LEVELS OF EMOTIONAL AWARENESS: A PSYCHOPHYSIOLOGICAL INVESTIGATION

THESIS

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By

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ABSTRACT

The study of emotion has received a lot of attention from the scientific community. Several models of emotion and its associated processes have been proposed. One of particular interest is the model of “levels of emotional awareness.” This model suggests that the ability to identify and describe emotion in oneself and others is a cognitive skill that develops in stages over time. The current study sought to investigate the relationship between the psychophysiological system and the “levels of emotional awareness” model. Influence of gender on this relationship was also examined. Psychophysiological measures were obtained using electromyography (EMG), skin conductance response (SCR), and electrocardiography (ECG) as participants viewed high and low arousal pleasant, high and low arousal unpleasant and neutral International Affective Picture System (IAPS) images. Baseline ECG recordings were obtained before and after image viewing. Individual emotional awareness levels were assessed using the LEAS. Differences by sex were observed for EMG and both experimental and baseline ECG. Phasic heart rate response data, measured by ECG, revealed significant associations with LEAS scores that interacted with both sex and image valence. In contrast, EMG and SCR data revealed no associations with LEAS scores.
DEDICATION

Dedicated to my parents
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CHAPTER 1
INTRODUCTION

Emotion has interested the scientific community for well over one hundred years. Darwin’s 1872 publication, The Expression of Emotion in Man and Animals, examined the properties of emotional expression, including the relationship between emotional expression and the nervous system. This popular book captured the attention of researchers and proved fundamental in the development of models of emotion as an organic process (Lange & James, 1922).

In the mid 1880’s, William James and Carl Lange independently proposed a model of emotion incorporating the physiological system. The James-Lange theory of emotion posits that in the presence of an activating stimulus, physiological arousal occurs, thus resulting in emotional experience (Lange & James, 1922). This model generated much controversy in the field of emotion research and led to the proposal of an opposing theory by Walter Cannon and Philip Bard in the 1920’s.

The Cannon-Bard theory of emotion states that physiological arousal and emotional experience occur simultaneously, suggesting that emotional experience is not dependent on physiology (Cannon, 1927). The role of cognition in emotional experience and how it relates to physiology has also been questioned. In the 1960’s Stanley Schachter and Jerome Singer argued that emotional experience is dependent upon the
cognitive interpretation of physiological arousal, such that similar physiological patterns can give rise to multiple emotional experiences (Schachter & Singer, 1962).

While many questions regarding the mechanics of the emotional system still exist, the interconnectedness of emotional experience and physiology is indisputable. This relationship allows for the objective study of emotion. The ability to study an intangible psychological construct with accurate and objective psychophysiological measures is unique within the field and has made the study of emotion an exciting and popular area of research.

The development and advancement of techniques designed to directly measure physiological activity have allowed scientists to precisely measure many physiological factors as emotional experience is occurring. Different emotional states are often associated with distinct physiological profiles. The nature of the relationship between emotion and physiology allows researchers to conceptualize and test theories of emotion in ways that would be difficult or impossible if relying strictly on subjective measures.

1.1 Psychophysiological Techniques of Emotion Research

Many different psychophysiological techniques have been used in emotion research. Some of the most common methods include electromyography (EMG), electrocardiography (ECG) and measurement of the skin conductance response (SCR). EMG is a technique used to measure electrical activity of a given target muscle. Electrodes are placed on the skin above the muscle of interest. These electrodes detect electrical activity resulting from muscle activation and then send this information to a computer where it is amplified, rectified, and quantified.
Facial EMG is of particular relevance to the study of emotion as several emotional experiences are reflected by universal facial expressions associated with specific muscle movements (Ekman, 1970). In 1976, Ekman and Friesen developed the Facial Action Code (FAC) as a way to consistently and accurately measure visible facial movements involving one or more muscles. In a 1980 study, the FAC system was able to differentiate between the intensity of reported pleasant and unpleasant emotional experience in a group of 35 Caucasian females (Ekman, Friesen & Ancoli, 1980). Unique facial actions associated with disgust were also identified in this experiment. In a more recent study, the FAC system was used to code facial expressions from 128 photographs (Kohler, Turner, Stolar, Bilker, Brensinger, Gur, & Gur, 2004). A lip corner pull was observed in all expressions associated with happiness. Expressions of sadness had several characteristic features, including furrowing of the brow, opening of the mouth, and a raised upper lip. However, no single feature was found across all expressions of sadness (Kohler et al., 2004).

