RESPIRATORY CHARACTERISTICS

AND THE EFFECTS OF REGULATED BREATHING

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This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge and belief, this thesis contains no material previously published or written by another person, except when due reference to such material is made in the text.

P.K. Budzyna - Dawidowski

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ABSTRACT

The present study investigated the influence of sex and body position on respiratory characteristics and the effects of thoracic, abdominal and paced breathing, and relaxation training on psychological and physiological indices of arousal. Two separate experiments were conducted, each using equal numbers of male and female subjects. The psychological measures of arousal used were: the Taylor Manifest Anxiety Scale, a self-report measure of arousal, and Time Estimation. Physiological data collected included: Skin Conductance, Heart Rate, Respiratory Rate, thoracic-abdominal index and the inspiration/expiration ratio. Respiratory characteristics were measured using mercury-in-rubber strain gauges.

In Experiment 1 the respiratory patterns of 28 subjects were assessed in two body positions: sitting and supine. Subjects were divided according to sex, and allocated randomly to either the sitting-supine order, or the supine-sitting order. In this way four experimental groups were formed. The differences in respiratory patterns, psychological measures, and physiological indices could, therefore, be attributed to either: sex, body position, or the order in which assessment occurred.

Experiment 1 revealed that in the sitting position female subjects breathe relatively more thoracically than do male subjects. In the supine position both sexes breathe predominantly abdominally. Thoracic I/E ratios were found to be higher in male subjects than in female subjects and both thoracic and abdominal I/E ratios were effected by body position and order of position. In the supine position subjects displayed longer inspiratory times than in the sitting position. Similarly, in the sitting-supine order subjects displayed longer inspiratory times than in the supine-sitting order. It was shown that

predominantly abdominal breathing was associated with longer thoracic and abdominal inspirations than was thoracic breathing.

Experiment 2 used 48 subjects who were also divided according to sex and randomly allocated to one of four treatment conditions: thoracic, abdominal or paced breathing, or relaxation training. In this experiment subjects were assessed only in the sitting position. Thoracic and abdominal training was accomplished with the aid of visual and auditory feedback procedures. Subjects in the paced breathing treatment were required to inhale and exhale as indicated by the sweep of an analogue meter indicator. Relaxation training required subjects to perform tape-recorded relaxation exercises. Subjects in the paced breathing condition served as attention controls, whilst the subjects in the relaxation training condition served as an arousal control group.

Experiment 2 revealed that training subjects to breathe thoracically or abdominally failed to produce consistent changes in the indices of arousal. Both male and female subjects reported feeling less aroused following relaxation training. Time Estimation and the physiological indices failed to parallel the self-report data.

The present results are discussed in respect to current respiratory literature and major methodological issues were identified for future research.

CHAPTER 1.

Introduction

"Respiration proves itself to be the psychosomatic system par excellence. It is no wonder that in many languages - Sanskrit, Hebrew, Greek, Latin, German - breathing is synonymous with spirit. The self can relate through the medium of respiration with greater and smaller intensity to the waking and sleeping pole. The oriental image of the snake which bites itself by the tail, symbolising the self, may be found in the relation of the self to respiration."

(Schaefer, 1979, p.88)

Historical Perspective

Modern studies into the respiratory function began in the mid 1800s. Bulow (1963) reports that Sharling, a Danish chemist, published, in 1843, the results of an investigation showing a diurnal difference in the expired amount of CO_2. Similarly, Smith (1860), Mosso (1878) and Czerney (1892) are reported, by Bulow, to have demonstrated the existence of differences in respiratory patterns associated with wakefulness and sleep.

Studies of mystical and meditational practices (Allison, 1970; Benson, Beary & Carol, 1974; Cuthbert, Kristeller, Simons, Hodes and Lang, 1981; Elson, Hauri & Cunis, 1977; Farrow & Hebert, 1982; Naranjo & Orrestein, 1971; Shapiro & Zifferblatt, 1976; Wallace & Benson, 1972) show that techniques for altering states of consciousness usually involve changes in breathing. Benson, Beary and Carol (1974) provide a summary of some practices used in the major mystical disciplines. The Byzantine Hesychasm technique encourages the person to breathe out gently whilst saying a short prayer. In Judaism a technique called Abulafia's System concentrates on breathing patterns in a similar way to some yoga practices. The Sufis of Islam employ rhythmic breathing called Dhikr. Indian scriptures, from the sixth century BC, promote the restraint of breathing amongst techniques prescribed for achieving unification with the Deity. Hartha Yoga stresses the value of respiratory training by promoting the control of the duration of inspiration and of expiration and of controlling the pause between breaths. In this way voluntary control of respiration may be achieved. Similarly, Zen practices regulate respiration by requiring that several slow, deep breaths be followed by brief and forceless inspirations and long and forceful expirations with subsequent natural breathing. Shintoism and Taoism place importance on inspiring through the nose, holding inspiration for a short time and expiring through the mouth.

Therapeutic Considerations

Recently developed techniques such as Autogenic Training (Luthe, 1963), Progressive Relaxation (Jacobson, 1964), Transcendental Meditation (Bloomfield, Cain & Jaffe, 1975) and Paced Respiration (McCaul, Solomon & Holmes, 1979) influence respiratory patterns either directly, as in pacing techniques, or indirectly, as in Transcendental Meditation.

Autogenic Training. Autohypnosis was originally described by Vogt at the turn of the century and later developed into what is now called Autogenic Training by Schultz (Luthe, 1963). Both writers observed that particular patients undergoing hypnotherapy were able to induce an autohypnotic state without the continued assistance of the therapist. Using the principle of auto-suggestion, Schultz developed a set of verbal exercises to improve mental and physical functioning (Luthe, 1963).

These exercises are organised according to their physiological or psychological orientation. The six physiological statements concentrate on sensations of warmth, coolness, heaviness and regularity (see Luthe, 1963, 176-178). Each statement is concerned with a particular body system, for example, the respiratory system is modified with the statement "It breathes me". If bronchial dysfunction is the focus of therapy, a seventh statement may be added, "My breathing is calm and regular". The sequence of exercises is practiced twice daily. Mastery of the "warmth and heaviness" formulae occurs when the trainee begins to feel that these sensations have generalised to other parts of the body. The time needed to master the whole sequence is usually between four and ten months (Luthe, 1963). The second series of exercises resembles more traditional forms of meditation and is not introduced until the trainee is successful with the first series and even then they are not introduced to the average patient, (see Luthe, 1963, p. 148).

Included in the procedures which conclude each training session is a period of deep breathing. Apart from the "breathing statements" in the physiologically orientated series of exercises, this is the only direct instruction requiring the trainee to alter his or her breathing pattern. Despite this, Luthe (1963) reports a significant decrease in the repiratory rate, an increased respiratory amplitude and an increase in inspiratory time.

The reason for such changes may be in Luthe's explanation of the therapeutic effects of Autogenic Training. He hypothesized that this training results in a "self-induced modification of cortico-diencephalic interrelations, which enables natural forces to regain their otherwise restricted capacity for self-regulatory normalization". (Luthe, 1963, p. 193). In particular, according to Luthe, this implies that the cortex, thalamus, reticular system, hypothalamus, hypophysis and the adrenals are all directly involved with the regulatory processes and therefore the "therapeutic mechanism is not unilateraly restricted to either bodily or mental functions". (p. 193).

<u>Progressive Relaxation</u>. Whilst the principles of Autogenic Training go beyond the induction of somatic relaxation, Progressive Relaxation (Jacobson, 1938) concentrates on the therapuetic effects of muscular relaxation. Jacobson based his ideas on the fact that psychological stress, for example the state of anxiety, results in non-adaptive muscular contraction. He calls this unnecessary muscular contraction, "residual tension", the release of which was expected to be therapeutic. To achieve this release, Jacobson instructed his patients to actively contract specific muscle groups whilst attending to the feelings of muscular tension thus created. Following the release of this tension, attention is focused on the difference between the presence of tension and the absence of tension (relaxation). With considerable practice the patient learns to relax muscles which are not required to be contracted. Although Jacobson included breathing exercises, he did not emphasize these above any other part of therapy. Deep rhythmic breathing was incorporated into Progressive Relaxation by

Sherman and Plummer (1973) and by Deffenbacher and Snyder (1976) in order to enhance deeper and more rapid relaxation. In both investigations subjects were instructed to take a deep breath, hold it for a moment and exhale slowly whilst focusing on feelings of deeper relaxation.

Transcendental Meditation (T.M.). Introduced to the West by Maharishi Mahesh Yogi, this technique focuses the individual's attention on internal experiences in an attempt to achieve the meditator's unity with the Absolute Being (Bloomfield, Cain & Jaffe, 1975). The technique requires no physical effort, no prolonged concentration, nor any adherence to a particular philosophy. Similarly, mental effort is minimal and the recommended practice time is between 10 and 20 minutes twice each day. In return the meditator is expected to lead a much more calm, stress free life with enhanced creative intelligence (Forem, 1973).

The actual procedure involved choosing a comfortable posture in a quiet environment and continually repeating a mantra. Attention is refocused on the sound of the mantra when it has been found to wander. There are no instructions to alter breathing in any way (Bloomfield et. al., 1975).

In an experimental analysis of this technique Farrow and Hebert (1982) found that breath suspension was significantly correlated with reported episodes of "pure consciousness" which were defined by these authors as a "de-excited mental state in which no thoughts exist yet consciousness [is] maintained" (Farrow & Hebert, 1982, p. 149). Such correlations were far more common for the T.M. subjects than for the control group. Farrow and Hebert concluded from their results that breath suspension has a direct and immediate influence on changes in consciousness.

Benson, Beary and Carol (1974) consider that the above mentioned techniques share common physiological responses. These authors maintain that the practice of Autogenic Training, Progressive

Relaxation and Transcendental Meditation results in decreases in: oxygen consumption, respiratory rate, heart rate and muscle tension; whilst skin resistance and EEG alpha wave activity increase. Similarly to Luthe (1963), Benson et al. (1974) hypothesize that such physiological changes result from an integrated hypothalamic response which leads to decreased sympathetic nervous system activity. Some support for such a conclusion may be obtained from studies investigating the use of Paced Respiration to modify autonomic responsivity to psychological and physiological stimuli.

Paced Respiration. Numerous authors (Azrin & Nunn, 1974; Azrin, Nunn & Frantz, 1979; Clark, 1978; Cogan & Kluthe, 1981; Harris, Katkin, Lick & Habberfield, 1976; Jones, 1981; Lane, 1981; Longo & vom Saal, 1984; McCaul, Solomon & Holmes, 1979) have described the use of patterned breathing in clinical or experimental procedures. Most of these investigators have used alterations in respiratory rate in order to effect a change in psychological and physiological indices. As stress reduction is often the goal of such procedures these manipulations generally occur under anxiety-provoking conditions.

Grossman (1983) suggests that individual differences in breathing may exist along a continuum of respiratory patterns which relate systematically to changes in cardiovascular function and to variations in psychological characteristics and environmental stress. He states that one end of the continuum is characterized by a slow, deep, predominantly abdominal pattern of ventilation with relatively high alveolar and blood concentration of CO_2. Such a pattern, Grossman (1983) maintains, is associated with emotional stability, a sense of control of perceived or objective environmental stressors. The other end of this hypothesized continuum is characterized by a rapid, shallow, predominantly thoracic ventilation with relatively low alveolar and blood concentrations of CO_2. Psychological characteristics associated with this pattern include anxiety, neurosis, depression and high levels of perceived and objective environmental stressors. Changing this pattern of breathing has recently become the focus of anxiety reducing therapies.

Azrin and Nunn (1974) and Azrin, Nunn and Frantz (1979) used slow inhalation exercises as a method for disrupting speech the moment stuttering started or was anticipated by the speaker or the clinician. This technique was, however, only one component of the treatment. Breathing exercises were incorporated into the general treatment for two reasons: such breathing is incompatible with stuttering, and also the authors considered that deep breathing had some relaxing properties.

Longo and vom Saal (1984) used a technique (Respiratory Relief Therapy) with phobic clients which combined deep, regular breathing with "maximum voluntary respiratory arrest". The latter procedure required that the subjects exhale and voluntarily refrain from inhaling for as long as possible. Longo and vom Saal (1984) explain that clients suffering from anxiety disorders display more rapid and more shallow breathing than do control subjects. Their rationale for the effectiveness of Respiratory Relief Therapy appears to be based on the fact that deep, regular breathing increases the level of the CO_2 build up in the blood and in the cerebrospinal fluid which has a "tranquilizing" effect on the sympathetic nervous system. Using heart rate and subjective measures to indicate the level of arousal, Longo and vom Saal (1984) found that Respiratory Relief Therapy effectively lowered physiological and psychological indices of arousal of phobic subjects. Unfortunately these authors failed to provide any data correlating respiratory rate with physiological and psychological indices of arousal.

Other authors (Clark, 1978; Cogan & Kluthe, 1981; Lane, 1981; McCaul et al., 1979) have shown that paced breathing can reduce psychological and physiological responses to pain or to the expectation of pain. Clark (1978) for example, used respiratory pacing with women who were highly anxious in dental situations. Subjects were randomly assigned to one of five conditions: either 8, 16 or 24 cycles per minute respiratory pacing; attention control group, and no-treatment control group. A graphic film of dental treatment was shown to all of the women while they were under the experimental procedure. All subjects were administered the Dental Anxiety Scale (a scale designed to assess subjective degree of anxiety). Analysis of the anxiety scale revealed that the 16-cycles-per-minute group did not differ significantly from the two control groups. The 8-cycle-per-minute group reported least anxiety whereas the 24-cycle-per-minute group reported the highest level of anxiety. Although these findings reveal high significant correlations between anxiety ratings and respiratory rate, anxiety ratings failed to correlate with either cardiac or electrodermal activity.

Lane (1981), in a similar experiment, investigated respiratory pacing at rates of either half, or twice the normal respiratory rate in an attempt to discover which rate would change physiological responses to experimentally induced pain (cold pressor test). In this study, slow breathing (7.5 breaths/minute) was found to have a significantly different effect on the subjects' Heart Beat Interval than did fast breathing (30 breaths/minute). Lane (1981) found that the slow-pacing condition reduced the subject's heart rate during the stress procedure and concluded that control of respiratory rate may reduce cardiovascular responses to stressful and painful events.

McCaul, Solomon and Holmes (1979) provide further evidence that changing the respiratory rate influences physiological responses to stress. They found that reducing the subject's respiratory rate to 8 breaths per minute was an effective strategy for reducing physiological arousal as measured by skin resistance and finger pulse volume. Harris, Katkin, Lick & Habberfield (1976) substantiate this conclusion by reporting that skin conductance (change in log conductance) was lower for subjects in the paced respiration condition than in the attention control condition. These authors also found that pacing respiration at 8 breaths per minute was successful in reducing autonomic responsivity to the threat of electric shock.

From the above research it can be concluded that inducing a slow and deep respiratory pattern may cause a reduction of subjective and physiological indices of anxiety under conditions of stress and, in some clinical populations, may diminish psychological difficulties e.g. chronic anxiety responses (Longo & vom Saal, 1984). Conversely, voluntary performance of rapid and shallow breathing seems to intensify subjective and physiological indicators of anxiety during stress. Such a conclusion tends to support Luthe (1963) and Benson et al. (1974) in that it indicates an interaction between the respiratory system (over which there is some voluntary control) and the apparently involuntary autonomic system.

Although current research indicates that respiratory pacing may reduce, or exacerbate, subjective and objective indices of anxiety, it is important to note that ventilatory parameters other than respiratory rate (I/E ratio, T-A index, tidal volume, CO_2 levels) are also likely to covary with changes in the respiratory rate. Whilst these other parameters have not been considered by the current pacing literature it has been shown that changes in these indices are associated with changes in arousal levels (see section entitled "Respiratory Parameters").

Respiratory Mechanisms

It has been argued in the preceding sections that the control of respiration has been an important element in many mystical and therapeutic techniques. As these techniques have breathing as a common feature, it is appropriate here to consider the mechanism which controls the respiratory function.

The characteristics of an individual breath depend on the integration of several physiological elements: muscular movement, stretch receptors in the lungs, vagal nerve afferents, chemoreceptors and the pneumotaxic centre in the pons (Bouhuys, 1977; Cherniack, Cherniack & Naimark, 1972; Eckberg, Kifle & Roberts, 1980). Muscular involvement may be separated into two components: thoracic and abdominal. The contraction of the diaphragm and the intercostal and accessory thoracic musculature results in the expansion of the rib-cage thus facilitating initial inspiration (Cherniack et al., 1972). Thoracic volume increases further when the intercostal muscles attached to the ribs contract and force the thorax upward and outward (Vander, Sherman & Luciano, 1980), thus completing the thoracic inspiratory phase of the respiratory cycle. When the diaphragm contracts during inspiration it becomes flatter and forces the abdomen downwards and outwards, thus affecting both thoracic and abdominal respiratory movements (Cherniack et al., 1972). In this way a decreased intra-pleural pressure is obtained which causes an inflow of air into the alveoli where the gaseous exchange takes place (Hassett, 1978). Toward the end of the inspiratory phase the respiratory musculature relaxes allowing the rib-cage to descend. At the same time the diaphragm rises reducing the thoracic volume and thereby initiating the expiratory phase of the cycle. Full expiration is achieved with the activation of specific intercostal muscles and by the active intrusion of the diaphragm into the thoracic area with the help of the abdominal muscles (Vander et al., 1980).

The muscular control of the respiratory cycle is governed by two feedback mechanisms: mechanical and chemical. Firstly, stretch receptors in the lungs initiate the Hering-Breuer reflex which, via the vagal nerve afferents delimits tidal volume during lung inflation and controls the breathing rate (Bouhuys, 1977; Gandevia, McCloskey & Potter, 1978). Proprioceptive feedback is also available from muscle spindles (located in the thoracic muscles) which, when triggered, inhibit lung inflation (Bouhuys, 1977). Further feedback is provided by biochemical means. Chemoreceptors sensitive to CO_2 in the circulatory system are found in the reticular formation of the brain and in peripheral arteries (Asmussen, 1977). Through the reticular formation an increase of the amount of CO_2 in the circulating blood influences respiratory rate and tidal volume of the lungs (Bouhuys, 1977). According to Cherniack et al. (1972) the vagal afferents from the various feedback mechanisms converge on the pneumotaxic centre located in the upper third of the pons. It is postulated (Bouhuys, 1977) that this centre initiates commands to the structures which are responsible for inspiration and expiration.

Having considered the mechanics of breathing it is now appropriate to consider how this function interacts with other physiological processes. As the respiratory centres and the reticular formation are anatomically related, and because most body processes require oxygen, it is expected that respiratory rate and tidal volume will closely reflect physiological arousal (Bulow, 1963). Thus, with changing metabolic requirements, as for example during exercise, respiratory rate increases providing greater availability of oxygen to the muscle tissue. It is interesting to note the differential effects that intensive breathing has on thoracic and abdominal respiratory movements. Danon, Druz and Sharp, (1974) report that during heavy exercise (higher arousal) the intercostal muscles of the thorax are activated before the muscles of the diaphragm are activated. The converse appears to be true during slow breathing (Sharp, Goldberg, Druz & Danon, 1975). As arousal is considered by these authors to exist along a continuum from low to high (Alexander, 1972; Duffy, 1972; Sternbach, 1967), it seems that thoracic respiration may be more dominant during higher arousal (greater metabolic requirement) whilst abdominal respiration may be employed during resting.

Respiratory Parameters

There are three common indices of respiratory characteristics: Respiratory Rate, Inspiration/Expiration Ratios and the Thoracic-Abdominal Index.

Respiratory Rate. Despite the wide use of respiratory rate as an indicator of physiological state during meditation and relaxation (Allison, 1970; Benson, et al., 1974; Cuthbert et al., 1981; Elson et al., 1977; Farrow & Hebert 1982; Hoffman, Benson, Arns, Stainbrook, Landsberg, Young & Gill, 1982; Paul, 1969; Wallace & Benson 1972; Wallace, Benson & Wilson, 1971), the use of this measure as a sole respiratory index of arousal has recently been criticised. Whilst it is true that respiratory rate generally decreases with decreasing arousal (Hassett, 1978), some experimental studies (Cohen, Goodenough, Witkin, Oltman, Gould & Shulman, 1975; Mathews & Gelder, 1969; Sues, Alexander, Smith, Sweeney & Marion, 1980) failed to find significant reduction in respiratory rate concomitent with decreased arousal. These authors, therefore, support Grossman's (1967) suggestion that respiratory rate alone is an inadequate measure of the respiratory system's sensitivity to changes of arousal.

Inspiration/Expiration Ratio. According to Grossman (1967) the three components of the respiratory cycle (inspiration, expiration and post-expiratory pause) may vary independently of each other and consequently merit independent assessments. Two of the major studies investigating the duration of the inspiratory phase and the duration of the expiratory phase of the respiratory cycle were those of Feleky (1916) and Clausen (1951). Both authors studied subjects under various conditions and calculated a ratio of inspiratory time and expiratory time (I/E ratio) for each breath.

