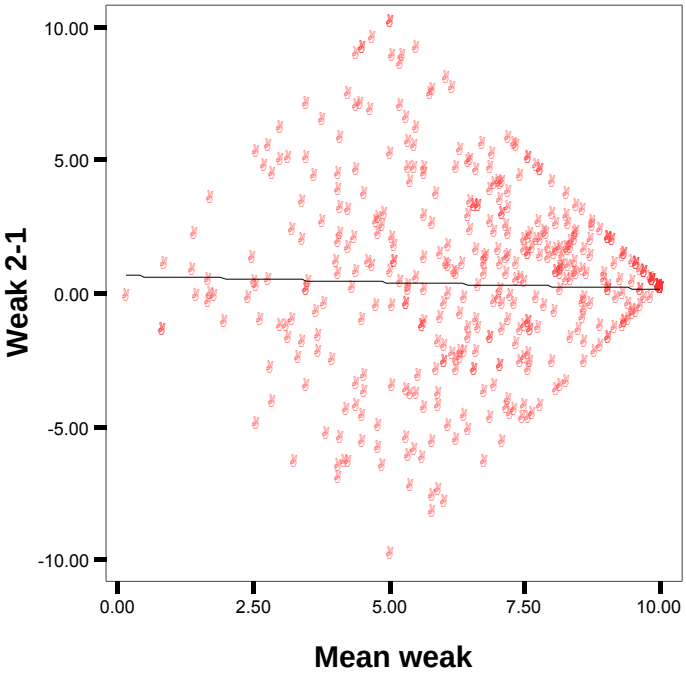
Linear Regression

Range 2-1 = 1.02 + -0.12 * mean_s7
R-Square = 0.01



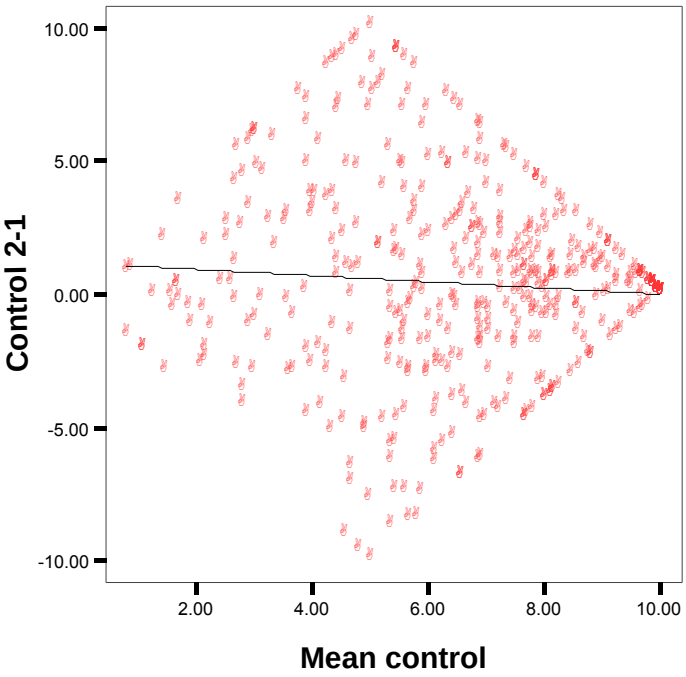
Linear Regression

Weak 2-1 = 0.66 + -0.05 * mean_s6
R-Square = 0.00

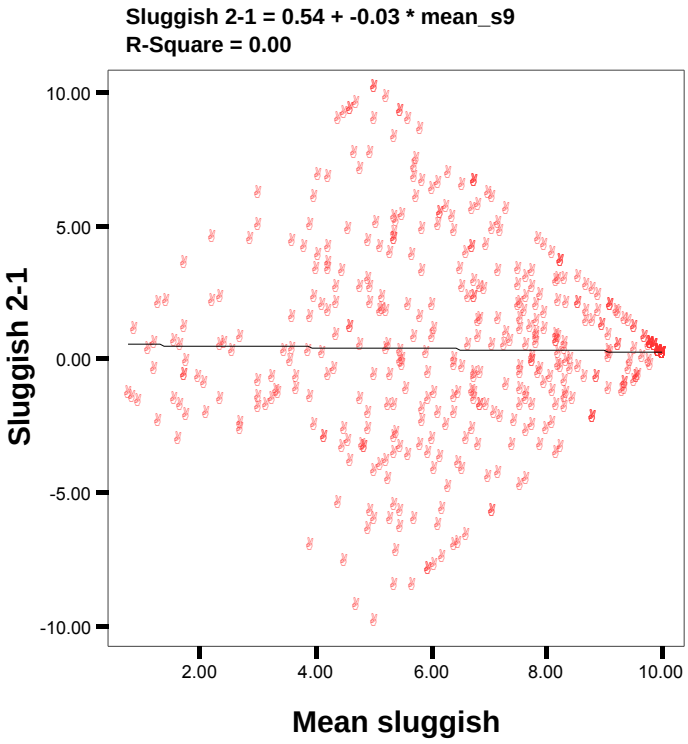


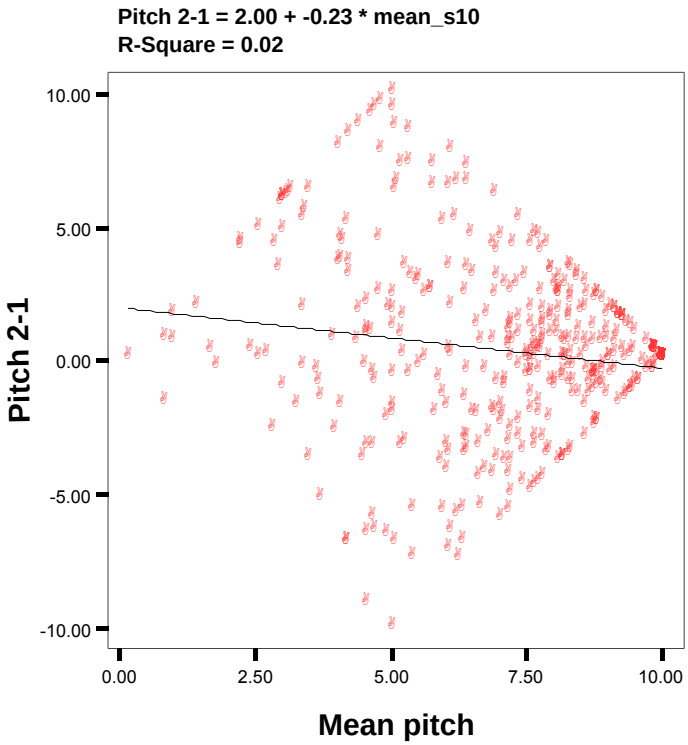
Linear Regression

Control 2-1 = 1.18 + -0.12 * mean_s8
R-Square = 0.01



Linear Regression


Sluggish 2-1 = 0.54 + -0.03 * mean_s9
R-Square = 0.00
Linear Regression
10.00
5.00
0.00
-5.00
-10.00
Sluggish 2-1
2.00
4.00
6.00
8.00
10.00
Mean sluggish


Pitch 2-1 = 2.00 + -0.23 * mean_s10
R-Square = 0.02
Linear Regression
10.00
5.00
0.00
-5.00
-10.00
Pitch 2-1
0.00
2.50
5.00
7.50
10.00
Mean pitch