EMG provides a quantitative measure of these facial movements, even at levels unobservable to the human eye. It has been demonstrated that particular muscles are activated across individuals when imagining positive and negative thoughts (Schwartz et al., 1979, 1980, 1976). The zygomaticus major, a cheek muscle essential in the production of a smile, was universally activated in participants during positive thoughts. The corrugator supercillii, muscles essential in furrowing of the eyebrows, were found to be activated while participants imagined negative thoughts (Schwartz et al., 1979, 1980, 1976). In addition to emotional valence differentiation, several studies have demonstrated that intensity of affective arousal is reflected by EMG recordings (Cacioppo, Petty, Losch
& Kim, 1986; Lang, Greenwald, Bradley & Hamm, 1993; Lang, Bradley, & Cuthbert, 1998). In essence, as the level of negativity of a given stimuli increases the amount of activity in the corrugators supercilli also increases, suggesting more furrowing of the eyebrows. Likewise, as the positivity of a stimulus increases the activity of the zygomaticus major increases, indicating widening of the smile. The ability to confidently associate the electrical activity of these particular muscles with affective valence and arousal has led to frequent use of facial EMG in emotion research.

ECG is another technique that is frequently used in emotion research. An ECG measures activity of the heart and records the electrical activity associated with the physical filling and pumping of blood. One measure of interest obtained from ECG is the amount of time elapsed between each heart beat, or the inter-beat interval (IBI). This value is obtained by measuring the amount of time (in msec) between successive R spikes of the ECG. The R spike is used because of its larger magnitude and sharper inflection relative to other ECG components. IBI length is influenced by both sympathetic and parasympathetic (vagal) influences of the autonomic nervous system. The sympathetic system works to increase heart rate while the parasympathetic system simultaneously works to decrease it. Actual heart rate is a product of influence from both systems. Although both systems are continuously active, the heart responds much faster to signals from the parasympathetic system, implicating its dominance in beat-to-beat regulation (Levy, 1984; Kristal-Boneh, Raifel, Froom, & Ribak, 1995).

To assess the levels of influence from each system, different measures of heart rate variability (HRV) are obtained. HRV is analyzed in terms of time and frequency domains. Common time domain methods used to assess HRV include mean and standard
deviation of the IBIs, the square root of the mean of the sum of the squares of differences between adjacent IBIs (RMSSD), the number of pairs of adjacent IBIs differing by more than 50 ms in the entire recording (NN50), and the number of pairs of adjacent IBIs differing by more than 50 ms divided by the total number of IBIs (pNN50). Time domain measures are thought to provide estimates of overall HRV (Task Force, 1996). To obtain frequency domain measures of HRV a power spectral density (PSD) analysis is first required to determine the distribution of power (variance) as a function of frequency. Low frequency power (LF), high frequency power (HF), and their ratio (LF/HF) are obtained from the PSD analysis. LF is thought to reflect both sympathetic and parasympathetic (vagal) influences of the autonomic nervous system, whereas HF is thought to primarily reflect parasympathetic influence. The LF/HF ratio is believed to reflect the sympathovagal balance of the autonomic nervous system (Thayer & Brosschot, 2005). While time domain measures provide a good estimate of overall HRV, frequency domain measures allow contributions from different frequency levels to be assessed as well as overall HRV levels.

High heart rate variability is indicative of effective regulation of heart rate in response to environmental demands. It is critical that the autonomic subsystems, particularly the parasympathetic, are working properly to modulate heart activity. The heart of a healthy, adaptive organism is under dominant parasympathetic (vagal) control allowing for substantial yet quick changes in IBI over tasks of varying difficulty. A variety of research has demonstrated the importance of HRV in emotion and its regulation (Friedman and Thayer, 1998).
Other useful information can be obtained from ECG by recording phasic patterns of heart rate (HR). This pattern lasts for approximately 6 seconds after stimulus onset and usually produces a triphasic waveform. In neutral conditions, this waveform consists of an initial deceleration phased (D1), followed by an acceleration (A1) and ends with a second deceleration (D2). The initial deceleration, D1, is generally thought to be vagally mediated, reflecting an orienting response (OR) to novel stimuli (Sokolov & Cacioppo, 1997; Graham & Clifton, 1966; Sokolov, 1963). A1 may reflect general information processing regarding the presented stimuli and the required response of the expected upcoming stimuli (Coles & Duncan-Johnson, 1975; Bradley, Codispoti, Cuthbert, & Lang, 2001). It has also been proposed that the pronounced acceleration induced by positive stimuli may reflect activation of the appetitive motivational system (Fowles, 1988; Lang et al., 1993). D2 is thought to indicate anticipation of the next stimulus (Berg & Donohue, 1992).