In one of the first investigations of its type Feleky (1916) reported that she could distinguish six primary emotions on the basis of the concomitant changes in the I/E ratio. Feleky states that in normal breathing the mean I/E ratio is .805, i.e. the inspiration phase is shorter than the expiratory phase. The same was found to be true for laughter (.300) and hatred (.515). In comparison, she reports the mean inspiratory time was greater than the mean expiratory time for disgust (1.080), pleasure (1.110), anger (1.480), pain (1.546), wonder (2.490), and fear (2.660). Serious methodological inadequacies, namely the use of only six subjects and the fact that the subjects were required to imagine the experimental conditions, however, prevent these results from being recognized as conclusive.

Clausen (1951) studied the breathing of normal and psychiatric subjects and concluded that: 1) the position of the subject, whether supine or sitting, may be an important factor in determining the type of respiratory pattern, 2) normal males have larger thoracic and abdominal I/E ratios than do normal females, and 3) normal subjects have a sharper I/E transition point for the thoracic curve than do psychiatric subjects whilst psychiatric subjects have a sharper I/E transition on the abdominal curve than do normal subjects.

Clausen (1951) considered this I/E transition difference to be the major distinguishing feature between the psychiatric and the normal subjects. In his opinion people with chronic emotional conflicts develop a "cautious respiratory pattern" which is characterized by fast and shallow breaths, and which results in the "suppression of emotions". The emotionally disturbed subjects had a shorter period of maximal contraction of the diaphragm than did the normal subjects. Such an inability or unwillingness to keep the diaphragm contracted long enough to make the abdominal transition from inspiration to expiration a gradual one might be, Clausen suggests, a result of the condition of the abdominal wall musculature. When the diaphragm is contracted during inspiration the abdominal wall muscles have to be relaxed in order to compensate for the increased pressure (volume) in the abdomen (Clausen, 1951). Thus, it appears that the rapid abdominal I/E transition observed in the emotionally disturbed subjects might be due to their inability to relax the muscles of the abdominal wall.

Other researchers (Bulow, 1963; Cohen et al., 1975; Kumar, Diest, van Hofman, Poelstra & Bakker, 1979; Timmons, Salamy, Kamiya & Girton, 1972; West, 1983) have sought to correlate the I/E ratio with levels of physiological arousal. These studies suggest that during the initial stages of sleep, both thoracic and abdominal I/E ratios change. Timmons et al. (1972) found that most subjects displayed a longer abdominal inspiratory phase during wakefulness. At stage 2 sleep, however, most subjects showed a longer thoracic inspiratory phase. It appears that with the decrease in arousal during sleep, the thoracic I/E ratio increases whilst the abdominal I/E ratio decreases. During increased arousal, Cohen et al. (1975) found that significant changes in I/E ratios occur only in the thoracic respiratory mode. Their study revealed that when subjects were under stress the thoracic expiratory phase increased at the expense of the post-expiratory pause.

In a study of sleep stages, West (1983) concluded that whilst in general the thoracic I/E ratio increased and the abdominal I/E ratio decreased during lower arousal levels, the I/E ratios (with or without the post-expiratory pause) did not change consistently during sleep. The differences between the ratios could not, therefore, be used as indices of arousal at the lower end of the arousal continuum (West, 1983). Despite this, however, during stage 2 sleep transcient changes in arousal levels (EEG) were reflected in I/E ratio changes. Thus, the literature indicates that the I/E ratios of the two respiratory modes may be useful in detecting some changes in arousal levels. Although there is some disagreement as to the degree of change in I/E ratios in each respiratory mode, it appears that the thoracic respiratory mode may be particularly responsive to changes in levels of arousal. Periods of higher arousal levels have been shown to be associated with increases in the expiratory phase (Cohen et al., 1975), whilst periods of lower arousal levels have been shown to be associated with increases in the inspiratory phase (Timmons et al., 1972; West, 1983).

A factor which may influence the differential responding of the thoracic and abdominal I/E ratios is body position. Whilst differences between the supine, prone and lateral decubitus body positions have been reported (Vellody, Nassery, Druz and Sharp, 1978) differences between the supine and sitting body positions appear not to be documented. Such a comparison seems to be important as Agostoni (1970) found that abdominal movement is restricted in the sitting position because of the change in the compliance of the gut. It may be expected that such a change would also influence the I/E ratios.

Thoracic-Abnominal Index. The third parameter of respiration to be considered here is the recently developed Thoracic-Abdominal (T-A) index (Naifeh & Kamiya, 1981). The T-A index was specifically devised to quantify the relative contribution of simultaneously recorded thoracic and abdominal respiratory movements. An increase in T-A index indicates relatively greater thoracic contribution. The independent variability of thoracic and abdominal respiratory movements has been suggested by several authors (Clausen, 1951; Goldie & Green, 1961; Grossman, 1967; Timmons et al., 1972). Some previous research (Konno & Mead, 1967; Tusiewicz, Moldofsky, Bryan & Bryan, 1977; Vellody et al., 1978), however, did not use the T-A index.

Whilst Bulow (1963) did not consider differences in thoracic-abdominal respiratory movements, his study is one of the first large correlational investigations aimed at relating general respiratory indices with arousal levels. Bulow revealed that changes in the EEG record between wakefulness, drowsiness and sleep were invariably accompanied by changes in ventilation and alveolar CO_2 tension (P_ACO_2). The loss of wakefulness was associated with a decrease in ventilation and an increase in P_ACO_2 (the inverse was found during a rise in wakefulness). Such changes were found to occur even during transcient shifts in wakefulness. Bulow reported that during awakening from deep sleep, the first sign of alpha activity often preceded (by 1 or 2 seconds) the increase in the volume of ventilation, thus suggesting that the EEG record is the first to indicate a change in arousal. Such a conclusion was challenged by Naifeh & Kamiya (1981) who claim that the T-A index reveals the respiratory measures to be more sensitive than the EEG in detecting changes of arousal. These authors found that transcient rises in the T-A index (i.e. increases toward thoracic predominance) and P_ACO_2 can occur simultaneously with, or even prior to, changes in the EEG record indicative of sleep onset.

In a recent study, West (1983) revealed that not only was sleep onset (as defined by the EEG record) associated with an increase in thoracic breathing (higher T-A index) but that the thoracic contribution to the respiratory cycle increased progressively (i.e. the T-A index increased) as arousal decreased from wake to stage 4 sleep. In addition, T-A index values appeared relatively constant within each sleep stage, although transcient EEG indications of increased arousal were "always associated with substantial and immediate decreases in the [T-A] index value" (West, 1983, p.56).

These results are supported by the earlier studies of Goldie and Green (1961) and Timmons, Salamy, Kamiya and Girton (1972) which investigated the relationship between thoracic and abdominal respiratory movements and the EEG indices of wakefulness. These investigations revealed that the predominant mode of breathing during light sleep was the thoracic mode and that with increased arousal the abdominal mode became predominant.

It appears that the above conclusion is not supported by a previously reported study (Danon et al., 1974) which found that during greater arousal the thoracic muscles were activiated prior to the activation of the diaphragm. If this is true, then it would appear that thoracic respiratory movements may be associated with greater arousal levels whilst abdominal movements may be associated with lower arousal levels. Such a notion is supported by two previous authors. Christian (1957, in Schaefer, 1979) measured changes in thoracic, abdominal and lateral respiratory movements and found that increased attention was associated with an increase in thoracic respiratory movements. Similarly, Pearn (1982) used a range of arousal manipulations, high arousal to low arousal, and observed that her data contradicted "sleep research" in as much as respiration became increasingly thoracic as arousal levels increased. At the "relaxed" end of the arousal continuum some support for these suggestions is provided by Timmons et al. (1972) who found that the alpha state (8 - 13 Hz) was associated with a breathing pattern in which the amplitude of the abdominal movement exceeded that of the thoracic. In other words, relaxed wakefulness was associated with predominently abdominal breathing.

Whilst the relaxed wakeful state necessarily exhibits greater arousal than sleep does, there appears to be some disagreement as to which end of the arousal continuum is characterized by predominantly thoracic respiration. One possible explanation for this disagreement may be the fact that studies investigating higher arousal levels (Danon et al., 1974; Pearn, 1982) assess subjects in the upright position while those studies investigating sleep onset naturally use the horizontal position. The importance of body position during the assessment of respiratory characteristics is discussed in the section entitled "Position Effects".

Respiration and Cardiac Activity

Having thus far concentrated on the relationship between the respiratory system and levels of arousal (EEG) it is now appropriate to explore how the respiratory function relates to other phyiological indices of arousal.

Changes in heart rate have often been used to indicate changes in arousal levels (Benson, Beary & Carol, 1974; Farrow & Hebert, 1982; Paul, 1969; Wallace & Benson, 1972). Respiratory activity is also reported to have an influence on the cardiac cycle (Bouhuys, 1977). It is necessary, therefore, to consider the interaction between the respiratory system and cardiac activity.

Lopes and Palmer (1976) proposed a gating mechanism for cardiac activity which they suggest is controlled by the respiratory cycle. According to these authors heart rate is under vagal and sympathetic nerve control, however, bradycardia (slowing of the heart due to increased blood pressure, increased carotid chemoreceptor activity or direct electrical stimulation of the carotid sinus nerve) can occur only if the vagal stimulus is delivered during the expiratory phase of the respiratory cycle. Similarly, direct stimulation of the brain centres which produce an inhibition of bradycardia during inspiration also results in an increase in respiratory activity (Lopes & Palmer, 1976). The reason for this according to Lopes and Palmer, is the close anatomical and physiological interrelationship between the nucleus ambiguus, the vagus nerve and the tractus solitarius which are found in the medullary reticular formation. Lopes and Palmer state that, "all known efferent stimuli which cause reflex bradycardia converge on the area of the nucleus tractus solitarius where `inspiratory' type neurones abound before passing on to the nucleus ambiguus. [They propose] that these inspiratory neurons may actually be part of a 'gate' which controls the passage of impulses through this reflex pathway" (Lopes & Palmer, 1976 p. 455).

The "gating" theory is supported by the respiratory-cardiac coupling mechanism described by Yongue, McCabe, Porges, Rivera, Kelley and Ackles (1982). These authors suggest that inspiration blocks vagal efferent influences to the heart and therefore is associated with heart rate acceloration (tachycardia). Expiration is not associated with vagal inhibition and thus allows the parasympathetic effects of the vagal nerve to produce periodic bradycardia (Bouhuys, 1977).

The respiratory-cardiac coupling mechanism is also influenced by other factors. When long inflation, for example, stimulates the stretch receptor efferents found in the thoracic musculature virtually all vagal control of the heart is blocked (Lopes & Palmer, 1976; Porges & Coles, 1982). Similarly, cardiac activity can be influenced by the respiratory system because the heart is responsive to the level of CO_2 in the blood (Grossman, 1983; Obrist, 1976). Grossman (1983) points out that hyperventilation can produce selective suppression of parasympathetic activity by changing blood CO_2 levels. This results in dominance of the sympathetic nervous system and a consequent increase in heart rate and cardiac output. During natural breathing, however, the metabolic requirement for extra O_2 produces an increase in cardiac activity (Obrist, Webb, Sutterer, & Howard, 1970). Such an increase in cardiac activity appears to be associated with the stimulation of the thoracic muscles prior to the stimulation of the abdominal muscles (Danon, Druz & Sharp, 1974). The relationship between cardiac activity and thoracic expansion has recently been demonstrated by Hurwitz (1981) who found that the increased cardiac output and higher heart rate, which are observed during inspiration, appear to be correlated with thoracically dominant breathing whilst abdominal breathing tends to reduce such effects.

Another possible influence on the respiratory-caridac relationship has been suggested by Porges and his co-workers (Cheung & Porges, 1977; Porges & Coles, 1982; Walter & Porges, 1976). By investigating physiological reactions to various attention tasks, it was found that the task component influenced respiratory-cardiac interaction. These authors conclude that the degree of cognitive involvement in an attention task may override the subcortical mechanisms responsible for respiratory-cardiac coupling. However, as breathing has been found to be suppressed during demanding tasks (Porges & Humphrey, 1977), it may also be that the cognitive influence on the respiratory-cardiac interaction (reduced heart rate variability) was due to the disruption of respiration.

In summary, current research implicates subcortical processes as being responsible for the interaction between cardiac activity and the respiratory cycle. It has been found that inspiration blocks vagal influences to the heart and thus induces tachycardia. Expiration does not inhibit the vagus nerve and thus allows bradycardia to occur. Other influences on cardiac activity include thoracic stretch receptor efferents, blood CO_2 levels, thoracically dominant breathing and possibly cognitive processes.

Methodological Considerations

Some of the major methodological problems eminating from respiration research are concerned with a) differences in respiratory characteristics between males and females, b) the influence of position (sitting or supine) on respiratory characteristics, and c) the effect attention to pacing and feedback signals in respiration experiments has on arousal levels.

Sex Differences. Of the respiratory research concentrating on breathing characteristics other than respiratory rate (Bulow, 1963; Christian, 1957, in Schaefer, 1979; Clausen, 1951; Cohen et. al., 1975; Faithfull, Jones & Jordan, 1979; Goldie & Green 1961; Hurwitz, 1981; Naifeh & Kamiya, 1981; Sharp et al., 1975; Timm, 1982; Timmons et al., 1972; Vellody et al., 1978) only four studies report using large enough numbers of male and female subjects to make reliable inter-sex comparisons possible. Two of these studies (Sharp et al., 1975; Vellody et al., 1978) failed to find any significant differences between the sexes, and while Bulow (1963) included comparable numbers of male and female subjects he did not provide detailed analysis of the differences between these samples. Such an analysis was provided by Clausen (1951) though not in terms of the T-A Index. Clausen concluded that females have faster, more unstable breathing patterns than do males, and that females breathe more thoracically than do males. Clausen proposed that the predominantly thoracic breathing observed in female subjects is a result of cultural influence. He suggested that females in Western society are taught from an early age to breathe predominantly with the chest. Similarly, Clausen suggested that in the past, wearing restrictive clothing such as corsets, did not allow full diaphragmatic breathing. In support of this notion Clausen draws attention to two facts. Firstly, the sex difference does not appear until after puberty and secondly, women of cultures without such clothing restrictions do not appear to breathe differently from the men of such cultures. Clausen states that earlier authors attributed the differences to "specific feminine anatomy and physiology" (Clausen, 1951, p.14) without fully considering the issue.

Most other investigations which do mention the sex of their subjects (Cohen et al., 1975; Naifeh & Kamiya, 1981; Timmons et al., 1972), with the exception of Feleky (1916) (who exclusively used female subjects) used males with, at best, only a token number of female subjects. Of these only the Naifeh and Kamiya (1981) study, with eight male subjects and four female subjects, allows a reliable comparison. Their data substantiate Clausen's (1951) finding that female subjects tend to have greater thoracic involvement in their respiratory pattern than do male subjects. Both of these studies, however, assessed subjects only in the supine position.

<u>Position Effects.</u> Investigations of relaxation procedures (Jacobson, 1964; Luthe, 1963; Wallace & Benson, 1972) indicate the importance of posture. Similarly, meditation techniques (e.g. Zen and Yoga) usually require that practice occur in a certain position. More recent investigations of the effects of position on breathing, however, have appeared in physiological literature (Goldman & Mead, 1973; Konno & Mead, 1967; Sharp, Goldberg, Druz & Danon, 1975; Tusiewicz, Moldofsky, Bryan & Bryan, 1977; Vellody, Nassery, Druz & Sharp, 1978). Tusiewicz et al., (1977) suggest that in the supine position diaphragmatic contraction is less likely to produce expansion of the thoracic region, than it is in the upright position. This appears to be due to the fact that in the supine position, the force of gravity is not operating in the same direction as is the diaphragm. Also, the abdominal cross-section area actually decreases in the supine position whilst the thoracic cross-section area remains unchanged (Tusiewicz et al., 1977). These authors (Tusiewicz et al., 1977) suggest that as diaphragmatic influences on the thoracic area decrease when moving from the upright to the supine position, then in order to produce an equivalent thoracic expansion (as in the upright position) the intercostal muscles must be actively contracted. There appears, however, to be inconclusive evidence available in regard to whether the intercostal muscles actually contract in the supine position during resting respiration (Sharp et al., 1975).

There is an additional factor which influences respiratory differences between the supine and the upright positions. Due to the fact that in the sitting position the gut and its contents are relatively incompressible, diaphragmatic movement in the sitting position is restricted (Agostoni, 1970). Thus, in order for breathing to occur in the sitting position there must be more thoracic involvement than when breathing in either of the standing or the supine positions. It is important to note that whilst the literature makes a clear distinction between the sitting and the supine body positions, such a clear distinction is not made between the upright and the sitting body positions. For instance, while some authors (Sharp et al., 1975; Vellody et al., 1978) define "upright" as a sitting position, other authors (Christian, 1957, in Schaefer, 1979; Konno & Mead, 1967) define "upright" as standing. Still other authors (Tusiewicz et al., 1977) fail to define the term. Notwithstanding the problem with definition Christian (1957, in Schaefer, 1979) indicates that both the sitting and the standing positions are characterized by predominantly thoracic breathing.

Thus, it seems that the respiratory cycle is differentially affected by gravitational, diaphragmatic, and gut compliance factors which are, in turn, influenced by the position in which assessment takes place. The standing and sitting positions are characterized by predominantly thoracic breathing, whilst the supine position is characterized by predominantly abdominal breathing (Agostoni, 1970; Christian, 1957, in Schaefer, 1979; Goldman & Mead, 1973; Konno & Mead, 1967; Sharp et al., 1975; Vellody et al., 1978). Such a conclusion runs somewhat contrary to Clausen's (1951) study which revealed that female subjects in the supine position actually breathed thoracically whilst the male subjects breathed abdominally in that position. Clausen, however, did not study subjects in the sitting position. Considering this discrepancy, it seems apparent that further investigation of the effects of body position on the respiratory patterns of male and female subjects is required.

In relation to different body positions, McLaughlin, Goldman, Kleinman and Korol (1978) studied the interaction between body position and autonomic measures. They found that body position has a significant influence on basal levels of heart rate, finger blood volume, skin resistance and blood pressure. Their study showed that in the vertical position, sympathetic arousal was higher than in the horizontal position. Such differences were not found, however, between the two positions on the EMG of the frontalis muscles indicating that the explanation may only involve the autonomic nervous system. McLaughlin et al. (1978) also found that the order in which a subject was tested influenced physiological measurement; subjects tested in the horizontal position first showed less sympathetic arousal in the subsequent vertical position, than did subjects tested vertically first. Although, the higher arousal of the "vertical position first" subjects could be attributed to an anxiety response in reaction to the laboratory situation, such a reaction would be expected in both first positions. This did not occur. Alternatively subjects tested vertically first had to cope with the novelty of the laboratory setting in addition to the arousal needed to maintain a vertical posture. Irrespective of the actual process, McLaughlin's group found consistent differences in autonomic indices between the sitting and supine positions.

Attention Effects. Whilst results eminating from the literature about respiratory pacing appear to be relatively convincing as to the effectiveness of this method in either decreasing, or increasing, subjective and physiological indices of arousal, there is one major methodological problem: Does attending to pacing procedures have a significant impact on psychological and physiological indices?

Of the studies investigating the effects of paced respiration on subjective and objective indices of arousal, two used visual stimuli (lights) to indicate the rate at which the subject should breathe (Clark, 1978; Harris, Katkin, Lick and Habberfield, 1976), two used auditory stimuli (Cogan & Kluthe, 1981; Lane, 1981) whilst another two studies used visual tracking stimuli to indicate the rate of inspiration and expiration (Holmes, McCaul & Solomon, 1978; McCaul, Solomon & Holmes, 1979).

Harris et al. (1976) evaluated autonomic responses to the threat of electric shock and found significantly higher skin conductance in their attention control group compared to their paced respiration group. Whilst this outcome tends to indicate that the control group had higher arousal levels than the paced respiration group, such a result was not observed on other indices. In interpreting their data Harris and his co-workers claim that simply attending to the pacing stimulus did not lower arousal in the paced subjects, as subjects in the attention control group actually showed "increased arousal". These authors postulate that the reason for such a result might be that the attention control group was required to perform a more difficult task (signalling to the experimenter after every tenth light flash) than the paced subjects who were asked to inhale and exhale as indicated by a flashing light.

A similarly confounded result was obtained by Holmes et al. (1978) when they instructed their attention control subjects to manipulate a knob to produce a tracing of their resting respiratory pattern. The paced subjects were required to synchronize their breathing, using a video monitor, with a pre-recorded pattern of their own resting breathing (see Holmes et al., 1978). These authors also used the threat of electric shock as the anxiety eliciting stimulus and discovered that the subjects who were not provided with a task to perform (i.e. no attention task and no paced breathing) were the only subjects to show a decline in physiological arousal (as mesured by heart rate). Holmes et al. (1978) suggest that the no-treatment subjects were the most efficient in reducing stress because they were free to develop their own cognitive strategies for dealing with threat. This investigation points out the importance of including adequate control groups and proposes that no-treatment control subjects are not necessarily congitively inactive simply because they are not prescribed a task to perform.

The results of both preceding studies (Harris et al., 1976 ; Holmes et al., 1978) tend to imply that attention control tasks, such as counting light flashes and manually tracing a respiratory pattern on a polygraph, are tasks which are significantly different from the respiratory pacing procedures. It appears that in both studies the attention control procedure was more difficult than the respiratory pacing task and consequently a reliable comparison cannot be made. Similarly it seems important to consider that no-treatment control group subjects may actually develop their own strategy for coping with stress.

In another study investigating the effectiveness of paced breathing in reducing the anxiety levels produced by the threat of an electric shock, McCaul, Solomon and Holmes (1979) used two attention control groups. The paced subjects were required to synchronize their breathing with the rise and fall of a sine wave which moved from left to right across a video monitor at the rate of 8 breaths per minute. The "normal-breathing" control group was required to do precisely the same as the experimental group with the exception that their breathing rate was 16 breaths per minute. The "non-regulated-breathing" group was required to watch a test pattern on the monitor. McCaul et al. (1979), found that the two attention control groups did not differ significantly from each other indicating that attention to pacing was not a major contributing factor. These authors also found that those subjects in the slow pacing condition displayed significantly lower anxiety levels (as measured by skin resistance, finger pulse volume, and self-report) than the subjects in either of the control conditions. Such a result suggests that an appropriate control group to use in experimental pacing procedures is a group which would follow the same instructions but breathe at their normal rate.

Due to the experimental design employed by McCaul et al. (1979), it is possible to conclude that attention to visual tracking stimuli may not necessarily result in changes of arousal. Thus, whilst most previous investigators seem to favour the use of discrete visual or auditory signals, the effects of continuous visual stimuli do not appear to interfere with the experimental effects. Nevertheless, in order to accurately assess experimental effects the subjects in the control condition must be required to perform a task which not only includes an attentional component but which also includes an almost identical attentional component to the experimental procedure. Thus, in order to assess the influence of continuous visual stimuli on arousal levels, such as those which may be used to change a subjects respiratory pattern, an adequate attention control condition should require the control subjects to perform breathing manoeuvres which demand some concentration but which do not change the subjects' arousal levels.

Summary

The use of respiratory manipulation appears to have had a long history; initially in ancient mystical and meditational practices and more recently in a variety of relaxation procedures. It has been hypothesized that the physiological changes occuring during such procedures (decreases in O_2 consumption, respiratory rate, heart rate, muscle tension and skin conductance; increase in EEG alpha wave activity) result from an integrated hypothalmic response which decreases sympathetic nervous system activity. There is evidence to suggest that such a response may be associated with either increased or decreased thoracic respiration.

There appear to be two major approaches within the literature dealing with this subject. The first approach, investigating sleep and respiratory characteristics, indicates that increased thoracic breathing is associated with the decrease of arousal so that during stage 1 sleep breathing is predominently thoracic. Similarly, with an increase in arousal, breathing returns to being predominantly abdominal. It has been suggested that the change from predominantly abdominal to predominantly thoracic breathing is a more accurate indicator of sleep onset than is the EEG.

The second approach, investigating breathing during periods of increased arousal, indicates that thoracic breathing is more predominant during higher levels of arousal than during lower levels of arousal. Such a conclusion is supported by several findings. Firstly, the muscle stretch receptors which provide proprioceptive feedback about the state of the lungs, are located in the thoracic region. When these receptors are stimulated by lung inflation, parasympathetic influences of the heart are reduced so that cardiac activity increases. Also, it has been found that cardiac activity increases during thoracic breathing whilst abdominal breathing tends to reduce such activity. As increases in cardiac activity are generally associated with higher arousal levels and greater metabolic demands, it is noteworthy that during a respiratory cycle under physical exercise the thoracic muscles are activated prior to the abdominal muscles, whilst during resting the abdominal muscles are activated first. It has also been found that psychological stress may result in greater thoracic contribution to the respiratory cycle.

Although there appears to be some disagreement in the literature as to which end of the arousal continuum is characterized by predominantly thoracic breathing these differences may possibly be explained by the effects of body position. It is noticeable that whilst the subjects in the sleep research were assessed in the supine position, subjects in the studies investigating higher levels of arousal were usually assessed in the sitting or upright positions. Research investigating the effects of body position on the respiratory function has revealed that the degree to which the gravitational, diaphragmatic and gut-compliance factors influence the respiratory cycle is dependent on the position in which subjects are assessed. The influence of these factors decreases in the supine position thus allowing predominantly abdominal breathing. By comparison, in the sitting position the effects of the gravitational, diaphragmatic and gut-compliance factors increase and produce thoracic breathing.

Irrespective of which end of the arousal continuum is associated with thoracic breathing, the link drawn between different arousal levels and respiration tends to suggest that changing the relative thoracic-abdominal contribution may influence the functioning of the autonomic nervous system. The voluntary manipulation of respiratory modes may, therefore, contribute to the understanding of the physiological changes occuring during meditational and relaxation procedures. Before such a relationship can be investigated there are some issues which require clarification. These concern the relationship between the three measures commonly used to study respiratory characteristics (respiratory rate, I/E ratios and T-A index) and the effect of the subject's sex and body position on respiratory measures.

The Present Investigation

Rationale. From the previous literature review it is evident that: a) respiration has a direct impact on arousal through the autonomic nervous system, and has been shown to be useful in changing arousal levels, b) the two modes of respiration (thoracic and abdominal) may be associated with different levels of arousal, and c) the sex of the subject and the body position in which the subject is assessed may influence the subject's respiratory characteristics.

Some of the psychophysiological literature discussed in the previous sections involves the use of a stress inducing condition, for example, the threat of electric shock, difficult information processing tasks or other emotionally stimulating material. (Cheung & Porges, 1977; Harris et al., 1976; Holmes et al., 1978; Lane, 1981; McCaul et al., 1979; Porges & Coles, 1982; Porges & Humphrey, 1977; Walter & Porges, 1976). In this respect these studies were evaluating the subject's reactions to particular stimuli. The purpose of the present investigation is quite different. This study endeavours to discover what physiological and psychological changes occur in normal subjects whilst resting or performing specific respiratory manoeuvres. The investigation was performed in two separate experiments.

CHAPTER 2

Experiment 1

The influence of sex and body position on respiratory characteristics and psychophysiological indices.

The influence of sex and body position on respiratory characteristics has been studied by a number of researchers. The investigations of breathing, however, have rarely focused solely on sex differences. On occasions when large enough numbers of subjects, of both sexes, have been included, authors have tended to concentrate on respiratory characteristics other than thoracic and abdominal differences or have not used the T-A index. Amongst the studies in which breathing differences have been observed, the concensus appears to be that females have a prodominantly thoracic breathing pattern, whilst males tend to display a predominantly abdominal breathing pattern.

Most studies of respiratory characteristics tend to pay little attention to the position of the subject. Conversely, clinical and meditational techniques tend to emphasize the importance of posture and body position. Whilst there is some evidence showing that body position affects respiration and autonomic indices, researchers have not applied the T-A index in such studies.

Aim and Hypotheses of Experiment 1. Experiment 1 has two aims: firstly, it is to investigate, using the T-A index and the I/E ratio, the differences characterizing the breathing styles of female and male subjects; and secondly, to discover whether position (sitting or supine) affects respiratory characteristics, and psychological and physiological indices of arousal.

This experiment is necessary because there is a lack of comparative data on the influence of these two independant variables and on the extent of any possible interaction between them.

It was hypothesized that,

1) female subjects will have larger T-A index scores than male subjects, i.e. female subjects will breathe relatively more with the thorax than will male subjects;

2) the T-A index scores will be larger in the sitting position than in the supine position, i.e. the sitting position will produce more

thoracic involvement than the supine position, and
3) the changes in thoracic and abdominal I/E ratios will be dependent on body position.

Method

Subjects and Design

Thirty-two volunteer (16 male, 16 female) subjects were selected. Participants were required to be non-smokers, of reasonable physical fitness and without any respiratory disease. Each subject was randomly allocated to either of two conditions: Order 1 in which subjects were first tested in the sitting position and then in the supine position, or Order 2 in which subjects were first tested in the supine position and then in the sitting position. Separate groups were formed for each sex in each of the two experimental conditions resulting in four experimental groups. An unscorable respiratory record from one subject necessitated the elimination of one subject from each of the other three experimental groups resulting in seven subjects in each group. In Order 1 (sitting-supine) the mean age for male subjects was 26 years (range 19-31) and for the female subjects it was 23 years (range 21-27). In Order 2 (supine-sitting) the mean age for the male subjects was 21 years (range 18-29) and for the female subjects the mean age was 20 years (range 18-23).

A 2x2x2 factorial design was employed to assess the effects of sex, order and body position on respiratory characteristics and physiological and psychological indices. The dependent variables measured were Respiratory Rate, T-A index, I/E ratio, Heart-Rate, Skin Conductance, Time Estimation and the Psychophysiological State Questionnaire. All subjects in Order 1 and Order 2 underwent the same treatment during the experimental procedure. The only manipulation in this experiment was the changing of the order of body position. This manipulation was included in order to control for any change of arousal level solely due to the effect of an initial body position. Any differences in physiological or psychological data, therefore could be attributed to either effects of sex, position or order of body position.

Apparatus

The experiment was conducted in two adjoining rooms. The room in which the subjects were assessed was a 4 metre by 7.5 meter sound attenuated chamber. It was adequately lit by fluorescent lights and kept at a temperature of about 23-25^{o}C by a thermostatically controlled fan heater. All electronic equipment used was kept in the adjoining instrument room. Electrical access to the experimental chamber was possible through a plug-board.

Physiological Responses. A 4 channel Beckman R-511A Dynograph recorder was used to record the physiological measures. The paper speed was kept constant throughout the entire investigation at 2.5mm/sec. The time interval indicator marked every five seconds and every minute.

Channels 1 and 2 were used to record the thoracic and abdominal respiratory amplitudes. The respective respiratory movements were measured using two 20.5 cm Parkes Electronics Laboratory mercury-in-rubber strain gauges. The thoracic gauge was attached to the subject at the level of the armpits, whilst the abdominal gauge was placed at the level of the subject's navel. Male subjects had both strain gauges placed directly on the skin. Female subjects were asked to wear "T - shirts" over which the thoracic gauge was placed whilst the abdominal gauge was placed directly on the skin. The change in resistance of the mercury resulting from movement of the chest and abdomen was relayed via the plug-board into the instrument room. The strain gauges were fed separately into high resolution digital multi-meters (B & K Precision Digital Multi-Meter, Model 2810). The electrical resistance values were then relayed to Beckman 9801 (straight-through) couples. The sensitivity of both channels was kept constant at 0.2mv/mm. At this sensitivity a 10mm expansion of the strain gauge produced approximately a 4mm pen deflection on the Beckman recorder. The pen polarity was selected so that inspiration produced an upward pen deflection. Thoracic measures were recorded on channel 1 while channel 2 was used to record abdominal measures.

Channel 3 was employed to record Skin Conductance. This physiological index was measured using Grass gold plated cup electrodes (area = 0.785cm) filled with Beckman electrode paste. The electrodes were placed on the abraded surface of the distal phalanx of the first and third fingers of the non-dominant hand (usually the left). These electrodes were then relayed directly through the plug-board to a Beckman 9844 (Skin Conductance) coupler. The sensitivity of this channel was set at 0.05mv/mm so that a calibration signal of 0.5 umhos produced 10 mm pen deflection. Polarity of this channel was selected so that increases in Skin Conductance produced upward pen deflections.

Channel 4 was used to record Heart Rate which was measured using two Grass gold plated electrodes filled with Beckman electrode paste. The electrodes were attached using surgical Micropore tape, to the left and right lateral regions of the subject approximately at the level of the seventh rib. A third electrode, serving as an earth, was attached in a similar fashion to the region covering the anterior part of the trapezius muscle. The electrodes were connected via the plug-board to a Beckman 9806A (AC-DC) coupler. The sensitivity of this channel was set at 0.2mv/mm so that the R wave amplitude was between 3 and 8 mm of pen deflection.

<u>Psychological Variables</u>. Three psychological measures were assessed for each subject. These were: the Taylor Manifest Anxiety Scale (TMAS), the Psychophysiological State Questionnaire (PSQ) and Time Estimation.

The shortened, 50 item version (Bendig, 1956) of the Taylor Manifest Anxiety Scale (Taylor, 1953) was used to assess subjects' trait anxiety (see Appendix A).

The Psychophysiological State Questionnaire, a thirteen item scale, was developed specifically for the present investigation. Some items were drawn from the State - Trait Anxiety Inventory (Speilberger, Gorsuch & Lushene, 1970) whilst other items were included because of specific application to the present study (see Appendix B).

The third psychological variable was the estimation of time. In this investigation subjects were asked to estimate time (30 secs) by using the production method (Bindra & Waksberg, 1956) which requires the subject to delimit a temporal interval initiated by the experimenter. This method has been found to correlate well with physiological indices of arousal. Cahoon (1969) found an inverse relationship between arousal level, (as measured by heart rate & alpha frequencies), and time estimation. Hawkes, Joy and Evans (1962) obtained similar results using heart rate and respiratory rate. Cahoon concluded from his study that, under high arousal conditions, subjects underestimate chronological time (30 secs) while during low arousal subjects appeared to overestimate chronological time.

An accurate electronic timer connected to two sonalerts was set up so that pressing a switch in the instrument room reset the timer to zero, sounded a tone in the subject room and started the timing. One tone signalled the beginning of Time Estimation and the subject pressed a hand held switch when he or she considered that 30 seconds had elapsed. The pressing of this switch sounded a second tone and stopped the timer which displayed the subject's estimation of a thirty second period.

Procedure

Each subject was informed that the procedure involved completing some questionnaires and having physiological functions recorded in the sitting position and while lying on a bed. The terms "relaxation" and "arousal" were purposefully not mentioned. Subjects were allowed about five minutes to fill out the TMAS. Electrodes were then attached and the subjects were asked to adopt the first position. They were then given the PSQ to complete. This was followed by two minutes of further adaptation, during which subjects were instructed to think of "neutral" daily activities, and to continue such contemplation whilst recording was in progress. Frequently chosen themes concerned cooking or walking. After the two minutes of adaptation a 10 minute period of recording was started at the end of which five repeated estimations of 30 second intervals were performed and another PSQ completed.

Prior to the second recording period the experimenter helped the subjects assume the alternative position. The same sequence of events followed, however, the PSQ was only completed once, following Time Estimation at the end of the session. During debriefing, physiological recordings were explained and any questions answered.

Scoring

Physiological Responses. Physiological indices were scored during three 30 second sampling periods taken at the first, fifth, and tenth minute (unless the record was disrupted by yawning, coughing, or excessive movement).

The respiratory record was scored by measuring the height of each respiratory curve, the distance from the beginning of the breath to the apex of the curve (inspiration), and the distance from the apex of the curve to the end of the expiratory pause (expiration).

As the two strain gauges and the two multimeters did not give identical readings for equal amounts of strain gauge expansion, correction factors were calculated separately for each recording channel. The thoracic amplitude, as measured in mm of pen deflection, was multiplied by 0.641 in order to convert the recording to girth changes in mms. The abdominal amplitude was multiplied by 0.96 to give abdominal amplitude in mms.

To obtain the proportional thoracic-abdominal contribution of each breath the amplitudes from the thoracic and abdominal respiratory recordings were inserted into a formula based on that used by Naifeh and Kamiya (1981):

$$\text{T-A index} = \frac{T - A}{(T + A)/2} + 2$$

where T and A are thoracic and abdominal amplitudes respectively. This formula reduces the two numbers to an index with values ranging from 0 - 4. The higher the value the greater the thoracic contribution to any particular breath. A value of more than 2 represents a predominantly thoracic mode of respiration, conversely a value of less than 2 represents a predominantly abdominal mode of respiration.

The inspiration/expiration (I/E) ratio was calculated with the post-expiratory pause included in the expiratory phase of the respiratory cycle. The formula:

$$\text{I/E ratio} = \frac{I}{E}$$

where I and E are inspiration and expiration times respectively, was used to calculate this ratio for every breath scored. As the paper speed of the recorder was 2.5 mm/second each mm of inspiratory or expiratory curve equalled 0.4 seconds.

Respiratory Rate was scored by counting the number of respiratory curves in each 30 second sampling period. This score was then doubled to produce the number of breaths per minute.

Skin Conductance Level was scored by averaging two measures representing the lowest and the highest Skin Conductance values within each 30 second sampling period. An increase in Skin Conductance values (umhos) indicates an increase in physiological arousal.

Heart Rate was scored by counting the number of R-waves within the 30 second sampling period. This score was then doubled to obtain Heart Rate in beats per minute.

Psychological Variables. The TMAS was scored by adding together those responses reflecting the existance of anxiety.

The PSQ was scored by checking the responses against a scoring template (which was adjusted for the reversed polarity items) and adding together the positively marked items. Each score obtained in this way is referred to as a "self-report".

Time Estimation measures were obtained by averaging the five time estimations taken at the end of each recording session.

Results

Psychological Data

The data was collected and scored in the manner described in the section entitled "Scoring". The original data for each of the variables is presented in Appendix C. Separate ANOVAs were used to analyse the data from each variable (see Appendix J for ANOVA Summary Tables). The results of the analysis of each variable will be discussed individually.

Taylor Manifest Anxiety Scale. The mean, range and median of the TMAS scores for the male and female subjects were calculated. These are presented in Table 1.

Table 1
Mean, Range and Median of TMAS scores for Male and Female subjects

	Mean	Range	Median
Male	11.3	4-21	8
Female	14.1	6-27	13

The individual scores were analysed using a 2 x 1 ANOVA. The results revealed that the differences between male and female subjects were statistically non-significant ($F(1,26)=2.115, p>0.05$). Clinically significant scores were not found.

Psychophysiological State Questionnaire. The mean PSQ scores for the male and female subjects at baseline, and in the sitting and supine positions, were calculated. These results are presented in Table 2.

Table 2
Mean PSQ for Male and Female subjects
at Baseline and in the Sitting and Supine Positions

	Baseline	Sitting	Supine
Male	24.1	23.5	22.3
Female	26.4	25.3	23.1

The individual scores were analysed using a 2 x 3 (sex x self-report) ANOVA. This analysis revealed no statistically significant differences between male and female subjects ($\underline{F}(1,26)=0.652, \underline{p}>0.05$). Although not statistically significant, ($\underline{F}(2,78)=2.783, 0.1>\underline{p}>0.05$), there was a tendency for PSQ scores to differ according to when measures were taken (baseline, sitting, supine). Both male and female subjects tended to report lower arousal levels in the supine position than in the sitting position or at baseline. This occurred regardless of the order in which the measure was taken.

Time Estimation. The mean Time Estimation scores were calculated for male and female subjects for the sitting and the supine positions, and for both orders (sitting-supine; supine-sitting). These results are presented in Table 3.

The individual Time Estimations were analysed using a 2 x 2 x 2 (sex x order x position) ANOVA. Whilst this analysis revealed that no significant effects were found within the three variables, the interaction between order and position was shown to be significant ($\underline{F}(1,26)=7.449, \underline{p}<0.05$). This interaction is presented in Table 4.

Table 3
Mean Time Estimations (secs) for
Sex (a), Order(b), and Position(c)

a) Sex	male	33.1
	female	30.5
b) Order	sit-sup	29.4
	sup-sit	34.1
c) Position	sitting	32.1
	supine	31.5

Table 4
Mean Time Estimations (secs) for
the Order x Position Interaction

	Order 1	Order 2
Position	sit-sup	sup-sit
Sitting	27.6	36.5
Supine	31.2	31.7

The analysis of the order by position interaction indicates that when the supine position was followed by the sitting position, estimation of a 30 second interval in the sitting position resulted in a mean overestimation of 6.5 seconds. In the supine position the mean overestimation was only 1.7 seconds. A t-test revealed that the larger difference was statistically significant ($t=2.189, df=26, p<0.05$). Such an overestimation in the sitting position of Order 2 indicates that assessment, firstly in the supine position and then in the sitting position produced a decrease in arousal level. A similar change in arousal levels is not indicated by Time Estimation in Order 1. Also, by itself, the supine position in Order 2 does not appear to produce an overestimation of time. Furthermore, the difference in Time Estimation between the sitting position in Order 1 and the sitting position in Order 2 (t=1.709, df=26, $p<0.05$) suggests that the sitting position by itself is not responsible for the measured decrease in arousal level. It seems, therefore, that a combined effect of the initial supine position followed by the sitting position produced a reduction in the subjects' arousal level as measured by Time Estimation.