This triphasic waveform has been found to be modulated by valence and arousal levels of visual stimuli. The greatest initial deceleration (D1) is seen in response to low and high arousal negatively valenced pictures along with high arousal positively valenced pictures (Bradley et al., 2001; Simons, Detenber, Roedema, & Reiss, 1999). For negative images the deceleration (D1) typically remains until the end of the presentation, whereas a triphasic pattern is observed for positive and neutral pictures, with the largest amount of acceleration (A1) occurring for the positive images of low to medium arousal levels (Bradley et al., 2001). This pattern provides a unique method to objectively measure emotional experience. The ability to easily collect valuable information regarding heart rate and its variability make ECG an essential tool in the study of emotion.
SCR is a psychophysiological technique used to measure changes in electrodermal activity. Typically, two electrodes are placed on the skin and a small current is passed between them. Conduction of this current is influenced by sweat gland activity, which is thought to be mediated primarily by sympathetic activity of the autonomic nervous system (Fowles, Kochanska, & Murray, 2000). SCR measures are believed to be reflective of arousal level. Specifically, increased skin conductance has been observed in positively and negatively rated pictures in comparison to neutral images (Lang et al., 1993). Additionally, skin conductance has been shown to vary as a function of arousal level, with the most arousing positive and negative images producing the largest changes in SCR (Bradley et al., 2001). Similar findings have demonstrated skin conductance increases with increases in emotional arousal levels of both acoustic and film based stimuli (Bradley & Lang, 2000; Gomez & Danuser, 2004). SCR, along with EMG and ECG are valuable tools in the study of emotion. Together they provide an objective representation of emotional experience via the autonomic nervous system.

1.2 Levels of Emotional Awareness

In recent history many different models of emotion have been proposed. However, it is important to acknowledge that emotion is not an isolated system and is likely interrelated with many other cognitive processes. Thus, it is reasonable to predict that emotion related processes are involved in emotional awareness.

In 1987, Lane and Schwartz proposed that the ability to identify and describe emotion in oneself and others is a cognitive skill that develops in stages over time. This model has been titled “Levels of Emotional Awareness” and is thought to be a separate
line of cognitive development that can proceed independently from other cognitive
domains (Lane & Schwartz, 1987; Lane & Pollerman, 2002). The model consists of five
hierarchically related levels of emotional awareness. When an individual reaches a higher
level of development new abilities are attained and, while previous skill sets may be
modified, they are still part of the emotional awareness processing repertoire (Lane and
Schwartz, 1987).

The five levels of this model, in ascending order, are 1) awareness of physical
sensations, 2) action tendencies, 3) single emotions, 4) blends of emotions, and 5) blends
of blends of emotional experience. As an individual develops higher levels of emotional
awareness their feelings associated with a particular emotional response will be
comprised of factors from each level up to and including the highest level they have
attained in the developmental process (Lane & Schwartz, 1987).

The Levels of Emotional Awareness Scale was developed to measure the
approximate skill level for an individual along this particular developmental continuum
(Lane, Quinlan, Schwarz, Walker, & Zeitlin, 1990). This writing based behavioral
measure asks individuals to describe how they and others would feel given provided
situations. Based on the complexity of the responses the individual is assigned a
numerical score. The scale is designed such that a higher score indicates a higher skill
level.

1.3 Previous Research with the LEAS

High scores on the LEAS have been associated with a wide variety of factors.
Some of these include greater self-reported impulse control, greater openness to feelings,
greater emotion recognition ability, higher empathy ability, a higher tendency to seek help for emotional problems, and a larger actual amount of available social support (Lane, 2000; Lane et al., 1990; Lane, Sechrest, Reidel, Weldon, Kaszniak, & Schwartz, 1996; Lane, Sechrest, Reidel, Shapiro, & Kaszniak, 2000; Barchard & Hakstian, 2004).

LEAS scores have also been found to be associated with several clinical conditions. Individuals with essential hypertension obtained lower scores on the LEAS than those with hypertension resulting from another medical condition (Consoli, Roch, & Plouin, 2007). Lower LEAS scores have also been found in patients with eating disorders, PTSD, and morbid obesity (Bydlowski, Corcos, Jeammet, Paterniti, Berthoz, Laurier, Chambray, & Consoli, 2005; Frewen, Lane, Neufeld, Densmore, Stevens, & Lanius, 2008; Consolli, 2005). Interestingly, individuals with Generalized Anxiety Disorder have been shown to obtain greater LEAS scores than matched controls (Novick-Kline, Turk, Mennin, Hoyt, & Gallagher, 2005). This finding suggests that, for particular individuals, elevated levels of emotional awareness may actually be deleterious.

Imaging research has shown LEAS scores to be associated with activity levels in particular regions of the brain. Two studies employing Positron Emission Tomography (PET) have found LEAS scores to be correlated with regional cerebral blood flow (rCBF), which is believed to reflect brain activity levels. The first of these studies involved film and recall induced emotion in women (Lane, Reiman, Axelrod, Yun, Holmes & Schwartz, 1998). A cluster of activity was found in the right dorsal anterior cingulate cortex (dACC) during both conditions. Amount of rCBF and LEAS scores were found to be significantly correlated. This correlation was positive in direction, suggesting
that individuals with higher LEAS scores showed higher levels of rCBF in the right dACC.

The second study consisted of men and women and used the International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2001) to induce pleasant, unpleasant, and neutral emotion in participants (McRae, Reiman, Fort, Chen, & Lane, 2008). LEAS scores were significantly correlated with the difference in rCBF in the dACC of the high arousal conditions relative to the low arousal conditions. Essentially, LEAS scores predicted larger amounts of change in brain activity when comparing the amount of rCBF of the high arousal versus low arousal conditions. The LEAS has been shown to be associated with a variety of emotion related constructs in several experiments. However, studies investigating the psychophysiological factors associated with the LEAS are still needed.

1.4 Summary

The study of emotion has received a lot of attention from the scientific community. Several models of emotion and its associated processes have been proposed. One of these models is “levels of emotional awareness.” While there is a fair amount of research examining this model using the LEAS, there is a lack of research investigating the relationship between levels of emotional awareness and the psychophysiological properties of emotion. As EMG, ECG and SCR have all been shown to be influenced by emotional valence and arousal it is expected that variation in ability levels of emotional awareness, as measured by the LEAS, will be associated with differences in these physiological response measures.
1.5 The Proposed Study

The current study sought to investigate the relationship between the psychophysiological system and the “levels of emotional awareness” model. Influence of gender on this relationship was also examined. Specifically, the aim of the study was to determine if LEAS scores predict psychophysiological responses during emotion induction and to explore how these predictions vary by Sex. To address this question, psychophysiological measures were obtained using EMG, SCR, and ECG as participants viewed high and low arousal pleasant, high and low arousal unpleasant and neutral IAPS pictures. The LEAS was also administered.

It is predicted that, on average, females will obtain higher LEAS scores than males. It is also predicted that individuals obtaining higher LEAS scores will show more differentiated psychophysiological responses to the emotional stimuli. It is thought that the individual’s increased ability to process emotional stimuli, as reflected by a high LEAS score, will result in more adaptive physiological responses than their low scoring counterparts. The specific questions addressed by this study were:

1) Do high and low LEAS scores predict significantly different responses on EMG, SCR, and baseline ECG measures and do these predictions vary by Sex?

2) Do high and low LEAS scores predict significantly different phasic response patterns and do these predictions vary by Sex?
CHAPTER 2

METHODS

2.1 Participants

Participants consisted of 44 healthy adults (22 women; 22 men) ranging in age from 19 to 30 (mean = 24.75, SD = 3.35). Prospective subjects were screened and excluded from participation if they reported a history of neurological abnormalities, head injury, learning disabilities, current psychoactive medication use, current drug or alcohol abuse, current major depressive episode, or lifetime prevalence of bipolar disorder or other psychotic disorder. Participants were also excluded if they identified as non-native English speakers, as LEAS scores may not reflect true ability if participants are unable to effectively express themselves. Additionally, participants were excluded if they reported homosexual orientation as it would be difficult to ensure a pleasant response to heterosexual erotic stimuli for these individuals. Non-excluded participants completed a 5-hour session at the Banner Good Samaritan PET center in Phoenix, Arizona. Participants provided written informed consent and were compensated for their time.

2.2 Psychological Measures and Stimuli

Levels of Emotional Awareness Scale (LEAS)

The LEAS is a performance measure that asks an individual to write two to four sentences to describe the expected feelings for them and another individual in response to
each of 20 vignettes (Lane, Quinlan, Schwarz, Walker, & Zeitlin, 1990). Only the structure of the described experience is used in scoring. Each vignette receives a separate score, ranging from 0 to 5, for both the “self” and “other” response. Each point increase is intended to demonstrate an increase in the level of emotional awareness achieved within the response.