Physiological Data

The data was collected and scored in the manner described in the section entitled "Scoring". The original data for each of the variables is presented in Appendix D. Separate ANOVAs were used to analyse the data from each variable (see Appendix K for ANOVA Summary Tables). The results of the analysis of each variable will be discussed individually.

Skin Conductance. The mean Skin Conductance Levels were calculated across the three sampling periods for male and female subjects, for the sitting and the supine positions, and for both orders (sitting-supine, supine-sitting). The overall means for each variable were also calculated. These results are presented in Table 5.

The individual Skin Conductance Levels were analysed using a 2 x 2 x 2 x 3 (sex x order x position x sampling period) ANOVA. No significant effects were found for sex, order, position or sampling period. There was, however, a significant interaction between sex and sampling period ($F(2,78)=4.999$, $p<0.05$). As can be seen in Table 5(a) male subjects' Skin Conductance Levels (umhos) decreased across the three sampling periods indicating a decrease in arousal level. Conversely, the female subjects showed an increase in Skin Conductance Levels (umhos) demonstrating an increase in arousal levels.

Table 5
Mean Skin Conductance Levels (umhos)
in each Sampling Period for
Sex (a), Order (b) and Position (c)

		Overall Mean	Sampling Period 1	2	3
a) Sex	male	6.20	6.50	6.08	6.01
	female	5.77	5.49	5.83	5.98
b) Order	sit-sup	5.90	6.14	5.83	5.74
	sup-sit	6.10	5.85	6.09	6.24
c) Position	sitting	5.81	5.75	5.68	5.99
	supine	6.15	6.24	6.22	6.00

Although statistically non-significant the interaction between order and sampling period approached significance ($\underline{F}(2,78)=3.152, 0.1>\underline{p}>0.05$). Table 5(b) shows that the subjects who were assessed in the sitting-supine order tended to decrease arousal levels whilst the subjects who were assessed in the supine-sitting order tended to increase arousal levels.

Whilst non-significant ($\underline{F}(2,78)=2.016, \underline{p}>0.05$) the interaction between position and sampling period shows a tendency for the sitting position to be associated with increasing arousal levels and the supine position to be associated with decreasing arousal levels over time (see Table 5c).

<u>Heart Rate</u>. The mean Heart Rate (bpm) was calculated across the three sampling periods for male and female subjects, for the sitting and supine positions, and for both orders (sitting-supine, supine-sitting).

The overall means for each variable were also calculated. These results are presented in Table 6.

Table 6
Mean Heart Rate (bpm) for
Sex(a), Order(b) and Position(c)
in each Sampling Period

		Overall Mean	Sampling Period 1	Sampling Period 2	Sampling Period 3
a) Sex	male	58.9	59.3	59.1	58.4
	female	68.2	67.9	68.8	67.9
b) Order	sit-sup	64.6	65.1	64.8	64.0
	sup-sit	62.5	62.1	63.1	62.3
c) Position	sitting	64.4	64.4	64.4	64.2
	supine	62.8	62.8	63.4	62.1

The Heart Rate for each subject at each sampling period was analysed using a 2 x 2 x 2 x 3 (sex x order x position x sampling period) ANOVA. The position effect proved significant ($\underline{F}(1,26)=8.694, \underline{p}<0.01$) even though the differences in mean bpm between the two positions was not very great (see Table 6c). Larger differences between the means were found between male and female subjects ($\underline{F}(1,26)=6.669, \underline{p}<0.05$). As is seen in Table 6(a) male subjects averaged about 10 bpm below the average of the female subjects. Order effects did not reach significance. Changes in Heart Rate across the three sampling periods did not reach significance.

Whilst interactions between sex, order and position, and the sampling periods proved to be non-significant, the order by position interaction (see Table 7) approached significance ($\underline{F}(1,24)=3.922, 0.1>\underline{p}>0.05$).

Table 7
Mean Heart Rate (bpm) for the
Order x Position Interaction

	Order	
Position	sit-sup	sup-sit
sitting	66.0	62.8
supine	63.3	62.2

Analysis of the order by position interaction revealed that a significant difference between the positions only occurred in the sitting-supine order ($t=3.485, df=26, p<0.05$).

Respiratory Rate. The mean Respiratory Rate (breaths/min) was calculated across the three sampling periods for male and female subjects, for the sitting and supine positions, and for both orders (sitting-supine, supine-sitting). These results are presented in Table 8.

Individual Respiratory Rates were analysed using a 2 x 2 x 2 x 3 (sex x order x position x sampling period) ANOVA. No statistically significant results were obtained. It appears from the analysis that Respiration Rate was not greatly affected by the independent variables.

Inspiration/Expiration Ratio. Mean thoracic and mean abdominal I/E ratios were calculated for male and female subjects, for the sitting and supine positions, for both orders (sitting-supine, supine-sitting), and for each of the sampling periods. These results are presented in Table 9.

Table 8
Mean Respiratory Rate (breaths/minute) for
Sex(a), Order(b), Position(c) and Sampling Period(d)

		Breaths/min.
a) Sex	male	13.8
	female	14.9
b) Order	sit-sup	14.1
	sup-sit	14.6
c) Position	sitting	14.2
	supine	14.5
d) Sampling Period	1	14.1
	2	14.3
	3	14.7

The individual I/E ratios were analysed using two separate 2 x 2 x 2 x 3 (sex x order x position x sampling period) ANOVAs (one for each respiratory mode). The results for the thoracic respiratory mode show a significant effect for sex ($F(1,26)=14.958, p<0.001$) indicating that male subjects had a longer inspiratory phase in comparison to female subjects (see Table 9a). The abdominal I/E ratios show a non-significant difference between male and female subjects ($F(1,26)=2.863, p>0.05$). Order effects were significant for both the thoracic ($F(1,26)=6.591, p<0.05$) and the abdominal ($F(1,26)=5.676, p<0.05$) respiratory modes indicating that in the sitting-supine order both modes of respiration have a longer inspiratory phase than in the supine-sitting order (see Table 9b). The effect of body position on I/E ratios was also significant for both the thoracic ($F(1,26)=6.946, p<0.05$) and the abdominal ($F(1,26)=8.954, p<0.01$) respiratory modes, indicating that in the supine position subjects displayed a longer inspiratory phase than they did when assessed in the sitting position (see Table 9c). The effects of sampling period failed to reach statistical significance, however, the thoracic I/E ratio tended to increase across the three sampling periods ($F(2,78)=3.110$, $0.1>p>0.05$).

Table 9
Mean Thoracic and Abdominal I/E Ratios for
Sex(a), Order(b), Position(c) and Sampling Period(d)

		Thoracic	Abdominal
a) Sex	male	0.536	0.476
	female	0.426	0.427
b) Order	sit-sup	0.518	0.485
	sup-sit	0.444	0.418
c) Position	sitting	0.456	0.430
	supine	0.506	0.473
d) Sampling Period	1	0.462	0.463
	2	0.496	0.449
	3	0.484	0.442

An interaction between order, position and sampling period was shown to be significant for the thoracic respiratory mode ($F(2,108)=7.661$, $p<0.005$). This interaction is presented in Figure 1.

Whilst statistically non-significant ($F(2,108)=2.792, 0.1>p>0.05$) the abdominal I/E ratios also show a tendency to be influenced by the order by position by sampling period interaction (see Figure 2).

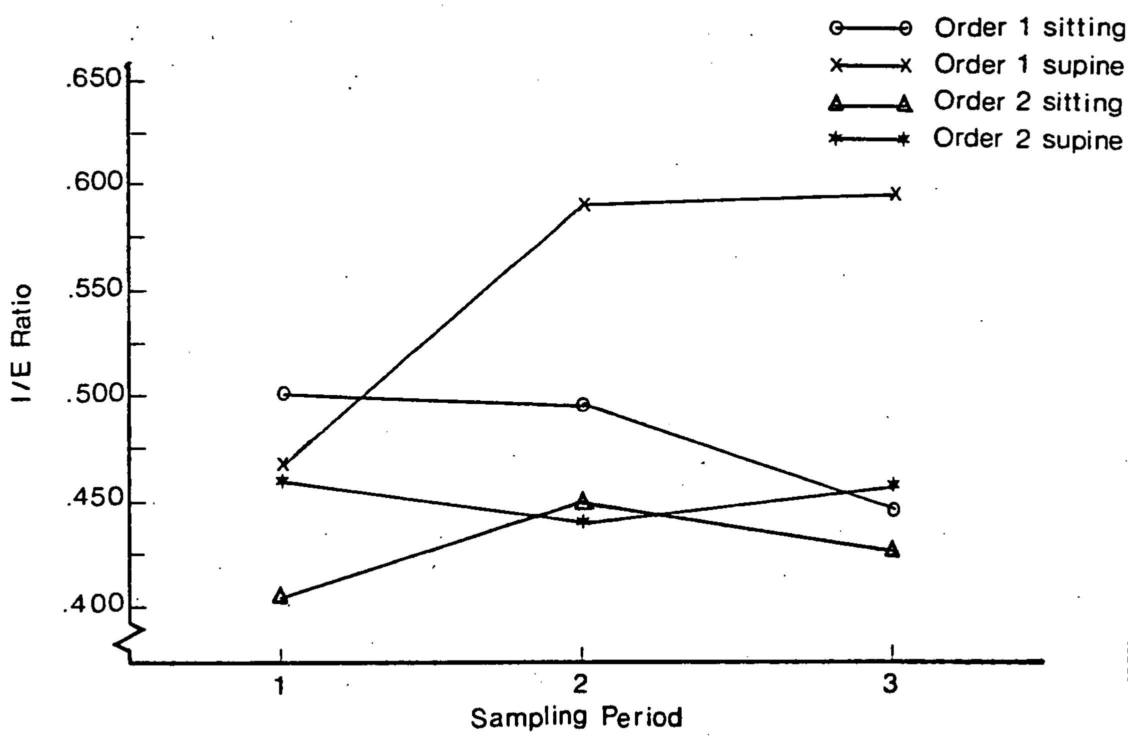

Figure 1. Interaction between Order, Position, and Sampling Period for Mean Thoracic I/E Ratios.

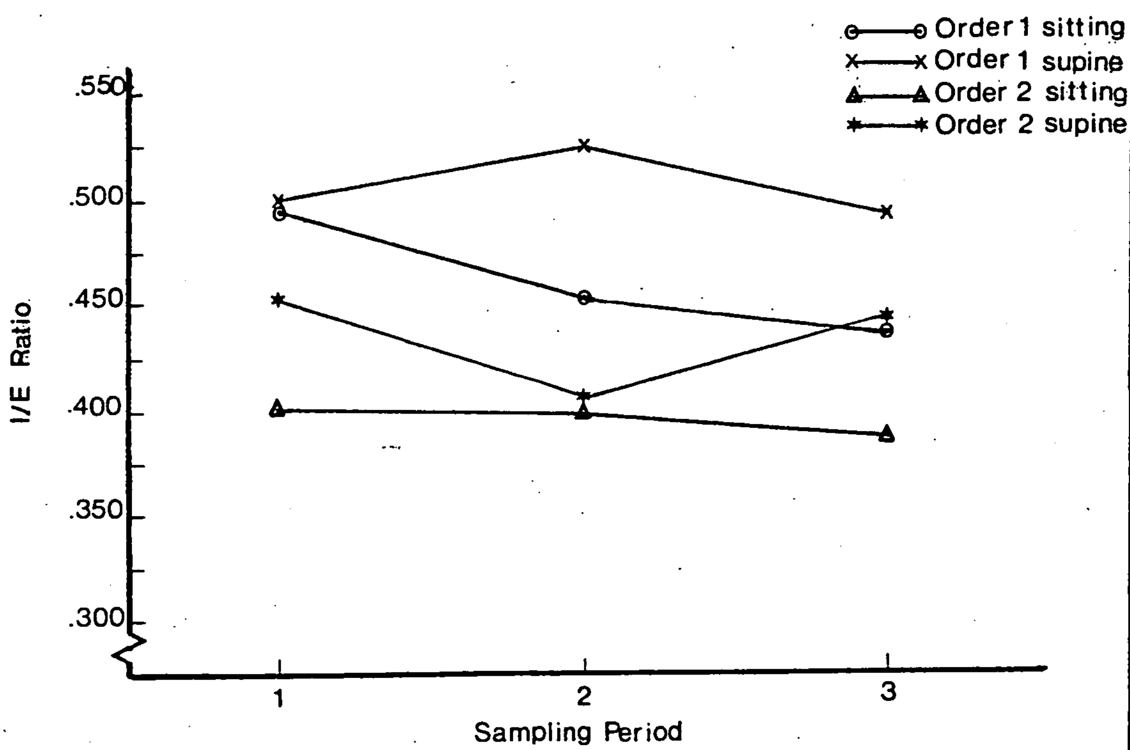

Figure 2. Interaction between Order, Position and Sampling Period for Mean Abdominal I/E Ratios

Figures 1 and 2 illustrate that the I/E ratios of both respiratory modes vary throughout the 10 minute recording period. Individual t-tests performed on the thoracic I/E ratios, however, reveal that in Order 1 (Figure 1) it is the difference between the two positions in sampling period 2 ($t=3.174$, $df=26, p<0.005$) and in sampling period three ($t=4.966$, $df=26, p<0.0001$) which accounts for most of the variation. In Order 2 (Figure 1) some variation in the thoracic I/E ratios appears to be accounted for by the position difference in sampling period 1 ($t=2.161$, $df=26, p<0.05$). Despite the fact that changes in body position appear to contribute to changes in the thoracic I/E ratios no clear pattern is apparent amongst the results for the order by position by sampling period interaction.

Thoracic - Abdominal Index. Mean T-A index scores were calculated for male and female subjects, for the sitting and supine positions, for both orders (sitting-supine, supine-sitting) and for each of the sampling periods. These results are presented in Table 10.

Table 10
Mean T-A Index scores for
Sex (a), Order (b), Position (c), and Sampling Period (d)

		T-A Index
a) Sex	male	1.196
	female	1.287
b) Order	sit-sup	1.779
	sup-sit	1.304
c) Position	sitting	1.458
	supine	1.026
d) Sampling Period	1	1.241
	2	1.236
	3	1.247

The individual T-A index scores were analysed using a 2 x 2 x 2 x 3 (sex x order x position x sampling period) ANOVA. The analysis revealed a strong main effect for position ($F(1,26)=18.246, p<0.0005$) which indicates that in the sitting position subjects tended to breathe more thoracically whilst in the supine position more abdominal respiratory movement was observed (see Table 10c). No statistically significant main effects were observed for sex, order or sampling period.

The interaction between sex and position was found to be significant ($F(1,26)=12.414, p<0.005$) and indicates that the differences in T-A index observed between the two positions are influenced by the sex of the subject. This interaction is presented in Figure 3.

Figure 3 illustrates that the difference between the T-A index in the supine position is mainly due to the female subjects. Male subjects tend to display similar T-A index scores in the sitting and in the supine positions. The female subjects, however, exhibit a relatively high T-A index in the sitting position and a low T-A index in the supine position. As a larger T-A index reflects greater thoracic involvement in the respiratory cycle, it is evident that female subjects display relatively more thoracic movement in the sitting position than do male subjects. Also, it seems that the female subjects display greater abdominal movement in the supine position than do male subjects.

A significant interaction between sex, order and position was revealed ($F(1,27)=4.285, p<0.05$) and is presented in Figure 4. It can be seen from Figure 4 that for the male subjects, the difference between the sitting and the supine T-A index scores is greater in Order 1 than in Order 2. Neither difference, however, reaches statistical significance. Female subjects in both orders show significantly larger T-A index scores (Order 1: $t=2.838, df=13, p<0.01$; and Order 2: $t=4.956, df=13, p<0.001$) in the sitting position than in the supine position.

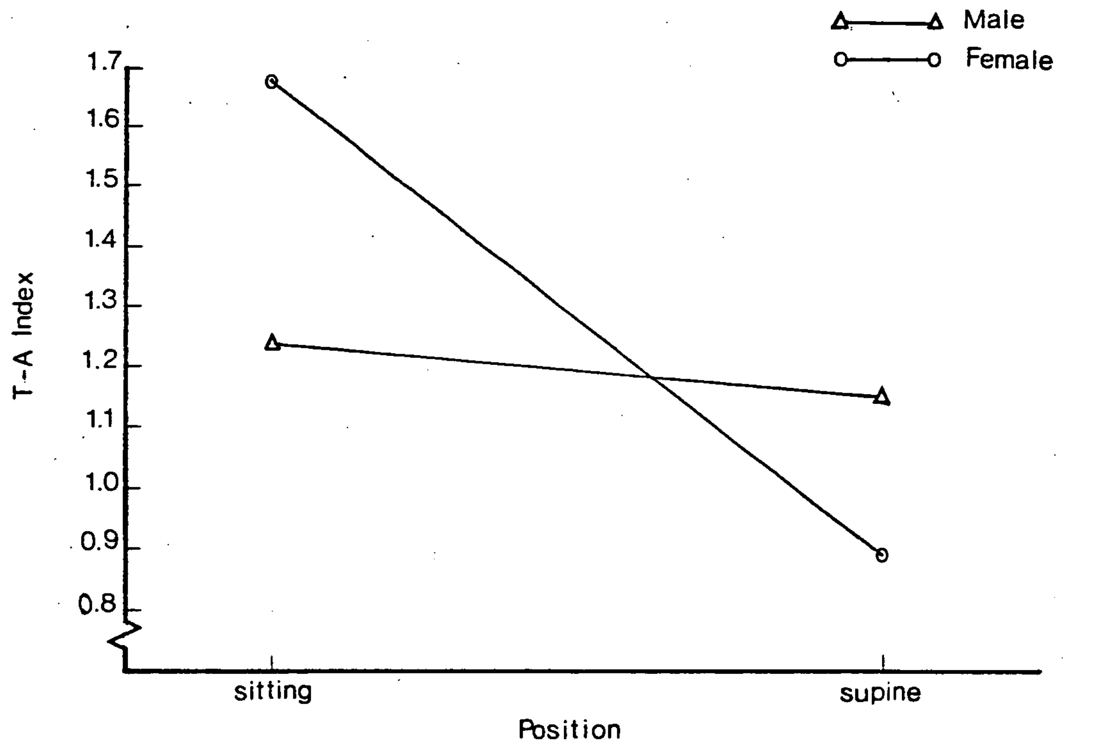

Figure 3. Interaction between Sex and Position for Mean T-A Index scores.

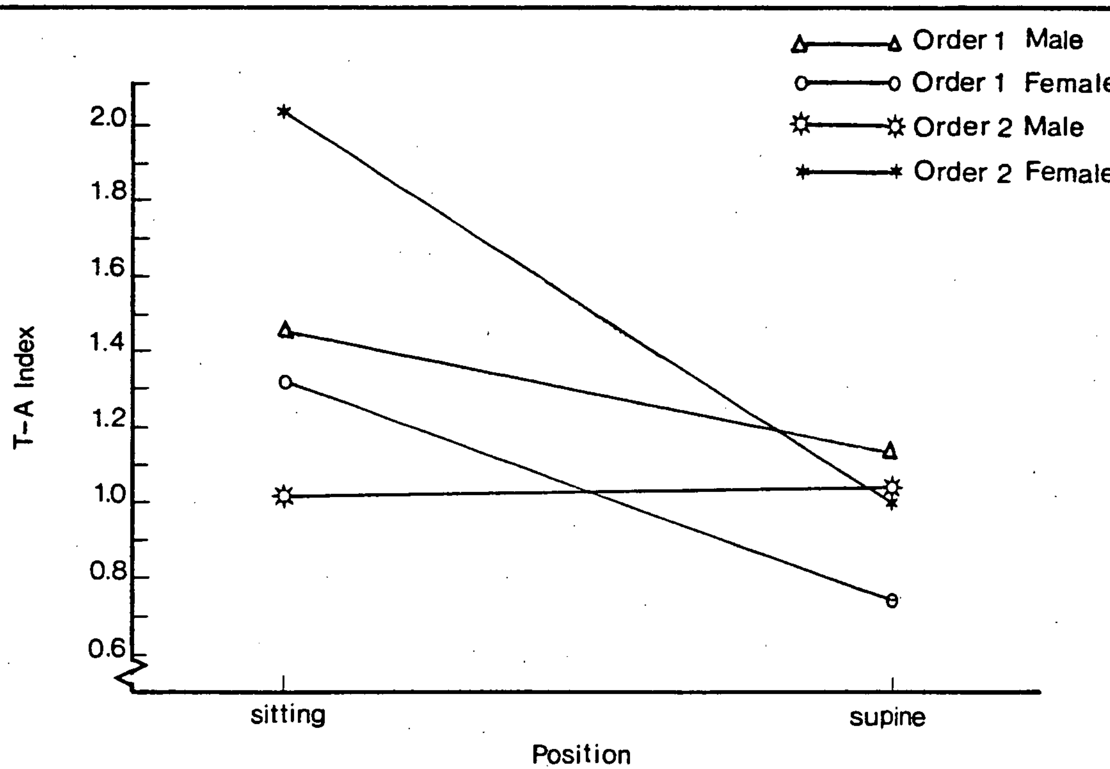

Figure 4. Interaction between Sex, Order, and Position for Mean T-A Index scores (N.B. Order 2 = supine - sitting)

The analysis of the T-A index data revealed that male subjects did not exhibit thoracically dominant breathing in either the sitting or the supine position, instead their respiration was characterised by abdominal movements. Female subjects, however, displayed greater thoracic movement in the sitting position and abdominally dominant breathing in the supine position. No significant differences in T-A index scores were observed across the sampling periods.

CHAPTER 3

Experiment 2

The effects of thoracic and abdominal
respiratory training on
psychological and physiological indices of arousal.

Previous studies suggest that the physiological changes related to changes in breathing result from an integrated hypothalmic response which influences sympathetic nervous system activity. Also, it appears that such central nervous system interaction may interact with thoracic-abdominal respiratory patterns. There are, however, conflicting reports as to which respiratory mode predominates during high or low physiological arousal. Some evidence suggests that thoracic and abdominal breathing patterns produce differential effects on cardiac activity. Thoracic respiration was found to increase activity whilst abdominal respiration appeared to decrease this response. Considering that changes in heart rate may reflect changes in physiological arousal, then manipulating the T-A index may allow access to some physiological indices of arousal.

Aim and Hypotheses of Experiment 2. The aim of the second experiment in this investigation was to evaluate the effects of two breathing patterns on psychological and physiological indices of arousal. It was considered that experimentally induced dominance of predominantly thoracic or predominantly abdominal respiratory patterns would differentially influence self-reported levels of arousal (PSQ) Time Estimation, Skin Conductance Level, Heart Rate and Respiratory Rate. To assess for any changes resulting from the manipulation of breathing patterns, a relaxation condition was included. Similarly, to assess whether attending to the training procedure was responsible for any changes in psychological and physiological indices of arousal, a group of subjects was required to breathe at a rate just below the mean respiratory rate (found in Experiment 1) using the same apparatus as the subjects in the thoracic and abdominal training groups. This treatment condition is referred to as Paced Respiration.

In this part of the investigation it was hypothesized that,

1) thoracic respiratory training will produce a decrease in the indices of arousal,

2) abdominal respiratory training will produce an increase in the indices of arousal,

3) paced respiration will not produce a change in the indices of arousal, and

4) relaxation training will produce a decrease in the indices of arousal.

Method

Subjects and Design

Forty-eight subjects (24 males, 24 females) were selected using the same criteria as used in Experiment 1 (i.e. non-smokers, reasonable fitness, no respiratory disease). Ten of the subjects included in the previous experiment participated in Experiment 2.

Each subject was randomly allocated to one of four treatment groups: thoracic training, abdominal training, paced respiration and a relaxation group. Each group consisted of equal numbers of subjects (12). As both sexes were used each experimental cell consisted of 6 subjects. Table 11 shows the mean ages and age range for each experimental group.

Table 11
Mean Ages and Age Ranges of subjects in the Four Experimental Groups

Treatment Group	Sex	Mean	Range
thoracic	M	25	19 - 28
	F	22	18 - 24
abdominal	M	22.5	18 - 27
	F	21	19 - 27
paced	M	22.5	19 - 28
	F	21	18 - 32
relaxation	M	22	18 - 28
	F	23	19 - 31

All subjects were assessed in the sitting position for two reasons: firstly, results from Experiment 1 indicate that it is in this position that sex differences between respiratory modes (T-A index) were most significant, and secondly this position is usually favoured in clinical relaxation training.

Subjects in the thoracic and abdominal training groups were required to learn to breathe either thoracically or abdominally. The subjects in the paced respiration group were required to synchronise their breathing with a visual analogue at 10 breaths per minute with equal inspiration and expiration times. This group was to serve as an attention control group; a breathing rate of 10 breaths per minute was not expected to significantly affect arousal levels. Nevertheless, these requirements were expected to approximate the necessary level of attention required in the thoracic and abdominal treatment conditions. The fourth treatment group was required to listen to, and perform, the instructions recorded on a "relaxation tape". This treatment group served as a control condition against which the arousal levels of the experimental groups could be assessed.

The results obtained from the thoracic, abdominal, paced and relaxation treatment conditions were analysed using between group analysis.

Apparatus

The instrumentation and methods used in Experiment 2 were similar to those used in Experiment 1. There were, however, a few modifications.

Physiological Responses. Channels 1 and 2 of the Beckman R-511A Dynograph recorder were used in an identical fashion as in Experiment 1 to record the thoracic and abdominal respiratory patterns.

Channel 3 was employed to record Skin Conductance, however, the Grass gold plated cup electrodes used in Experiment 1 were replaced by Ag - AgCl electrodes. The new electrodes had the same contact area (.785cm) as those used previously.

Channel 4 was used in precisely the same way as it was in Experiment 1 to record Heart Rate.

Respiratory Feedback. The mode of respiration being trained (i.e. either thoracic or abdominal) was presented to the subject using a large centre zero display volt meter. This meter was connected via the plug-board to the auxiliary output of either channel 1 (thoracic) or channel 2 (abdominal). Thus, the sweep of the meter needle directly represented the magnitude of the subject's respiratory movements. A second feedback stimulus was a low-frequency auditory signal which represented the respiratory mode which was not being trained. Whenever the amplitude of respiration in this mode exceeded a predetermined threshold a tone sounded indicating that the relative thoracic-abdominal contribution of the breath was incorrect. This tone was controlled by a Med Associates Dual Threshold Comparator which was set to switch on a Voltage Controlled Oscillator above a threshold corresponding to x mm of pen deflection. Such a threshold was equaled approximately to 1/4 of the subject's resting breathing amplitude. As the pen deflection exceeded the threshold a low frequency tone sounded through a speaker situated approximately two feet from the subject's right shoulder.

Pacing Apparatus. The IEC Interstate High Voltage Function Generator F41 was used in the paced treatment condition. A sine wave of 10 cycles per minute was generated with the Frequency Multiplier set at 10, the mode at normal and output level at OdB. The sine wave was displayed visually to the paced respiration subjects using the above-mentioned display volt meter which was connected to the generator via the plug-board.

During the first three treatment conditions the experimenter monitored the subject's feedback and pacing display by using a parallel analogue meter.

Relaxation Apparatus. During the relaxation treatment the display meter was removed from the subject's room. Instead, these subjects listened to a 15 minute tape recording of a Progressive Relaxation procedure (Lazarus, 1971) which was played through a loud speaker. The relaxation procedure concentrated on 16 muscle groups and utilized the difference between muscular tension and muscular relaxation as a cue for generalized relaxation (Jacobson, 1938).

Psychological Variables. Psychological measures (Taylor Manifest Anxiety Scale, Psychophysiological State Questionnaire, Time Estimation) employed in Experiment 2 were identical to those used in Experiment 1 with the exception that in Time Estimation only three instead of five trials were required.

Procedure

Each subject was provided with an introductory explanation to the experiment. The terms "relaxation" and "arousal" were not mentioned except to the relaxation treatment group. Subjects were informed that the procedure involved completing some questionnaires and learning to breathe in a particular pattern while having physiological responses recorded. Each subject was first asked to complete a Taylor Manifest Anxiety Scale, then the electrodes were attached and the subject was asked to sit down in a comfortable arm-chair and wait for instructions.

Feedback Training. Subjects assigned to either of the two feedback training groups (thoracic or abdominal) were given very similar instructions (Appendix E). These subjects were informed that during the experimental session they would be required to breathe with either their chest or their stomach. They were instructed to increase the sweep of the indicator of the meter (without hyperventilating) while keeping the low frequency tone to a minimum. Thus, the subjects were expected to increase the amplitude of one respiratory mode whilst keeping the amplitude of the other very low. It was stressed to each of these subjects that, whilst large breaths are encouraged, they were not to hyperventilate. Following these instructions subjects were told that, firstly they will be required to complete a Psychophysiological State Questionnaire (PSQ), then to do a series of three Time Estimations and after a break of 1 minute proceed with the training which consisted of a:

3 minute training period
2 minute rest
3 minute training period
2 minute rest

and a 5 minute training and recording period.

Subjects were also informed that immediately following the training they would be required to do another series of three Time Estimations and another PSQ.

During the thoracic and abdominal training procedures, the feedback tone and the analogue meter were disconnected while the subject was resting. Also the feedback tone was turned off after the first minute of the 5 minute recording session so that the assessment would not be contaminated by auditory stimuli.

Respiratory Pacing. In the paced breathing treatment, instructions were similar to those outlined above (Appendix F). Subjects, though, were informed that all that was required was for their respiratory cycle to be synchronised with the needle of the meter: inspiring as the needle swept to the right and expiring when it swept to the left. The training sequence consisted of the same 3, 2, 2, 2, 5 minute procedure described above and was followed by Time Estimation and another PSQ. During the rest period the pacing meter was disconnected.

Relaxation Training. Those subjects assigned to the relaxation training group were instructed to take off their shoes and to settle comfortably into the arm-chair. Following this, they were informed of their task (Appendix G) which initially required that they complete a PSQ and a series of three Time Estimations. These subjects were then told that they would be required to listen to a relaxation tape and to follow the instructions suggested. Subjects were asked not to clench the hand on which the skin conductance electrodes were placed. Also, they were told that at the end of the tape they would have 1 minute during which to continue relaxing. After this minute, a second sequence of Time Estimation and a second PSQ were completed.

Following each set of instructions subjects were asked whether they had any questions.

Scoring

Physiological Responses. Physiological indices (T-A index, Respiratory Rate, Skin Conductance Level, Heart Rate) were scored in a similar fashion to Experiment 1 with only two alterations. Instead of three sampling periods a single 30 second sampling period was analysed per subject from the last minute of recording. Also, the I/E ratios were not scored as this index was distorted by the training procedures.

Psychological Variables. Psychological variables (Taylor Manifest Anxiety Scale, Psychophysiological State Questionnaire, Time Estimation) were scored in the same way as in Experiment 1.

Results

Psychological Data

The data was collected and scored in the manner described in the section entitled "Scoring". The original data for each of the variables is presented in Appendix H. Sepatate ANOVAs were used to analyse the data from each variable (see Appendix L for ANOVA Summary Tables). The results obtained for each treatment condition will be considered together in relation to each dependent variable.

Taylor Manifest Anxiety Scale. Mean TMAS scores were calculated for male and female subjects in each of the four treatment conditions. These results are presented in Table 12.

Table 12
Mean TMAS scores for Male and Female subjects in Four Treatment Conditions

	Treatment Condition			
Sex	thoracic	abdominal	paced	relaxation
male	14.7	13.8	8.8	11.8
female	13.7	17.3	11.0	16.5

The individual scores were analysed using a 2 x 4 (sex x treatment) ANOVA. The analysis failed to reveal any significant differences between male and female subjects ($F(1,46)=1.307, p>0.05$) and amongst the treatment conditions ($F(3,44)=1.445, p>0.05$). Clinically significant TMAS scores were not found.

Psychophysiological State Questionnaire. Mean pre-test and post-test PSQ scores were calculated for male and female subjects in each of the four treatment conditions. These results are presented in Figures 5 and 6.

The individual mean PSQ scores were analysed using a 2 x 2 x 4 (sex x self-report x treatment) ANOVA. The analysis did not reveal any main effects. Though the sex by treatment interaction (see Figures 5 and 6) was non-significant ($F(3,40)=0.243, p>0.05$) it illustrates that following the relaxation treatment male and female subjects reported feeling less aroused than before such treatment ($t=2.839, df=11, p<0.05$). Figures 5 and 6 also indicate that whilst male subjects in the paced respiration treatment tend to feel more aroused following this treatment, female subjects tend to feel less aroused following paced respiration. Female subjects, however, show a tendency to feel more aroused following training in abdominal breathing. It appears from these results that thoracic training has no effect on subjective reports of arousal.

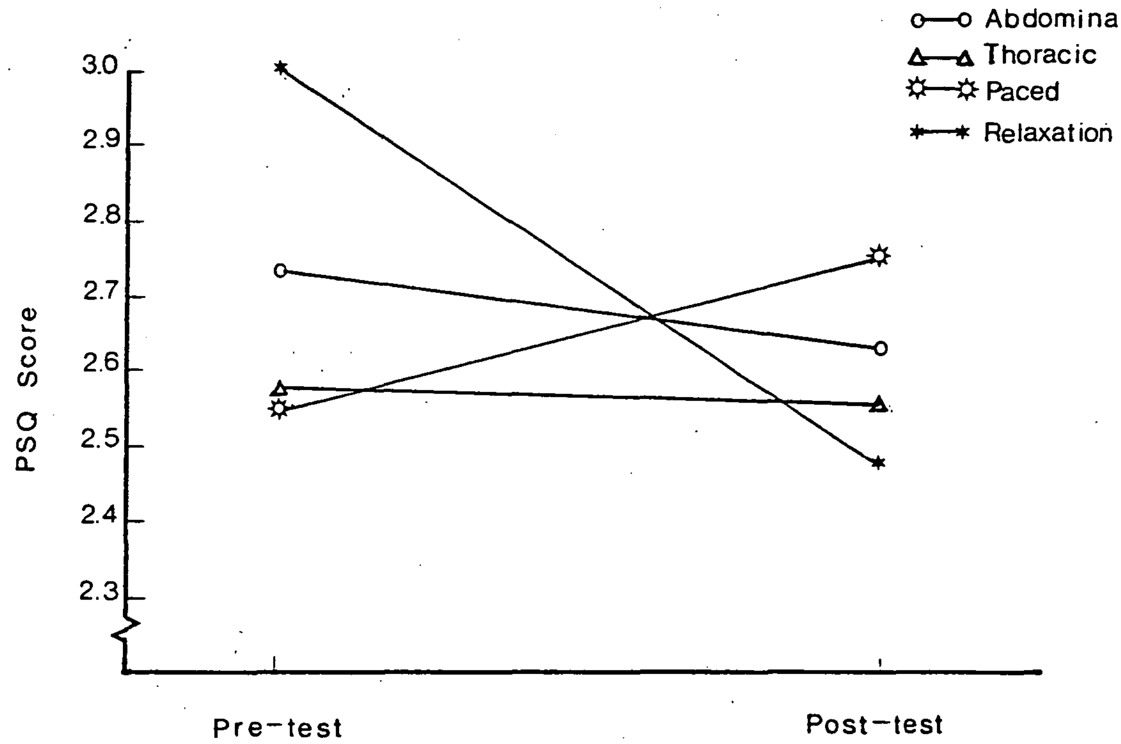

Figure 5. Mean Pre-test and Post-test PSQ scores for Male subjects in Four Treatment Conditions.

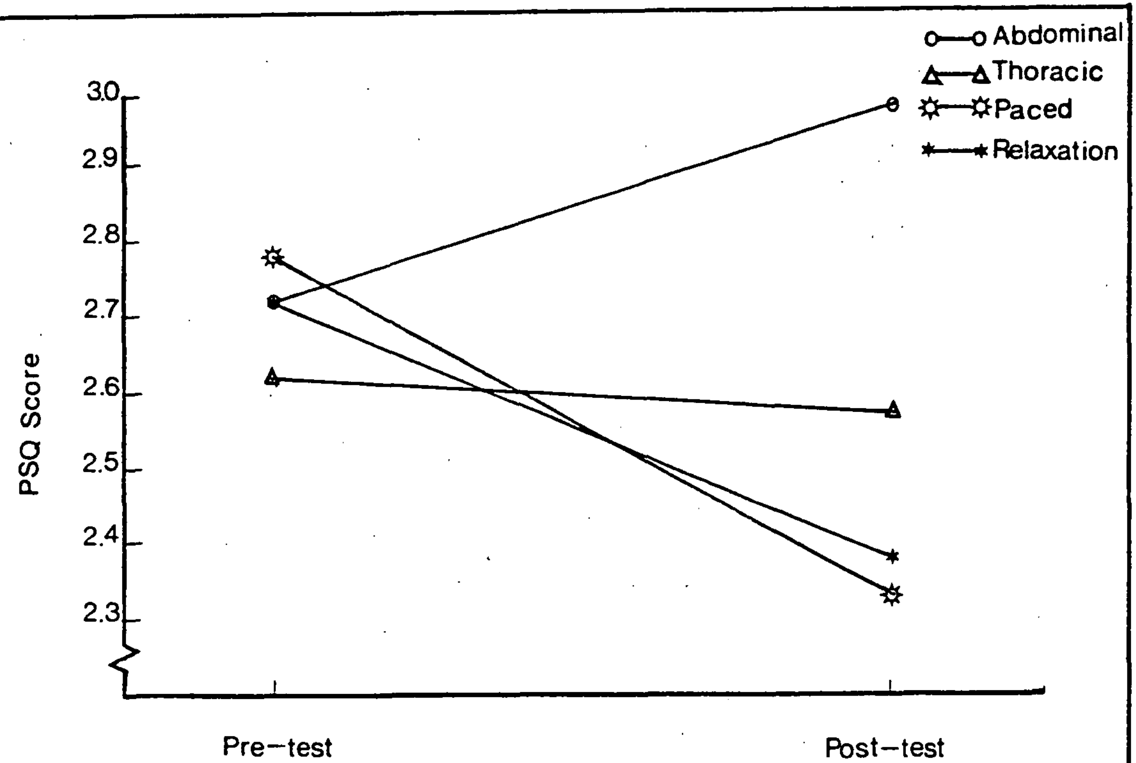

Figure 6. Mean Pre-test and Post-test PSQ scores for Female subjects in Four Treatment Conditions.

Time Estimation. As the individual Time Estimations displayed a very large inter-subject variation (3.8 secs - 128.2 secs) a post-test/pre-test ratio was calculated from each subject's pre-test and post-test means. Larger ratios indicate longer post-test Time Estimations. Mean Time Estimation Ratios were calculated for male and female subjects in each of the four treatment conditions. These results are presented in Table 13.

Table 13
Mean Time Estimations (post-test/pre-test Ratios) for Male and Female subjects in Four Treatment Conditions

	Treatment Condition			
Sex	thoracic	abdominal	paced	relaxation
male	1.117	1.687	1.103	1.120
female	1.387	1.088	1.120	1.238

The individual Time Estimations (ratios) were analysed using a 2 x 4 (sex x treatment) ANOVA. The analysis failed to reveal any significant main effects, however, the Duncan's New Multiple Range Test indicated that male subjects in the abdominal training group tended to significantly (at the 0.05 level) overestimate the 30 second period following this treatment condition. It appears, therefore, that only abdominal training in the male subjects was associated with a decrease in arousal levels (as shown by overestimation of chronological time).

Physiological Data

The data was collected and scored in the manner described in the section entitled "Scoring". The original data for each of the variables is presented in Appendix I. Separate ANOVAs were used to analyse the data from each variable (see Appendix M for ANOVA Summary Tables). The results obtained for each treatment condition will be considered together in relation to each dependent variable.

Skin Conductance. Mean Skin Conductance Levels were calculated for male and female subjects in each of the four treatment conditions. These results are presented in Table 14.

Table 14
Mean Skin Conductance Levels (umhos) for Male and Female subjects in Four Treatment Conditions

	Treatment Condition			
Sex	thoracic	abdominal	paced	relaxation
male	19.942	18.383	20.780	18.358
female	19.162	20.775	25.573	19.347

The individual Skin Conductance Levels were analysed using a 2 x 4 (sex x treatment) ANOVA. The analysis failed to reveal any significant differences between male and female subjects ($F(1,46)=0.583, p>0.05$) and amongst the four treatment conditions ($F(3,44)=0.651, p>0.05$). Similarly, the sex by treatment interaction was non-significant ($F(3,40)=0.236, p>0.05$).

It appears from these results that inter-subject variability was too great in each treatment condition for this index to have any differentiating value. The disparity between the Skin Conductance Levels observed in Experiment 1 and Experiment 2 will be discussed in the following chapter.

Heart Rate. Mean Heart Rate (bpm) was calculated for male and female subjects in each of the four treatment conditions. These results are presented in Table 15.

Table 15
Mean Heart Rate (bpm) for Male and Female subjects
in Four Treatment Conditions

	Treatment Condition			
Sex	thoracic	abdominal	paced	relaxation
male	62.3	76.3	72.0	63.3
female	73.7	75.3	78.7	72.7

The Heart Rates for subjects in each treatment condition were analysed using a 2 x 4 (sex x treatment) ANOVA. The analysis failed to reveal any main effects, though there was a tendency for male subjects to have lower Heart Rate than female subjects ($F(1,46)=3.356, 0.1>p>0.05$). The interaction between sex and treatment condition (see Table 15) was also shown to be non-significant ($F(3,40)=0.565, p>0.05$). Inter-subject variability appears to be too large to allow this physiological index to adequately differentiate between the four treatment conditions.