A score of zero is assigned when an individual uses nonaffective words or if the word “feel” is used to describe a thought rather than a feeling (e.g., I would feel like she didn’t deserve it) (Lane et al., 1990). A score of 1 would be assigned to strictly physical responses (e.g., I would punch the wall). A score of 2 would be assigned for a description of an action response using the word “feel” (e.g., I’d feel like hiding my face) or if words are used that do not differentiate emotion (e.g., I’d feel good). A score of 3 is applied when one word that conveys a typical, yet differentiated emotion is used (e.g., I’d be happy). A score of 4 is appropriate when two or more words from level 3 are used to indicate a more differentiated emotional experience than either word would on its own. A score of 5 can only be assigned if both responses receive a score of 4 and if they describe a unique emotional response for the “self” and the “other” condition. A glossary of words at each level is provided to guide scoring (Lane et al., 1987).

The LEAS has demonstrated high inter-rater reliability with an intraclass r(20) = .84 (Lane et al., 1990). Internal consistency has also been shown to be high with a Cronbach’s alpha of .81 (Lane et al., 1990). French and German versions of the LEAS have been validated (Bydlowski, S., Corcos, M., Paterniti, S., Guilbaud, O., Jeammet, P., & Consoli, S. M., 2002; Subic-Wrana, C, Thomas, W, Huber, M, & Kohle, K, 2001). A
version of the LEAS for children (LEAS-C) has also been published (Bajgar, J., Ciarrochi, J., Lane, R., & Deane, F. P., 2005).

*International Affective Picture System (IAPS)*

The IAPS consists of a set of photographs designed to induce emotion in participants in a reliable and predictable manner (Lang, Bradley, & Cuthbert, 1999). Valence and arousal of the content for each picture falls at different locations along these two dimensions. Pictures that are rated as high (very pleasant) and low (very unpleasant) on the dimension of valence have been associated with high levels of arousal in North American and Spanish samples. As content approaches the neutral region of the valence domain the level of associated arousal typically decreases (Lang, Bradley, & Cuthbert, 1999).

However, one study seeking to generate normative ratings for Brazilian populations found that pictures rated as highly positive on the valence dimension were not always rated as highly arousing (Ribeiro, Pompeia & Bueno, 2005). The reason for this difference in arousal ratings across cultures is unclear. The authors suggest that these findings may be a reflection of cultural differences or perhaps a difference in interpretation of the arousal scale rating resulting from translation of the original instructions into Portuguese (Ribeiro et al., 2005).

2.3 Procedures

Each participant was asked to take part in a Positron Emission Topography (PET) scanning session, during which several psychophysiological measures were collected.
Before each participant was scanned they answered several questionnaires requiring a total of 45 – 60 minutes to complete. Participants were then asked to lie down on the PET scanner table and place their head on the head rest which was adjusted to keep it from shifting during the scan. EMG, ECG, and SCR electrodes were then placed on the participant for psychophysiological data acquisition. Participants then received training on the task and completed a practice set. To provide a pre-scan baseline measure all of the psychophysiology channels were recorded for 2 minutes. Participants were then scanned while performing the experimental task (For descriptions of methodology relating to brain scan data collection see McRea et al., 2008). After completing this task, post-scan baseline psychophysiological measures were recorded on all channels for 2 minutes. Each participant was debriefed and compensated for their time.

Task

Images were presented to participants as part of an 8-condition session. The first and fifth conditions consisted of visual fixation for all subjects. The other six picture viewing conditions consisted of 13 IAPS pictures, shown for 6 seconds each, separated by 1 second of visual fixation. In the visual fixation conditions a cross hair was used in place of pictures and was displayed for 6 seconds separated by a blank screen for 1 second. The images for each block of picture viewing conditions were chosen using normative ratings of IAPS pictures. The blocks consisted of highly arousing pleasant, highly arousing unpleasant, less arousing pleasant, less arousing unpleasant, and two neutrally rated pictures. The high arousal pleasant and high arousal unpleasant images were different for men and women because ratings of arousal and valence for highly arousing pictures vary between Sexes. Images were chosen in an effort to maximize
normative ratings of arousal for each Sex. One block of neutral pictures contained human faces while the other contained no faces and consisted mostly of scenes and everyday objects. The six blocks of picture viewing conditions were counterbalanced around the two blocks of visual fixation. Before viewing any images, subjects were instructed to, “please look at the screen and allow yourself to feel whatever each picture evokes in you.”

2.4 Equipment

Electromyography (EMG)

During imaging, activity of the corrugator supercilli and the zygomaticus major muscles were measured in response to each image using EMG. Electrodes were placed over each muscle and activity was measured at 500 samples/s using a Biopac Systems amplifier, with a gain of 5000, a high-pass filter of 10 Hz and a low-pass filter of 500 Hz for the amplifier and 250 Hz for the Biopac Systems, Inc. AcqKnowledge© software used to acquire and analyze the data.

Electrocardiogram (ECG)

Heart activity was measured during the scans using ECG. One electrode was placed just under the right clavicle in the mid-clavicular line and a second electrode was placed on the left side of the abdomen, just over the floating rib. A third ground electrode was placed on the left abdomen directly opposite the second electrode. Before applying each electrode the skin was wiped with alcohol to ensure good contact.
Heart activity was measured at 500 samples/s using a Biopac Systems amplifier, with a gain of 1000, a high-pass filter of 0.05 Hz and a low-pass filter of 35 Hz. Data was acquired using Biopac Systems, Inc. AcqKnowledge© software created by and analyzed using MindWare© Technologies Ltd. Heart Rate Variability (HRV) Analysis software and Kubios Heart© Rate Variability (HRV) Analysis software.

Skin Conductance Response (SCR)

During imaging, skin conductance responses (SCRs) were collected in response to each picture. SCRs were recorded with two Ag/Cl electrodes on the left palm. Electrodermal activity was measured at 500 samples/s using a Biopac Systems, Inc. amplifier, with a gain of 20, a high-pass filter of 0.5 Hz, and a low-pass filter of 1 Hz. The data was acquired and analyzed using Biopac Systems, Inc. AcqKnowledge© software.

SCR amplitude was defined as the change in electrodermal activity from baseline to peak levels with onset occurring between 1 and 4 seconds after stimulus presentation. Trials in which SCR did not rise above 0.02 Siemens, steadily declined, or began outside specified onset window were assigned a value of zero and included in all subsequent analyses. Two female participants were missing SCR data as a result of equipment malfunction during data collection.

2.5 Data Reduction and Analysis Plan

EMG, SCR, and HRV data were averaged over the length of each condition. To obtain phasic HR data, IBIs were extracted for each image of each condition separately.
The first 6 IBIs following image onset were extracted for all 13 pictures of each condition. Averages were then calculated to create a single phasic response pattern for each condition. Participants were divided into two groups based on a median split of LEAS scores, creating a high LEAS Group and a low LEAS Group. To test for significant differences in the pre-scan and post-scan baseline HRV variables multivariate analysis of variance (MANOVA) were used. Statistically significant differences in EMG and SCR psychophysiological responses to the emotional stimuli were determined using repeated measures ANOVA. Within-subjects factors included Valence and Arousal with LEAS Group and Sex as between-subjects factors. Repeated measures ANOVA were also used to test for differences in phasic response patterns to the emotional stimuli. Within-subjects factors were Valence, arousal, and IBI and between-subjects factors were LEAS Group and Sex.

Repeated measure ANOVA is often criticized because of the violation of the assumption of sphericity. MANOVA does not require this assumption and, as demonstrated by Vasey and Thayer (1987), the Greenhouse-Geiser univariate solution is comparable to the MANOVA solution in repeated measure analysis of psychophysiological data. Thus, the repeated measure approach using the multivariate solution was employed in this study.

A trend analysis was performed to analyze the shape of the phasic response patterns. This was done using orthogonal polynomial contrasts. Previous research demonstrates triphasic cardiac response patterns to emotional stimuli, making the use of cubic contrasts appropriate. In order to examine differences in trends for each level of
every factor, weights of the contrast factors were systematically varied in successive
trend analyses.

In preliminary analysis, anomalous data were removed. This was done by plotting
the data as frequency distributions with a normal curve superimposed. Any data that were
located outside the normal curve, with a value two standard deviations greater or less
than the mean, were removed. Thus, some participant data is incomplete which is
reflected by different N values for different analysis. A significance value of $p \leq 0.05$ was
applied for the present study. All statistical analysis were conducted with the Statistical
Package for the Social Sciences (SPSS©) version 16.0.

Brief Glossary of Heart Rate Variability Variables:

- **MEAN_RR**: Average amount of time between successive R-spikes (RR).
- **STD_RR**: Standard deviation of all RR intervals.
- **RMSSD**: Square root of the mean of the sum of the squares of differences between
  adjacent RR intervals.
- **NN50**: Number of pairs of adjacent RR intervals differing by more than 50 ms in
  the entire recording.
- **PNN50**: Number of pairs of adjacent RR intervals differing by more than 50 ms
  divided by the total number of RR intervals.
- **LogLF**: Natural logarithm of low frequency power.
- **LogHF**: Natural logarithm of high frequency power.
- **Rel_LF**: Percentage of total power attributable to low frequency power.
- **Rel_HF**: Percentage of total power attributable to low frequency power.
- **NORM_LFHF**: Normalized low to high frequency power ratio.
CHAPTER 3

RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Female (N = 22)</th>
<th>Male (N = 22)</th>
<th>Total (N = 44)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>24.09 (2.76)</td>
<td>25.14 (3.65)</td>
<td>24.61 (3.25)</td>
</tr>
<tr>
<td>LEAS</td>
<td>66.95 (8.60)</td>
<td>65.68 (9.56)</td>
<td>66.32 (9.01)</td>
</tr>
</tbody>
</table>

Levels of Emotional Awareness Scale Score (LEAS)

Table 3.1 Sample Descriptive Statistics (Means and Standard Deviations).

3.1 Descriptive Statistics

To explore potential differences in Age and LEAS scores between females and males, independent group t-tests were performed. No statistically significant differences were found for Age, t(42) = -1.068, p = .291, r = 0.16, or for LEAS score, t(42) = 0.464, p = .645, r = .07. Previous research consistently reports higher average LEAS scores for females over males (Barret, Lane, Sechrest, & Schwartz, 2000). While the difference observed in this study is in the appropriate direction, with slightly higher scores obtained by females as compared to males, it was not statistically significant and is incongruent with previous research. LEAS scores all fell within the expected range and mean LEAS values are comparable to previously reported values (Subic-Wrana, Bruder, Thomas, Lane, Kohle, 2005; Barret, Lane, Sechrest, & Schwartz, 2000). The median LEAS score of 65.50 was used to create high and low LEAS Groups.
Table 3.2 Prewscan HRV variables Descriptive Statistics by LEAS Multivariate ANOVA LEAS Effects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low LEAS (N = 22)</th>
<th>High LEAS (N = 22)</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
<th>(1-(\beta))</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN_RR_BASE</td>
<td>956.77</td>
<td>155.93</td>
<td>1.070</td>
<td>n.s.</td>
<td>.026</td>
<td>.172</td>
</tr>
<tr>
<td>STD_RR_BASE</td>
<td>55.36</td>
<td>25.07</td>
<td>.172</td>
<td>n.s.</td>
<td>.004</td>
<td>.069</td>
</tr>
<tr>
<td>RMSSD_BASE</td>
<td>48.25</td>
<td>25.06</td>
<td>.355</td>
<td>n.s.</td>
<td>.009</td>
<td>.090</td>
</tr>
<tr>
<td>PNN50_BASE</td>
<td>26.83</td>
<td>18.26</td>
<td>.012</td>
<td>n.s.</td>
<td>.000</td>
<td>.051</td>
</tr>
<tr>
<td>LogLF_BASE</td>
<td>6.45</td>
<td>1.216</td>
<td>1.059</td>
<td>n.s.</td>
<td>.026</td>
<td>.171</td>
</tr>
<tr>
<td>LogHF_BASE</td>
<td>6.78</td>
<td>.9950</td>
<td>.000</td>
<td>n.s.</td>
<td>.000</td>
<td>.050</td>
</tr>
<tr>
<td>REL_LF_BASE</td>
<td>28.05</td>
<td>16.21</td>
<td>5.338</td>
<td>.026</td>
<td>.118</td>
<td>.616</td>
</tr>
<tr>
<td>REL_HF_BASE</td>
<td>36.31</td>
<td>20.43</td>
<td>.133</td>
<td>n.s.</td>
<td>.003</td>
<td>.065</td>
</tr>
<tr>
<td>NORM_LFHF_BASE</td>
<td>.9848</td>
<td>.6359</td>
<td>2.676</td>
<td>n.s.</td>
<td>.063</td>
<td>.358</td>
</tr>
</tbody>
</table>