Respiratory Rate. As subjects in the paced treatment group maintained a constant breathing rate (10 breaths per minute) this group was excluded from the analysis of Respiratory Rate.

Mean Respiratory Rate (breaths/min) was calculated for male and female subjects in each of the three treatment conditions. These results are presented in Table 16.

Table 16
Mean Respiratory Rate for Male and Female subjects in Three Treatment Conditions

	Treatment Condition		
Sex	thoracic	abdominal	relaxation
male	8.0	12.7	12.7
female	10.8	11.7	16.0
combined	9.4	12.2	14.3

The individual Respiratory Rates were analysed using a 2 x 3 (sex x treatment) ANOVA. A main effect for sex was revealed ($\underline{F}(1,34)=4.429$, $\underline{p}<0.05$) even though the difference between the mean male rate (11.1 breaths/min) and the mean female rate (12.8 breaths/min) was not very large. Significant differences ($\underline{F}(2,33)=12.088, \underline{p}<0.0005$) were observed between the three treatment conditions on combined male and female data (see Table 16). The Duncan's New Multiple Range Test revealed that the thoracic and abdominal training groups displayed significantly (at the 0.01 level) lower Respiratory Rates than did the relaxation group. Furthermore, the thoracic training group was shown, by the same test to display a significantly (at the 0.01 level) lower Respiratory Rate than the abdominal training group. Whilst the sex by treatment interaction proved non-significant ($\underline{F}(2,30)=2.797, 0.1>\underline{p}>0.05$) further analysis (Duncan's New Multiple Range Test) revealed that in the thoracic training group male subjects have a significantly (at the 0.01 level) lower Respiratory Rate than female subjects. Therefore, the difference in breathing rates between the thoracic treatment and the abdominal and relaxation treatments can largely be attributed to the decrease in

Respiratory Rate observed in the male subjects of the thoracic group. Also, it appears that the female subjects are responsible for the significantly higher (at the 0.01 level) Respiratory Rate in the relaxation treatment.

<u>Thoracic-Abdominal Index</u>. Mean T-A index scores were calculated for male and female subjects in each of the four treatment conditions. These results are presented in Table 17.

Table 17
Mean T-A Index scores for Male and
Female subjects in Four Treatment Conditions

	Treatment Condition			
Sex	thoracic	abdominal	paced	relaxation
male	2.500	0.235	1.632	1.827
female	3.280	0.575	3.158	2.422
combine	2.915	0.405	2.395	2.124

The individual T-A index scores were analysed using a 2 x 4 (sex x treatment) ANOVA. The analysis revealed a highly significant ($\underline{F}(1,46)$= 18.403,$\underline{p}$<0.0005) difference between male and female subjects (1.561, 2.359 respectively). Such a result reflects the female subjects' predisposition for thoracic breathing and the male subjects' tendency to breathe relatively more abdominally irrespective of the treatment (see Table 17). It is evident from Table 17 that both male and female subjects were able to learn to breath predominatly thoracically and predominently abdominally. This is reflected in the analysis of the combined male and female T-A index scores across the four conditions which indicated large differences between the treatment conditions ($\underline{F}(3,44)$= 34.164,$\underline{p}$<0.000001).

Whilst the interaction between sex and treatment conditions (see Table 17) was non-significant ($\underline{F}(3,40)=1.894, \underline{p}>0.05$), individual Duncan's New Multiple Range Test conducted separately on the male and on the female T-A index scores revealed that for both sexes the T-A index scores obtained in the paced and in the relaxation treatment conditions differed signficantly (at the 0.05 level) from the T-A index scores obtained in the thoracic and abdominal treatment conditions.

The results obtained on this index show that male and female subjects can easily be taught to breathe predominantly thoracically and predominantly abdominally. Also, during respiratory pacing and relaxation the female subjects breathed predominantly thoracically while the male subjects breathed predominantly abdominally.

CHAPTER 4

Discussion

Interpretation and Inferences of Experiment 1

As the aim of Experiment 1 was to assess the effects of sex and body position on respiratory characteristics, and psychological and physiological indices of arousal, the results will be discussed under the headings: "Sex Effects" and "Position Effects". The effects of Order of the two positions were also assessed and are discussed under the heading "Order Effects". Interactions between the effects of sex, position, order and sampling period are discussed at the end of this section. Respiration Rate, thoracic and abdominal I/E ratios, and the T-A index will be discussed more fully in the section entitled "Respiratory Characteristics".

Sex Effects. Experiment 1 failed to reveal any differences between male and female subjects on the psychological variables. Such a result indicates that the sex of the subjects in the experimental groups did not consistently influence Time Estimation, or their responses on the TMAS, or the PSQ. Similarly, Skin Conductance Level, Respiratory Rate, abdominal I/E ratios and the T/A index failed to differentiate between male and female subjects. Heart Rate was found to be higher for female subjects than for male subjects. Conversely, male subjects were found to have higher thoracic I/E ratios than female subjects, indicating that the thoracic inspiratory phase was longer in the male subjects than in the female subjects.

Support for the hypothesis (1) that female subjects would have a larger T-A index score than male subjects, was not found.

Position Effects. Whilst differences in body position were found not to significantly influence psychological variables, a tendency for subjects to report feeling less aroused in the supine position was observed. Although Skin Conductance and Respiratory Rate failed to differentiate between the sitting and the supine positions, Heart Rate, thoracic I/E ratio, abdominal I/E ratio and the T-A index significantly differentiated between the sitting and the supine body positions. Table 18 shows how the differences in these body positions are related.

Table 18
Means of Physiological Indices for
the Sitting and Supine Positions

	Physiological Index					
Position	SCL	HR	RR	Th I/E	Ab I/E	T-A Index
Sitting	5.81	64.4	14.2	0.456	0.430	1.458
Supine	6.15	62.8	14.5	0.506	0.473	1.026

The physiological measures (see Table 18) indicate that in comparison to the sitting position, the supine position was characterized by lower Heart Rate, longer thoracic and abdominal inspiratory phases, and a respiratory pattern which displayed relatively more abdominal movement (i.e. lower T-A index). These results support the hypothesis (2) that the T-A index score would be larger in the sitting position than in the supine position. Similarly, support is obtained for the hypothesis (3) that changes in thoracic and abdominal I/E ratios would be dependant upon body position.

Order Effects. Psychological variables were not affected by the order of position in which subjects were assessed. Similarly, Skin Conductance Level, Heart Rate, Respiratory Rate and the T-A index were not affected by the difference in the order of body position. The thoracic and abdominal I/E ratios, however, both reveal that inspiration is longer in the sitting-supine order than in the supine-sitting order. It appears, therefore, that whilst other indices may be considered irrespective of the order in which body positions are assessed, the I/E ratios ought to be considered with regard to which body position is assessed first.

In addition to the main effects found for sex, position and order, a number of important interactions amongst these variables were found by further analysis. An interaction between order and position effects on Time Estimation revealed that assessing subjects in the supine position first, and then in the sitting position, reduced arousal levels (as indicated by overestimation of chronological time, see Cahoon, 1969) more than when subjects were assessed first in the sitting position and then in the supine position. The present results suggest that such a reduction in arousal level is due to the effects of the initial supine position.

The effects of the interaction between sex and sampling period on Skin Conductance Level produced a progressive change in arousal levels during each 10 minute recording period. The decrease in Skin Conductance Level displayed by the male subjects agrees with the notion that during a time of adaptation, or rest, lower arousal levels are reflected by an increase in skin resistance due to the reduced sympathetic effect on the eccrine sweat glands. This lowers the skin's moisture content which reduces the skin's ability to conduct electrical current (Sternbach, 1967). The increase in Skin Conductance Level observed in the female subjects, however, defies the usual explanation and indicates that their arousal levels did not decrease throughout the assessment.

The effect of the order by position interaction on Heart Rate revealed that subjects reduce cardiac activity when moving from the sitting to the supine position. Such a result is supported by previous authors (McLaughlin, Goldman, Kleinman and Korol, 1978) who explained the difference in terms of the additional sympathetic arousal required to maintain an upright (standing) posture. McLaughlin et al. (1978) found a 20 bpm(+) difference in Heart Rate between the vertical and the horizontal body positions (with the vertical-horizontal order showing greatest difference) indicating a decrease in sympathetic activity in the horizontal position. The rather small, but consistant decrease (3.3 bpm), found in the current investigation between the sitting and the supine positions may reflect the comparitively minimal extra sympathetic arousal required to maintain the sitting posture.

The effects of the interaction between position, order and sampling period on I/E ratios revealed that in the thoracic respiratory mode the major differences between the sitting and the supine I/E ratios occurred in the sitting-supine order during the second and third sampling periods. In the supine-sitting order a similar difference was observed during the first sampling period (see Figure 1). In both cases the supine position displayed a longer inspiratory phase than did the sitting position. Such differences were not paralleled by the abdominal I/E ratios.

An interaction between sex and position was found to have a significant effect on subjects' T-A index scores. The results revealed that in the sitting position the female subjects displayed a relatively more thoracic respiratory pattern than did the male subjects; and in the supine position the female subjects displayed a more abdominal respiratory pattern than did the male subjects. These differences will be discussed in a later section.

The effects of the interaction between sex, position, and order, on the T-A index revealed that whilst male subjects failed to show consistent changes, the female subjects displayed relatively more thoracic respiratory movement in the sitting position than in the supine position, irrespective of the order in which they were assessed.

Interpretation and Inferences of Experiment 2

As the aim of Experiment 2 was to evaluate the effects of three respiratory manipulations and relaxation training on psychological and physiological indices of arousal, the results will be discussed under the general heading "Treatment Effects". Differences between male and female subjects are considered under the same heading. Results for respiratory measures are further discussed in the section entitled "Respiratory Characteristics".

Treatment Effects. In the thoracic and the abdominal training conditions (Experiment 2) the T-A index scores obtained reveal that both the male and the female subjects were able to learn to breathe predominantly thoracically and predominantly abdominally throughout a five minute recording period.

The TMAS failed to differentiate between the sexes and between the treatment conditions. The PSQ revealed that only the relaxation treatment significantly affected subjective reports of arousal levels for both male and female subjects. Whilst similar trends were not revealed by Time Estimations, male subjects in the abdominal breathing condition displayed significant overestimations indicative of lowered arousal levels. Such indications of lower arousal were not supported by other indices of arousal and are, therefore, inconclusive.

Physiological measures were also differentially influenced by the treatment conditions. Skin Conductance Level and Heart Rate were not significantly affected by the three respiratory manipulations, nor were they affected significantly by relaxation training. The analysis of Respiratory Rate revealed that female subjects have higher breathing rates than do male subjects. The treatment conditions seem to have only limited effect on breathing rate; thoracic breathing appeared to have produced a lower breathing rate in male subjects, and relaxation training produced higher breathing rates in the female subjects. Increases in Respiratory Rate have been found to be associated with higher arousal levels (e.g. Benson & Klipper, 1975; Farrow & Hebert, 1982). The latter result, therefore, does not agree with the PSQ which indicated that the female subjects felt less aroused following the relaxation treatment.

Experiment 2 failed to provide consistent support for the hypothesis (1) that thoracic respiratory training would produce a decrease in the indices of arousal. Similarly, no consistent support was found for the hypothesis (2) that abdominal respiratory training would produce an increase in the indices of arousal.

The results of Experiment 2 provide support for the hypothesis (3) that paced respiration would not produce a decrease in the indices of arousal. Some support was also found for the hypothesis (4) that relaxation training would produce a decrease in the indices of arousal.

Nevertheless, whilst the self-report measure showed significant reductions in perceived arousal levels following relaxation training, Time Estimation, Skin Conductance, Heart Rate and Respiratory Rate failed to substantiate such a result.

The T-A index scores obtained in Experiment 2 provide support for the findings of Experiment 1; in the paced respiration treatment and in the relaxation treatment (both performed in the sitting position) the female subjects had considerably higher T-A index scores than did the male subjects. These results will be discussed in the next section.

Respiratory Characteristics

The ability of respiratory rate to assess differences in arousal levels adequately has been questioned previously (Grossman, 1967) despite claims that it accurately reflects decreases in arousal levels (Benson & Klipper, 1975; Elson, Hauri & Cunis, 1977; Wallace & Benson, 1972). In Experiment 1 of the current investigation respiratory rate proved to be the physiological index least affected by the independent variables (remaining at approximately 14 breaths/minute irrespective of condition). Whilst arousal levels were not deliberately manipulated in Experiment 1, the results fail even to support McLaughlin, Goldman, Kleinman and Korol's (1978) contention that a change from the vertical to the horizontal body position would decrease respiratory rate. In Experiment 2, although significant differences in respiratory rates between the treatment conditions were revealed, these results appear inconclusive as, for example, the higher rates (16 breaths/minute) observed (in female subjects) during relaxation training contradict self-reported levels of arousal. Such inconclusive results tend to agree with previous authors (Cohen, Goodenough, Witkin, Oltman, Gould & Shulman, 1975; Mathews & Gelder, 1969; Sues, Alexander, Smith, Sweeney & Marion, 1980) who also failed to find positive correlations between respiratory rate and other indices of arousal.

The results obtained for the I/E ratios support the general contention (Clausen, 1951; Cohen, Goodenough, Witkin, Oltman, Gould & Shulman, 1975; Feleky, 1916; Grossman, 1967; Timmons, Salamy, Kamiya & Girton, 1972) that the components of the respiratory cycle (inspiration/expiration) ought to be analysed separately.

Whilst some previous literature did not consider sex differences (Cohen et al., 1975; Timmons et al., 1972; West, 1983), the present results indicate that in the thoracic respiratory mode male subjects have higher I/E ratios than do female subjects. A significant difference between the sexes was not observed in the abdominal I/E ratios. Clausen's (1951) finding that male subjects have a longer inspiratory phase for both the thoracic and abdominal respiratory modes was, therefore, only confirmed in respect of the thoracic mode. Whilst the effects of the two body positions may influence male and female subjects differently, no sex by position interaction was revealed for the I/E ratios by the present study.

The results obtained for the I/E ratios in the two body positions indicate that both thoracic and abdominal respiratory modes display a longer inspiratory phase in the supine position than in the sitting position. Such a finding tends to support previous research (Agostoni, 1970) which found that breathing in the sitting position was restricted due to the relative incompressibility of the gut and its contents. The increase in the length of the abdominal inspirations may be explained by the fact that abdominal respiration is less restricted in the supine position than in the sitting position. The increase in the length of the thoracic inspirations is best explained by the fact that due to reduced diaphragmatic and gravitational influences on the thoracic respiratory structures in the supine position, the intercostal muscles are actively contracted in an attempt to maintain thoracic ventilation (Tusiewicz, Moldofsky, Bryan & Bryan, 1977). The present results also indicate that when assessing the I/E ratios in the sitting and in the supine body positions it is important to consider the order in which assessment will be conducted. Inspirations were longer in the sitting-supine order than in the supine-sitting order.

The current investigation revealed that whilst both I/E ratios were affected by body position and the order in which assessment was made, the effects of sampling period (i.e. the effects of a 10 minute resting period) influenced only the thoracic respiratory mode. In particular, it was shown that when the supine position followed the sitting position, the thoracic I/E ratio for the fifth and the tenth minute of assessment in the supine position, was significantly higher than the I/E ratio for the sitting position (see Figure 1). It is unclear from these isolated changes, however, whether the increased thoracic I/E ratios were associated with higher, or lower, levels of arousal. Consequently, the present results cannot be seen as supporting the previous research which indicates that a longer thoracic inspiratory phase is associated with a decrease in arousal levels (Cohen et al., 1975; Timmon et al., 1972; West, 1983). Nevertheless, meditational (Benson, Beary & Carol, 1974), therapeutic (Azrin & Nunn, 1974; Luthe, 1963), and physiological (Bouhuys, 1977; Lopes & Palmer, 1976) evidence suggests that further study of thoracic and abdominal I/E ratios may yield important information regarding voluntary control of autonomic activity.

Although a T-A index of 2, which was considered to be the lower threshold for predominantly thoracic breathing (see Chapter 2), was only reached by a few subjects in Experiment 1, Experiment 2 revealed considerably higher T-A index scores. A comparison of the T-A index scores obtained in the sitting and supine positions for male and female subjects in Experiment 1, and in the paced and relaxation treatments of Experiment 2, is illustrated in Table 19.

It is clear from Table 19 that the distinction between male and female subjects observed in the sitting position of Experiment 1 was substantiated by the results in the paced and relaxation treatment conditions of Experiment 2. Whilst the paced T-A index scores may possibly have been influenced by attention to breathing instructions, the relaxation T-A index scores provide convincing support for the

Table 19
Mean T-A Index scores
for Male and Female subjects
in Experiment 1 and in Experiment 2

		Male	Female
Experiment 1	sitting	1.234	1.682
	supine	1.158	0.893
Experiment 2	paced	1.632	3.158
	relaxation	1.827	2.422

argument that in the sitting position female subjects breathe predominantly thoracically, whilst male subjects breathe predominantly abdominally (Clausen, 1951; Naifeh & Kamiya, 1981). Despite the fact that relative differences between the T-A index scores of the male and female subjects found in Experiment 1 are reproduced in Experiment 2, the reasons for the observed higher T-A index scores found in Experiment 2 are not evident.

The results of the present investigation appear to support Clausen's (1951) study, however there is one major difference. Clausen concluded that in his non-psychiatric group the female subjects breathed predominantly thoracically while the male subjects breathed predominantly abdominally. Although Clausen alluded to the importance of body position he studied subjects only in the supine position. The two investigations, therefore, agree that in the supine position male subjects breathe predominantly abdominally. Clausen's contention however, that female subjects breathe predominantly thoracically in the supine position, is not upheld (see Table 19). Similarly, Naifeh and Kamiya's (1981) suggestion that female subjects display a relatively larger T-A index than do male subjects in the supine position, is not supported by the present results. It appears that a reason for such contradictory evidence may be that Clausen (1951) and Naifeh and Kamiya

(1981), whilst studying subjects of both sexes, investigated their respiratory movements only in the supine position. Research which has involved the study of respiratory patterns in the two body positions tends to find more support in the present results. Agostoni (1970), Goldman and Mead (1973), Konno and Mead (1967), Sharp, Goldberg, Druz and Danon (1975) and Vellody, Nassery, Druz and Sharp (1978) all concluded that thoracic breathing predominates in the upright or sitting position whilst abdominal breathing predominates in the supine position. Although such findings are in general agreement with the present results the issue of sex differences is not clear.

The present study revealed considerable sex differences such that the T-A index differences between the sitting and the supine body positions are virtually entirely attributable to the female subjects (see Figure 3). Sharp et al. (1975) and Vellody et al. (1978) concluded that no significant differences between male and female subjects exist in respect to their thoracic-abdominal respiratory contributions in either the sitting or the supine positions. These studies suggest that both male and female subjects breathe predominantly thoracically in the sitting position and predominantly abdominally in the supine position. Experiment 1 of the present study revealed that whilst breathing was predominantly abdominal, the female subjects demonstrated a strong abdominal component when supine and a shift toward thoracic dominance when seated. Male subjects remained moderately abdominal breathers in both positions (see Figure 3).

It is evident, then, that the present study disagrees with Clausen (1951) and Naifeh and Kamiya (1981) with regard to body position and with Sharp et al. (1975) and Vellody et al. (1978) with regard to sex differences. However, the present study agrees with the former authors that female subjects breathe more thoracically than do male subjects, and it agrees with the latter authors that in the sitting position breathing is relatively more thoracic than it is in the supine position.

Some of the differences between research results described above may be due to the fact that the present investigation incorporated various methodological aspects which appear not to have been previously considered together. It is possible that the use of equal numbers of male and female subjects, the study of the two body positions and the utilization of the T-A index resulted in a more standardized procedure than that used previously. A further methodological difference is found in the placement and the type of devices used to measure thoracic and abdominal expansion. The present investigation used mercury-in-rubber strain gauges placed at the level of the armpits and at the level of the navel. Sharp et al. (1975) and Vellody et al. (1978) used magnetometers placed over the mid-line at, or below, the level of the fifth chondro-costal junction and over the mid-line 2cm above the navel (see Sharp et al., 1975). In comparison to the strain gauge arrangement the thoracic and abdominal magnetometers appear to be more closely positioned, thus perhaps the thoracic-abdominal differences were reduced. Also, in the above studies, the thoracic magnetometer in the female subjects would have been placed over the mid-line and not over the breasts as in the present study. Although it is unlikely that this difference would be significant on its own it is possible that by placing the measuring device at a lower level subtle differences between male and female subjects were not detected.

Further differences between male and female subjects have been considered by Clausen (1951). He suggested that it may be a Western cultural influence which encourages female adolescents to minimize the abdominal protrusion while, at the same time, emphasizing the chest. If this is the case, then it is possible that in the supine position a different breathing pattern may be exhibited. This could be due to the more relaxing posture and to the fact that the extra weight of the breasts on the ribcage in the supine position could, to some degree, restrict thoracic expansion. Consequently, whilst male subjects breathe abdominally in both positions the female subjects change their "trained thoracic breathing" observed in the sitting position, to a more natural, predominantly abdominal, pattern of respiration.

Whilst not supporting Clausen's (1951) contention that female subjects in the supine position breathe predominantly thoracically, the current results appear to agree with previous literature in relation to diaphragmatic, gravitational and gut compliance influences. It has been postulated, by previous authors, (Sharp et al., 1975; Tusiewicz et al., 1977; Vellody et al., 1978), that in the supine position diaphragmatic and gravitational influences on thoracic structures are reduced, resulting in proportionally greater abdominal respiratory movements. Also, the compliance of the gut and its contents is increased in the supine position making more abdominal movement possible (Agostoni, 1970). According to these findings both male and female subjects should, in comparison to the sitting position, display predominantly abdominal breathing in the supine position. Whilst the present study supports this notion, the female subjects were found to be responsible for the difference between the two body positions (see Figure 3). Thus, although the anatomical differences between males and females have been dismissed previously (Clausen, 1951) the current research indicates that they may be worthy of further investigation.

In summary, the present study substantiates previous research which questionned the use of respiratory rate as the sole respiratory measure of arousal levels. It was found in Experiment 1 that breathing rate failed to differentiate significantly between sex, body position and order of position effects. Also, whilst thoracic breathing and relaxation training significantly influenced breathing rate in Experiment 2, these changes were not supported by other measures of arousal. Other respiratory indices (I/E ratios, T-A index) were significantly affected by the independent variables. These respiratory measures were also not associated with consistent changes in psychological or physiological indices of arousal. However, predominantly abdominal breathing (in the supine position) was associated with longer thoracic and abdominal inspirations. Also, whilst previously reported differences between male and female subjects on T-A index scores were substantiated, these differences only appeared in the sitting position. An explanation of these results ought to consider, together with diaphragmatic, gravitational and gut compliance factors, the effects of anatomical differences and stereotype training of adolescent females.

The Effects of Respiratory Manipulation on Indices of Arousal

The thoracic and abdominal training conditions included in Experiment 2 of the current investigation failed to support either the literature which indicates that predominantly thoracic breathing is associated with decreasing arousal levels (Goldie & Green, 1961; Naifeh & Kamiya, 1981; Timmons, Salamy, Kamiya & Girton, 1972) and the literature which suggests that thoracic breathing is associated with higher arousal levels (Christian, 1957, in Schaefer, 1979; Danon, Druz & Sharp, 1974; Hurwitz, 1981; Obrist, 1976; Pearn, 1982; Porges & Coles, 1982; Sharp, Goldberg, Druz & Danon, 1975). It is noteworthy that most of the research which associates predominantly thoracic respiration with higher levels of arousal was conducted with the subject in the sitting position. As it has been shown by the current investigation that this position is associated with higher T-A index scores, the increased thoracic respiratory movements may be a result of the sitting position rather than of increased arousal levels.

Whilst the finding of consistent differential effects may have resolved some issues concerning the relationship between the T-A index and arousal levels, and may have ellucidated some meditational and therapeutic procedures (Benson, Beary & Carol, 1974; Jacobson, 1938; Luthe, 1963), indices of arousal generally were unaffected by either thoracic or abdominal breathing. Consequently, no further information is provided about the hypothesized CNS interaction between respiratory and arousal centres (Benson et al., 1974; Naifeh & Kamiya, 1981; Luthe, 1963; Schaefer, 1979).

The only index which appeared to differentiate between treatment conditions was the self-report measure (PSQ). Such evidence, however, was not generally supported by physiological responses. Although it is reassuring that the greatest decrease in self-reported arousal levels occurred for both male and female subjects following relaxation training, such a result may simply be a product of the subjects' expectations or the demand effects of this treatment. That is, in spite of the effort made to not mention the term "relaxation", subjects in the relaxation treatment were the only ones in the experiment who had some idea of the purpose of the treatment. Consequently, it is possible that in the relaxation treatment subjects reported feeling less aroused after treatment as a result of either expecting to feel this way, or because they were simply obliging the experimenter, knowing that such a result was desired. Unfortunately such artifacts are usually inseparable from relaxation procedures. The fact that the reported decreases in arousal levels were not substantiated by other indices of arousal supports the artifact hypothesis, however, the issue of physiological responses in the present experiments must be considered in relation to previous research.

It is necessary to emphasize here, that the purpose of the current investigation was to evaluate physiological and psychological changes occuring in male and female subjects while resting in the sitting and supine positions and while performing specific respiratory manoeuvres. Unlike some previous authors (Cheung & Porges, 1977; Harris, Katkin, Lick & Habberfield, 1976; Lane, 1981; McCaul, Solomon & Holmes, 1979; Porges & Coles, 1982) who related respiration patterns to specific stressful conditions, the present study did not use any stress inducing components. Consequently, when considering the indices of arousal used in both experiments of the present investigation, it should not be overlooked that subjects in all of the experimental conditions may have remained relatively relaxed throughout the assessment procedure. In particular the general inability of the physiological indices to differentiate between the treatment conditions in Experiment 2 was most likely due to the lack of a stressor component. Had such a component been included, the effect of each respiratory manipulation could have been evaluated by assessing the differences in the physiological responses. As such a component was not included in the present study, and as physiological and psychological variables were not found to be consistently associated with specific treatment conditions, implications for therapeutic procedures cannot be extrapolated from the results.

The lack of consistent changes in psychological and physiological indices of arousal in the four treatment conditions of Experiment 2 also indicates that continuous visual feedback of respiratory characteristics did not, by itself, influence subjects' arousal levels. Specifically, requiring subjects to pace their breathing rate according to an analogue meter did not produce psychological and physiological changes which were consistently different from the effects of thoracic, abdominal, and relaxation treatment conditions. These results support previous research (McCaul, Solomon & Holmes, 1979), such that attention to a continuous visual signal did not appear to produce significant changes in arousal levels. At the same time it is evident that pacing respiratory rate at 10 breaths per minute failed to produce significant reductions in arousal levels. Such a result does not support previous literature (Clark, 1978; Cogan & Kluthe, 1981; Lane, 1981; McCaul et al., 1979) which found that a reduction in breathing rate was associated with reductions in psychological and physiological indices of arousal. However, while previous authors reduced breathing rate to 7.5 or 8 breaths per minute, the current investigation used a breathing rate of 10 breaths per minute. It can be concluded from the current result and from previous research (Clark, 1978) that pacing subjects' breathing at 16 or at 10 breaths per minute does not significantly reduce psychological or physiological indices of arousal. In this respect pacing respiration at 10 breaths per minute appears to have been an adequate attention control procedure.

The difference in Skin Conductance Levels observed between Experiment 1 and Experiment 2 is best explained by a seasonal temperature change which may have influenced electrodermal activity (EDA). Brown (1967) reported EDA changes of 3% for every 1°C change in ambient temperature. As Experiment 1 was run during winter months and Experiment 2 was run during summer, the present investigation does not control for the effects of changes in ambient temperature on Skin Conductance Levels.

In summary, training subjects to breathe predominantly thoracically, or predominantly abdominally, failed to significantly, and consistently, change the subjects' arousal levels as measured by psychological and physiological indices of arousal. The inability of these indices to consistently differentiate between the four treatment conditions is explained by the fact that subjects in this investigation were not exposed to any specific stressful stimuli and therefore it is very likely that they remained relatively relaxed in each condition. The association between the relaxation treatment condition and the lower scores on the self-report measure (PSQ) may be best explained, in the absence of corroborating physiological support, by either expectation or demand effects.

Summary and Implications for Future Research.

The present investigation indicates that the study of respiratory characteristics must take into account the sex of the subject and the position in which the subject is assessed. Previous research appears to have failed to consider these issues adequately. The current research has revealed that in the sitting position female subjects breathe more thoracically than do male subjects, whilst in the supine position both sexes exhibit predominantly abdominal breathing.

Analysis of thoracic and abdominal I/E ratios indicated that male subjects had a longer thoracic inspiratory phase than did female subjects, whilst the abdominal inspiratory phase was similar for both sexes. The supine position was associated with an increase in the I/E ratios of both the thoracic and the abdominal respiratory modes. It appears, then, that the supine position is characterized by predominantly abdominal breathing and an increase in the inspiratory phase of both thoracic and abdominal respiratory modes. Such an increase in inspirations may be due to greater gut compliance exhibited in the supine position which allows greater abdominal motion, and to the activation of specific thoracic respiratory muscles (intercostal muscles).

The current investigation has revealed that whilst previous studies have associated thoracic and abdominal respiratory modes with different ends of the arousal continuum, training subjects to breathe predominantly thoracically, or predominantly abdominally did not influence arousal levels. Although subjects of both sexes reported feeling less aroused following relaxation training this effect may be the result of expectation and demand factors as the other indices of arousal failed to reflect the change.

Whilst one of the goals of this investigation was to manipulate respiratory patterns in such a way as to change psychological and physiological indices of arousal, the between group comparison employed in the present investigation appears to have been a significant methodological drawback. As relatively small numbers of subjects (6) were used in each experimental cell of Experiment 2 the assessment of physiological changes may have benefitted from a pre-test, post-test analysis. Similarly, while it was appropriate to assess respiratory and physiological indices during an undisturbed experimental procedure in Experiment 1, the assessment of the treatment conditions of Experiment 2 may have been far more revealing if a stressful stimuli had been included.

Considering the results of the present investigation and the methodological drawbacks exposed, it is recommended that future research in this area concentrate on assessing: a) changes in the thoracic and abdominal I/E ratios during resting and relaxation, b) the effectiveness of predominantly thoracic and predominantly abdominal breathing in reducing arousal levels in response to stressful stimuli, and c) the effect of anatomical differences between males and females which may affect thoracic and abdominal respiratory patterns.

APPENDIX A

The Taylor Manifest Anxiety Scale (TMAS)

This scale normally consists of 50 items pertaining to the symptoms of anxiety. These items are interspersed amongst 175 "filler" items. It has been shown (Bendig, 1956) that the use of a shortened scale, consisting only of the 50 discriminating items, reaches a median internal consistancy reliability of 0.82. External validity of the whole scale was demonstrated by Taylor (1953) in a comparison of anxiety scores obtained from neurotic, psychotic and normal individuals. Taylor was satisfied that there was a significant relationship between the scores and clinical observations of manifest anxiety.

NAME:

SEX:

AGE:

Please consider each of the following statements and decide whether it is true or false according to your usual way of acting or feeling. Write your answer (True or False) next to each item. Work quickly and don't spend too much time over any question. The whole questionnaire shouldn't take more than a few minutes. Be sure not to omit any questions.

1. I do not tire quickly.
2. I am troubled by attacks of nausea.
3. I believe I an no more nervous than most others.
4. I have very few headaches.
5. I work under a great deal of tension.
6. I cannot keep my mind on one thing.
7. I worry over money and business.
8. I frequently notice my hand shakes when I try to do something.
9. I blush no more often than others.
10. I have diarrhoea once a month no more.
11. I worry quite a bit over possible misfortunes.
12. I practically never blush.
13. I am often afraid that I am going to blush.
14. I have nightmares every few nights.
15. My hands and feet are usually warm enough.
16. I sweat very easily even on cool days.
17. Sometimes when embarrassed, I break out in a sweat which annoys me greatly.
18. I hardly ever notice my heart pounding and I am seldom short of breath.
19. I feel hungry almost all the time.
20. I am very seldom troubled by constipation.
21. I have a great deal of stomach trouble.
22. I have had periods in which I lost sleep over worry.
23. My sleep is fitful and disturbed.
24. I dream frequently about things that are best kept to myself.
25. I am easily embarrassed.
26. I am more sensitive than most other people.
27. I frequently find myself worrying about something.
28. I wish I could be as happy as others seem to be.
29. I am usually calm and not easily upset.
30. I cry easily.
31. I feel anxiety about something or someone almost all the time.
32. I am happy most of the time.
33. It makes me nervous to have to wait.
34. I have periods of such great restlessness that I cannot sit long in a chair.
35. Sometimes I become so excited that I find it hard to sleep.
36. I have sometimes felt that difficulties were piling up so high that I could not overcome them.
37. I must admit that I have at times been worried beyond reason over something that really did not matter.
38. I have very few fears compared to my friends.

39. I have been afraid of things or people that I know could not hurt me.
40. I certainly feel useless at times.
41. I find it hard to keep my mind on a task or job.
42. I am usually self-conscious.
43. I am inclined to take things hard.
44. I am a high-strung person.
45. Life is a strain for me much of the time.
46. At times I think I am no good at all.
47. I am certainly lacking in self-confidence.
48. I sometimes feel that I am about to go to pieces.
49. I shrink from facing a crisis or difficulty.
50. I am entirely self-confident.

APPENDIX B

The Psychophysiological State Questionnaire (PSQ)

Because small changes in anxiety would be likely to produce ideosyncratic changes in response profile (Individual Response Stereotypy), items reflecting anxiety in a number of different response systems were included in the P.S.Q. to ensure basic content validity. Reliability estimates were not computed, as the operation of Individual Response Stereotypy at an individual level would necessarily result in group data showing low inter-item and item-to-total correlations.

Some items incorporated in this questionnaire (1, 7, 10) were taken from the State - Trait Anxiety Inventory (Speilberger, Gorsuch & Lushene, 1970). It was considered that these items measured physiological and psychological symptoms of anxiety. To help with this assessment other items (2,3,4,5,6,8,9,11,12,13) were added specifically for this investigation. The polarity of some questions was reversed to avoid response set answering.

Please answer the following set of questions according to the way you feel at the present moment. Do not think too long about each question, just long enough to become aware of the feeling. Circle the appropriate number corresponding to the degree of the feeling, from 1 (not at all) to 5 (very much).

		NOT AT ALL	SLIGHTLY	AVERAGE	MODERATELY	VERY MUCH
1)	Do you feel comfortable?	1	2	3	4	5
2)	Are your forehead muscles tense?	1	2	3	4	5
3)	Does your body feel relaxed?	1	2	3	4	5
4)	Do you feel tension in your stomach?	1	2	3	4	5
5)	Are the muscles of your hands tight?	1	2	3	4	5
6)	Does your face feel hot?	1	2	3	4	5
7)	Do you feel mentally calm?	1	2	3	4	5
8)	Are the palms of your hands sweaty?	1	2	3	4	5
9)	Are the muscles of your face relaxed?	1	2	3	4	5
10)	Do you feel anxious?	1	2	3	4	5

In the following two questions please indicate any change in the speed of your heart rate and respiration rate.

		MUCH SLOWER	SLIGHTLY SLOWER	AVERAGE	SLIGHTLY FASTER	MUCH FASTER
11)	What do you estimate your present heart rate to be?	1	2	3	4	5
12)	What do you estimate your present respiration rate to be?	1	2	3	4	5

13) Normally when you are relaxed you experience particular feelings. To what extent does the way you feel now approximate those feelings?

1 VERY MUCH
2 MODERATELY
3 SOMEWHAT
4 SLIGHTLY
5 NOT AT ALL

APPENDIX C

Psychological Data, Experiment 1

Taylor Manifest Anxiety Scale

Psychophysiological State Questionnaire

Time Estimation

Taylor Manifest Anxiety Scale

Order 1		Order 2	
Male	Female	Male	Female
10	11	17	21
4	11	21	13
10	6	13	19
8	10	12	15
8	13	9	13
6	27	8	8
14	13	18	18

Psychophysiological State Questionnaire for each Sampling Period

Order 1						Order 2					
Male			Female			Male			Female		
1	2	3	1	2	3	1	2	3	1	2	3
30	39	28	35	37	31	24	27	22	27	16	20
17	18	18	26	27	25	25	30	37	26	27	25
26	26	25	21	27	20	28	17	19	25	22	14
15	30	14	23	21	20	30	24	23	31	39	40
21	16	13	32	22	16	28	27	32	32	27	29
27	24	23	30	22	24	18	15	18	21	19	16
25	18	21	22	30	28	23	18	19	19	18	16

Time Estimation (means)

Order 1

Male		Female	
sitting	supine	sitting	supine
29.16	28.24	30.74	32.44
19.44	34.08	38.14	32.90
19.22	20.76	21.06	25.34
39.04	40.58	34.26	37.26
24.18	35.14	14.50	14.10
27.68	26.00	36.26	50.68
47.70	49.12	5.48	10.50

Order 2

Male		Female	
supine	sitting	supine	sitting
24.02	27.10	50.02	73.56
26.36	52.46	16.60	17.38
31.12	33.68	21.66	26.14
17.38	20.52	36.62	31.90
56.82	51.64	15.14	19.50
28.92	29.58	49.40	49.80
44.10	42.94	26.96	34.82

APPENDIX D

Physiological Data, Experiment 1

Skin Conductance

Heart Rate

Respiratory Rate

Thoracic I/E Ratio

Abdominal I/E Ratio

T-A Index

Skin Conductance (umhos)

Order 1 (male subjects)

Sitting sampling period			Supine sampling period		
1	2	3	1	2	3
4.00	3.00	2.60	3.25	2.50	2.00
7.00	3.00	3.50	6.20	1.40	1.90
1.55	1.20	1.20	2.00	1.75	1.75
7.00	6.50	6.00	5.10	5.10	4.90
9.30	12.05	12.80	25.20	23.45	20.70
10.80	10.80	9.80	9.60	9.60	10.10

Order 1 (female subjects)

Sitting sampling period			Supine sampling period		
1	2	3	1	2	3
6.80	5.50	6.70	7.20	8.50	7.75
4.75	6.00	6.85	3.10	5.10	5.60
2.90	2.25	1.80	3.90	4.43	4.40
8.40	8.20	8.40	8.30	8.50	9.50
5.50	5.30	5.60	4.70	4.50	5.20
2.40	3.20	4.15	2.40	2.40	2.90
5.90	6.00	5.90	6.20	6.20	2.20

Order 2 (male subjects)

Supine sampling period			Sitting sampling period		
1	2	3	1	2	3
7.80	7.90	7.40	6.60	7.20	7.70
6.30	6.50	6.70	6.20	6.60	6.70
2.60	2.50	2.50	6.20	5.70	5.95
4.80	4.90	4.20	3.80	3.70	4.20
8.90	8.80	9.00	8.50	8.50	9.75
8.10	7.90	7.60	7.30	7.60	7.00
3.20	3.20	3.70	2.25	2.50	2.00

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
6.00	6.30	5.90	7.40	8.20	8.70
4.20	4.50	5.50	3.50	4.10	5.30
10.70	10.30	9.50	8.70	9.00	9.35
3.80	3.85	3.60	3.30	3.40	3.80
7.13	9.85	8.10	7.75	7.33	7.55
6.00	6.00	7.25	4.90	5.10	6.10
3.90	5.15	4.65	4.00	4.10	5.15

Heart Rate (bpm)

Order 1 (male subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
56	52	56	50	54	54
52	52	50	56	46	50
58	56	60	56	52	52
68	64	76	68	76	66
72	78	68	66	72	64
66	62	60	62	58	54
66	66	68	60	62	60

Order 1 (female subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
62	56	58	58	58	56
66	66	66	66	64	66
86	88	88	84	82	78
66	64	64	66	66	64
60	60	56	52	52	52
70	72	70	66	66	62
84	80	82	80	90	92

Order 2 (male subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
60	54	58	58	58	60
70	72	70	76	74	70
68	66	64	60	68	68
58	52	56	60	54	52
46	48	46	44	46	48
48	48	46	44	48	48
56	58	56	56	58	54

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
84	84	80	80	80	84
56	54	56	56	54	60
64	64	62	62	68	62
68	68	68	70	72	68
66	78	80	78	80	78
68	72	66	66	68	64
56	60	60	62	60	60

<u>Respiratory Rate (breaths per minute)</u>

Order 1 (male subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
12	12	13	12	11	12
15	15	16	16	15	15
8	13	11	8	13	13
11	12	14	14	14	16
9	10	11	11	14	14
15	15	16	16	14	14
12	8	11	11	14	12

Order 1 (female subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
22	20	20	19	19	19
13	12	14	11	12	12
8	10	14	12	16	16
16	18	18	17	17	16
12	13	13	15	15	12
16	19	22	18	18	19
13	14	13	14	14	13

Order 2 (male subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
11	9	9	7	8	10
15	17	16	15	16	15
19	18	18	21	19	18
15	15	14	12	10	16
18	16	18	17	17	16
14	13	14	14	13	14
9	9	16	17	21	20

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
16	14	12	15	15	14
14	15	14	15	14	16
11	10	12	12	14	12
18	16	16	18	18	18
15	16	13	10	9	10
17	18	16	17	17	16
16	15	17	14	12	14

Thoracic I/E Ratios

Order 1 (male subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
.529	.773	.608	.522	.643	.600
.733	.777	.590	.587	.706	.689
.581	.499	.459	.583	.789	.700
.544	.640	.648	.667	.768	1.010
.563	.375	.351	.312	.448	.642
.550	.487	.417	.543	.592	.723
.516	.378	.435	.367	.867	.785

Order 1 (female subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
.455	.425	.464	.566	.458	.409
.486	.540	.449	.465	.613	.550
.397	.452	.450	.297	.503	.453
.429	.497	.413	.589	.641	.640
.309	.275	.320	.385	.369	.383
.479	.382	.340	.275	.393	.361
.483	.469	.353	.438	.461	.358

Order 2 (male subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
.399	.433	.481	.521	.489	.483
.446	.461	.563	.466	.371	.411
.604	.444	.468	.341	.518	.385
.753	.728	.617	.635	.607	.553
.726	.460	.613	.374	.430	.354
.503	.497	.573	.368	.443	.523
.256	.263	.274	.234	.474	.488

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
.481	.390	.310	.342	.350	.412
.456	.406	.442	.484	.484	.402
.353	.404	.471	.543	.477	.487
.562	.420	.441	.303	.461	.391
.415	.468	.571	.326	.337	.431
.269	.342	.330	.349	.506	.381
.330	.543	.372	.394	.364	.295

Abdominal I/E Ratios

Order 1 (male subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
.634	.632	.679	.645	.648	.539
.504	.574	.507	.636	.773	.700
.389	.430	.427	.428	.457	.419
.561	.551	.484	.593	.568	.548
.674	.473	.352	.357	.497	.482
.405	.374	.373	.549	.431	.425
.418	.372	.479	.367	.540	.500

Order 1 (female subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
.748	.480	.506	.653	.570	.543
.444	.497	.453	.471	.555	.506
.426	.368	.368	.359	.535	.477
.395	.445	.418	.529	.452	.495
.367	.354	.402	.404	.358	.413
.491	.455	.473	.556	.516	.479
.466	.372	.291	.422	.457	.402

Order 2 (male subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
.378	.369	.497	.527	.456	.469
.469	.467	.517	.467	.506	.420
.488	.438	.438	.523	.557	.448
.652	.650	.576	.449	.475	.353
.639	.407	.527	.405	.353	.449
.370	.350	.421	.279	.362	.278
.310	.315	.323	.301	.441	.430

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
.522	.392	.346	.330	.193	.320
.411	.376	.414	.365	.283	.350
.362	.364	.393	.360	.224	.199
.395	.516	.468	.474	.570	.580
.553	.378	.570	.491	.397	.406
.486	.482	.441	.374	.470	.381
.328	.328	.331	.317	.306	.280

<u>T-A Index</u>

Order 1 (male subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
1.741	1.565	1.660	.927	1.102	1.090
1.075	.829	.837	.700	.813	.597
2.121	1.351	1.624	1.478	1.491	1.713
2.265	1.602	1.467	1.425	1.191	1.370
1.504	1.168	1.076	.239	.363	.287
1.210	1.393	1.361	1.309	1.654	2.130
1.656	1.569	1.562	1.946	1.289	1.635

Order 1 (female subjects)

Sitting			Supine		
sampling period			sampling period		
1	2	3	1	2	3
1.870	3.077	2.220	1.046	.825	.797
.881	.890	.893	.445	.441	.491
1.289	1.232	1.131	.856	.728	.810
1.370	1.585	1.492	.980	1.066	.953
.603	.483	.611	1.178	1.209	1.011
.626	.557	.556	.107	.183	.178
2.266	2.640	2.211	.816	.840	.859

Order 2 (male subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
.989	1.049	1.190	.798	.969	1.040
.751	1.064	1.057	.685	.400	.448
1.579	1.288	1.601	.644	.668	.781
1.011	1.350	1.011	1.702	1.357	1.551
1.434	1.688	1.439	1.000	1.409	1.074
1.194	1.113	.929	1.683	1.066	1.704
.843	.665	.652	.478	.923	.810

Order 2 (female subjects)

Supine			Sitting		
sampling period			sampling period		
1	2	3	1	2	3
1.762	2.001	2.680	3.263	3.652	3.509
1.614	.976	1.090	1.861	1.717	1.728
.990	1.122	1.158	1.973	2.431	2.690
.583	.552	.456	1.174	1.405	1.287
.322	.552	.628	1.661	1.615	1.574
.211	.328	.261	.454	.559	.405
1.338	1.687	1.373	3.587	3.097	3.107

APPENDIX E

Instructions to Subjects in Feedback Training Groups

In this experiment you will be asked to breathe with your chest (stomach). The meter you see in front of you will indicate the size of the breath you take with your chest (stomach). A low frequency tone from the speaker on your right will sound to inform you when your stomach (chest) breathing becomes too large. I would like you to increase the sweep of the meter indicator, without hyperventilating, while decreasing the occurrence of the tone. Remember, large breaths are permitted but do not hyperventilate.

Firstly, you will be asked to complete the PSQ. This will be followed by a series of three time estimations. On hearing a short high frequency tone you will attempt to estimate 30 seconds (without counting) and when you consider that 30 seconds have elapsed you will press the switch next to your right hand. This will happen three times.

Following a break of 1 minute the training procedure will commence. This will consist of a

3 minute training period
2 minute rest
3 minute training period
2 minute rest

and a 5 minute training and recording period. Immediately following this there will be another set of three time estimations and another PSQ. Are there any questions?

APPENDIX F

Instructions to Subjects in the Paced Respiration Condition

In this experiment you will be required to match your breathing with the sweep of the indicator of the meter you see in front of you. As the indicator moves to your right you are to inhale, and as the indicator moves to you left you are to exhale. Look at the meter and try to match you breathing with the movement of the indicator. While you may take large breaths make sure you do not hyperventilate.

The sequence of events will be as follows: Firstly, you will be asked to complete the PSQ. This will be followed by a series of the time estimations. On hearing a short high frequency tone you will attempt to estimate 30 seconds (without counting) and when you consider that 30 seconds have elapsed you will press the switch next to your right hand. This will happen three times.

Following a break of 1 minute the training will commence. This will consist of a

3 minute training period
2 minute rest
3 minute training period
2 minute rest

and a 5 minute training and recording period. Immediately following this there will be another set of time estimations and another PSQ. Are there any questions?

APPENDIX G

Instructions to Subjects in the Relaxation Training Group

You will be required to listen to a short relaxation tape and to follow the instructions suggested. This will require some motivation. You will be asked to clench your fist tightly, please do not clench the hand with the electrodes.

The sequence of events will be as follows: First of all you will be asked to complete the PSQ, then three trials of time estimation. On hearing a short high frequency tone you will attempt to estimate 30 seconds (without counting) and when you consider that 30 seconds have elapsed you will press the switch next to your right hand. This will happen three times. Shortly after this you will hear a tape-recording of the relaxation session. At the end of the tape you will have one minute during which to continue relaxing. Another set of time estimation and another PSQ will complete the experiment. Have you any questions?

APPENDIX H

Psychological Data, Experiment 2

Taylor Manifest Anxiety Scale

Psychophysiological State Questionnaire

Time Estimation

Taylor Manifest Anxiety Scale

	Thoracic	Abdominal	Paced	Relaxation
	Treatment Condition			
Male subjects	7	16	11	22
	6	25	8	7
	13	25	8	10
	12	6	8	11
	39	6	12	9
	11	5	6	12
Female subjects	10	28	8	14
	9	23	16	7
	13	9	8	20
	11	10	7	23
	16	16	14	18
	23	18	13	17

Psychophysiological State Questionnaire (pre-test & post-test)

	Treatment Condition							
	Thoracic		Abdominal		Paced		Relaxation	
	1	2	1	2	1	2	1	2
Male subjects	22	17	38	40	28	36	33	28
	19	17	20	25	25	31	26	18
	23	28	19	18	24	28	34	25
	30	33	36	29	27	17	23	21
	38	35	26	25	30	29	29	29
	22	23	25	21	19	24	35	28
Female subjects	17	15	26	34	28	22	32	24
	26	33	32	32	19	22	29	23
	27	25	21	25	31	27	19	23
	22	16	30	32	26	24	35	21
	28	29	21	30	37	20	27	19
	37	36	33	26	26	25	31	33

Time Estimation (mean post-test/pre-test ratios)

	Treatment Condition			
	Thoracic	Abdominal	Paced	Relaxation
Male subjects	1.05	0.70	1.40	1.12
	0.71	0.97	1.02	1.28
	1.17	1.47	0.96	0.72
	0.89	3.79	1.22	1.19
	1.48	1.61	1.03	1.41
	1.45	1.58	0.99	1.00
Female subjects	1.51	1.16	1.33	1.27
	0.89	0.99	1.08	0.98
	1.77	1.11	0.77	1.40
	1.09	0.80	1.22	1.05
	1.49	1.60	1.44	1.55
	1.57	0.87	0.88	1.18

APPENDIX I

Physiological Data, Experiment 2

Skin Conductance

Heart Rate

Respiratory Rate

T-A Index

Skin Conductance (umhos)

	Treatment Condition			
	Thoracic	Abdominal	Paced	Relaxation
Male subjects	24.05	27.35	34.98	35.00
	13.50	13.73	20.70	12.77
	23.65	15.87	25.15	17.08
	22.50	12.10	17.10	16.65
	28.25	23.95	14.90	9.15
	7.70	17.30	11.85	19.50
Female subjects	22.70	13.60	26.20	9.05
	13.70	25.85	23.87	9.00
	28.75	27.55	13.27	20.02
	16.00	14.20	33.30	10.01
	17.60	14.50	37.40	38.70
	16.52	28.95	19.40	29.30

Heart Rate (bpm)

	Treatment Condition			
	Thoracic	Abdominal	Paced	Relaxation
Male subjects	52	68	76	58
	62	82	66	64
	64	106	80	66
	52	68	50	52
	84	56	90	72
	60	78	70	68
Female subjects	62	66	88	54
	72	82	64	78
	72	82	76	64
	72	62	104	74
	84	68	68	76
	80	92	72	90

Respiratory Rate (breaths per minute)

	Treatment Condition		
	Thoracic	Abdominal	Relaxation
Male subjects	9	16	14
	7	8	10
	8	14	14
	8	14	14
	6	12	10
	10	12	14
Female subjects	12	8	12
	8	16	14
	7	12	16
	14	12	16
	12	10	18
	12	12	20

T-A Index

	Treatment Condition			
	Thoracic	Abdominal	Paced	Relaxation
Male subjects	2.888	.166	2.680	.344
	2.122	.105	1.370	2.462
	1.887	.214	1.020	1.747
	3.599	.368	.810	2.239
	2.253	.151	2.470	2.010
	2.552	.406	1.440	2.160
Female subjects	3.073	.745	3.790	3.168
	3.774	.370	3.020	3.381
	3.397	.702	3.310	1.031
	3.593	.365	2.140	1.140
	2.899	.298	3.800	2.573
	2.945	.972	2.890	3.238

APPENDIX J

ANOVA Summary Tables for

Psychological Variables

Experiment 1

Taylor Manifest Anxiety Scale

Source	SS	DF	MS	F	P
Sex	57.1429	1	57.1429	2.1147	0.1579

Psychophysiological State Questionnaire

Source	SS	DF	MS	F	P
Sex	58.3333	1	58.3333	0.6521	0.4273
Order	0.0000	1	0.0000	0.0000	1.0000
Position	93.1667	2	46.5833	2.7834	0.0718
SxO	42.8571	1	42.8571	0.4791	0.4956
SxC	8.0238	2	4.0119	0.2397	0.7877
OxC	56.6428	2	28.3214	1.6922	0.1949
SxOxC	13.5000	2	6.7500	0.4033	0.6703

Time Estimation

Source	SS	DF	MS	F	P
Sex	97.3106	1	97.3106	0.2875	0.5968
Order	311.8032	1	311.8032	0.9212	0.3467
Position	4.3569	1	4.3569	0.1346	0.7169
SxO	27.9181	1	27.9181	0.0825	0.7764
SxP	2.6666	1	2.6666	0.0824	0.7765
OxP	241.0320	1	241.0320	7.4488	0.0117
SxOxP	0.1380	1	0.1380	0.0043	0.9485

APPENDIX K

ANOVA Summary Tables for

Physiological Variables

Experiment 1

(NB: Time (T) = Sampling Period)

Skin Conductance

Source	SS	DF	MS	F	P
Sex	7.7400	1	7.7400	0.1177	0.7345
Order	1.1468	1	1.1468	0.0174	0.8960
Position	5.0683	1	5.0683	0.4949	0.4885
Time	0.0637	2	0.0319	0.0425	0.9584
SxO	16.7076	1	16.7076	0.2541	0.6188
SxP	1.7856	1	1.7856	0.1743	0.6800
SxT	7.4916	2	3.7458	4.9991	0.0107
OxP	2.6702	1	2.6702	0.2607	0.6143
OxT	4.7240	2	2.3620	3.1523	0.0517
PxT	2.3982	2	1.1991	2.0163	0.1443
SxOxP	5.7646	1	5.7646	0.5628	0.4604
SxOxT	1.8042	2	0.9021	1.2039	0.3089
SxPxT	1.2604	2	0.6302	1.0597	0.3545
OxPxT	0.0355	2	0.0177	0.0298	0.9706
SxOxPxT	0.3049	2	0.1525	0.2564	0.7749

Heart Rate

Source	SS	DF	MS	F	P
Sex	3640.0248	1	3640.0238	6.6693	0.0163
Order	188.5952	1	188.5952	0.3455	0.5621
Position	106.8810	1	106.8810	8.6940	0.0070
Time	17.4762	2	8.7381	0.9826	0.3817
SxO	61.9286	1	61.9286	0.1135	0.7392
SxP	0.5952	1	0.5952	0.0484	0.8277
SxT	9.4762	2	4.7381	0.5328	0.5904
OxP	48.2143	1	48.2143	3.9219	0.0592
OxT	13.7619	2	6.8810	0.7738	0.4669
PxT	9.1905	2	4.5952	0.5190	0.5984
SxOxP	8.5952	1	8.5952	0.6992	0.4113
SxOxT	4.4286	2	2.2143	0.2490	0.7806
SxPxT	19.4762	2	9.7381	1.1000	0.3411
OxPxT	13.2857	2	6.6429	0.7503	0.4777
SxOxPxT	7.7619	2	3.8810	0.4384	0.6476

Respiratory Rate

Source	SS	DF	MS	F	P
Sex	57.1667	1	57.1667	1.4159	0.2457
Order	13.7143	1	13.7143	0.3397	0.5655
Position	2.8810	1	2.8810	0.3264	0.5731
Time	11.1786	2	5.5893	2.2709	0.1142
SxO	77.3571	1	77.3571	1.9160	0.1790
SxP	0.3810	1	0.3810	0.0432	0.8372
SxT	5.0119	2	2.5060	1.0181	0.3689
OxP	4.0238	1	4.0238	0.4558	0.5060
OxT	10.7500	2	5.3750	2.1838	0.1237
PxT	5.5833	2	2.7917	1.6313	0.2063
SxOxP	9.5238	1	9.5238	1.0789	0.3093
SxOxT	2.2500	2	1.1250	0.4571	0.6359
SxPxT	2.5119	2	1.2560	0.7339	0.4853
OxPxT	2.2976	2	1.1488	0.6713	0.5158
SxOxPxT	0.7976	2	0.3988	0.2330	0.7930

Thoracic I/E Ratio

Source	SS	DF	MS	F	P
Sex	0.5101	1	0.5101	14.9579	0.0007
Order	0.2248	1	0.2248	6.5914	0.0169
Position	0.1041	1	0.1041	6.9460	0.0145
Time	0.0334	2	0.0167	3.1102	0.0534
SxO	0.0854	1	0.0854	2.5033	0.1267
SxP	0.0285	1	0.0285	1.9005	0.1807
SxT	0.0135	2	0.0068	1.2582	0.2934
OxP	0.0130	1	0.0130	0.8692	0.3605
OxT	0.0136	2	0.0068	1.2647	0.2916
PxT	0.0409	2	0.0204	3.5078	0.0379
SxOxP	0.0016	1	0.0016	0.1046	0.7492
SxOxT	0.0146	2	0.0073	1.3580	0.2669
SxPxT	0.0177	2	0.0088	1.5168	0.2297
OxPxT	0.0893	2	0.0446	7.6614	0.0013
SxOxPxT	0.0412	2	0.0206	3.5310	0.0371

Abdominal I/E Ratio

Source	SS	DF	MS	F	P
Sex	0.0973	1	0.0973	2.8629	0.1036
Order	0.1929	1	0.1929	5.6766	0.0255
Position	0.0762	1	0.0762	8.9540	0.0063
Time	0.0122	2	0.0061	1.4347	0.2482
SxO	0.0000	1	0.0000	0.0000	0.9990
SxP	0.0026	1	0.0026	0.3036	0.5867
SxT	0.0066	2	0.0033	0.7762	0.4659
OxP	0.0001	1	0.0001	0.0060	0.9387
OxT	0.0057	2	0.0028	0.6671	0.5179
PxT	0.0068	2	0.0034	1.0558	0.3558
SxOxP	0.0010	1	0.0010	0.1192	0.7329
SxOxT	0.9000	2	0.0000	0.0110	0.9891
SxPxT	0.0023	2	0.0011	0.3552	0.7029
OxPxT	0.0179	2	0.0090	2.7921	0.0713
SxOxPxT	0.0053	2	0.0027	0.8285	0.4428

T-A Index

Source	SS	DF	MS	F	P
Sex	0.3495	1	0.3495	0.2049	0.6548
Order	0.6479	1	0.6479	0.3798	0.5435
Position	7.8473	1	7.8473	18.2464	0.0003
Time	0.0034	2	0.0017	0.0386	0.9622
SxO	5.7309	1	5.7309	3.3598	0.0792
SxP	5.3389	1	5.3389	12.4140	0.0017
SxT	0.1240	2	0.0620	1.4048	0.2553
OxP	0.0010	1	0.0010	0.0023	0.9622
OxT	0.0907	2	0.0454	1.0288	0.3652
PxT	0.0520	2	0.0260	0.6216	0.5414
SxOxP	1.8428	1	1.8428	4.2848	0.0493
SxOxT	0.0566	2	0.0283	0.6415	0.5310
SxPxT	0.1322	2	0.0661	1.5803	0.2164
OxPxT	0.0442	2	0.0221	0.5288	0.5927
SxOxPxT	0.1554	2	0.0777	1.8570	0.1672

APPENDIX L

ANOVA Summary Tables for

Psychological Variables

Experiment 2

Taylor Manifest Anxiety Scale

Source	SS	DF	MS	F	P
Sex	65.3333	1	65.3333	1.3067	0.2598
Treatment	216.7500	3	72.2500	1.4450	0.2441
SxT	53.8333	3	17.9444	0.3589	0.7810

Psychophysiological State Questionnaire

(NB: Report (R) = 1 administration of PSQ)

Source	SS	DF	MS	F	P
Sex	1.0417	1	1.0417	0.0175	0.8953
Treatment	51.2083	3	17.0694	0.2872	0.8343
Report	37.5000	1	37.5000	2.7898	0.1027
SxT	43.3750	3	14.4583	0.2433	0.8656
SxR	0.6667	1	0.6667	0.0496	0.8249
TxR	85.0833	3	28.3611	2.1099	0.1142
SxTxR	88.0833	3	29.3611	2.1843	0.1049

Time Estimation

Source	SS	DF	MS	F	P
Sex	0.0280	1	0.0280	0.1332	0.7171
Treatment	0.5021	3	0.1674	0.7949	0.5040
SxT	1.3075	3	0.4358	2.0702	0.1195

APPENDIX M

ANOVA Summary Tables for

Physiological Variables

Experiment 2

Skin Conductance

Source	SS	DF	MS	F	P
Sex	40.9960	1	40.9960	0.5831	0.4496
Treatment	137.3961	3	45.7987	0.6514	0.5867
SxC	49.8479	3	16.6160	0.2363	0.8705

Heart Rate

Source	SS	DF	MS	F	P
Sex	520.0833	1	520.0833	3.3557	0.0744
Treatment	681.5833	3	230.5278	1.4874	0.2325
SxT	262.9167	3	87.6389	0.5655	0.6410

Respiratory Rate

Source	SS	DF	MS	F	P
Sex	26.6944	1	26.6944	4.4286	0.0438
Treatment	145.7222	2	72.8611	12.0876	0.0001
SxT	33.7222	2	16.8611	2.7972	0.0769

T-A Index

Source	SS	DF	MS	F	P
Sex	7.6409	1	7.6409	18.4033	0.0000
Treatment	42.5533	3	14.1844	34.1638	0.0000
SxT	2.3589	3	0.7863	1.8939	0.1461

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