Table 3.3 Prewscan HRV variables Descriptive Statistics by Sex and Multivariate ANOVA Sex Effects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (N = 22)</th>
<th>Males (N = 22)</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
<th>(1-(\beta))</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN_RR_BASE</td>
<td>874.71</td>
<td>161.34</td>
<td>6.421</td>
<td>.015</td>
<td>.138</td>
<td>.696</td>
</tr>
<tr>
<td>STD_RR_BASE</td>
<td>43.52</td>
<td>25.17</td>
<td>9.560</td>
<td>.004</td>
<td>.193</td>
<td>.855</td>
</tr>
<tr>
<td>RMSSD_BASE</td>
<td>40.11</td>
<td>23.02</td>
<td>5.163</td>
<td>.029</td>
<td>.114</td>
<td>.602</td>
</tr>
<tr>
<td>PNN50_BASE</td>
<td>18.70</td>
<td>18.48</td>
<td>9.124</td>
<td>.004</td>
<td>.186</td>
<td>.838</td>
</tr>
<tr>
<td>LogLF_BASE</td>
<td>6.20</td>
<td>1.26</td>
<td>5.905</td>
<td>.020</td>
<td>.129</td>
<td>.660</td>
</tr>
<tr>
<td>LogHF_BASE</td>
<td>6.36</td>
<td>1.24</td>
<td>5.328</td>
<td>.026</td>
<td>.118</td>
<td>.615</td>
</tr>
<tr>
<td>REL_LF_BASE</td>
<td>33.73</td>
<td>16.13</td>
<td>.008</td>
<td>n.s.</td>
<td>.000</td>
<td>.051</td>
</tr>
<tr>
<td>REL_HF_BASE</td>
<td>38.24</td>
<td>16.13</td>
<td>.078</td>
<td>n.s.</td>
<td>.002</td>
<td>.059</td>
</tr>
<tr>
<td>NORM_LFHF_BASE</td>
<td>1.09</td>
<td>0.66</td>
<td>.815</td>
<td>n.s.</td>
<td>.020</td>
<td>.143</td>
</tr>
</tbody>
</table>

3.2 Pre-scan Baseline Heart Rate Variability

To examine potential effects of Sex and LEAS Group on baseline HRV variables Multivariate Analysis of Variance (MANOVA) were performed. Dependent variables
included MEAN_RR_BASE, STD_RR_BASE, RMSSD_BASE, PNN50_BASE, LogLF_BASE, LogHF_BASE, REL_LF_BASE, REL_HF_BASE, and NORM_LFHF_BASE. Between-subjects factors were Sex and LEAS Group. Males obtained higher average values on eight of the nine HRV variables, resulting in a nearly significant multivariate effect of Sex at pre-scan baseline, $F(9,32) = 2.145, p = .055, \eta^2_p = .376, (1-\beta) = .781$, and significant between-subjects Sex effects on MEAN_RR_BASE, STD_RR_BASE, RMSSD_BASE, PNN50_BASE, LogLF_BASE, and LogHF_BASE (see Table 3.3). Males had significantly higher resting HRV than females as reflected by a higher average LogHF_BASE value (see Table 3.3). Males also obtained significantly higher average MEAN_RR_BASE, STD_RR_BASE, RMSSD_BASE, PNN50_BASE, and LogLF_BASE values as compared to females, further reflecting higher resting HRV and a lower resting heart rate in males (see Table 3.3).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low LEAS (N = 22)</th>
<th>High LEAS (N = 22)</th>
<th>F</th>
<th>p</th>
<th>$\eta^2_p$</th>
<th>(1-\beta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN_RR_BASE2</td>
<td>913.36 144.93</td>
<td>873.93 155.82</td>
<td>.923</td>
<td>n.s.</td>
<td>.023</td>
<td>.155</td>
</tr>
<tr>
<td>STD_RR_BASE2</td>
<td>63.25 38.61</td>
<td>56.75 43.39</td>
<td>.301</td>
<td>n.s.</td>
<td>.007</td>
<td>.083</td>
</tr>
<tr>
<td>RMSSD_BASE2</td>
<td>60.00 40.72</td>
<td>51.77 46.40</td>
<td>.139</td>
<td>n.s.</td>
<td>.003</td>
<td>.065</td>
</tr>
<tr>
<td>PNN50_BASE2</td>
<td>21.26 17.71</td>
<td>21.57 19.85</td>
<td>.003</td>
<td>n.s.</td>
<td>.000</td>
<td>.050</td>
</tr>
<tr>
<td>LogLF_BASE2</td>
<td>6.99 .9281</td>
<td>7.07 1.57</td>
<td>.049</td>
<td>n.s.</td>
<td>.001</td>
<td>.055</td>
</tr>
<tr>
<td>LogHF_BASE2</td>
<td>6.42 1.16</td>
<td>6.48 1.40</td>
<td>.023</td>
<td>n.s.</td>
<td>.001</td>
<td>.052</td>
</tr>
<tr>
<td>REL_LF_BASE2</td>
<td>39.60 19.73</td>
<td>48.41 21.85</td>
<td>1.927</td>
<td>n.s.</td>
<td>.046</td>
<td>.273</td>
</tr>
<tr>
<td>REL_HF_BASE2</td>
<td>26.93 20.37</td>
<td>26.34 11.716</td>
<td>.013</td>
<td>n.s.</td>
<td>.000</td>
<td>.051</td>
</tr>
<tr>
<td>NORM_LFHF_BASE2</td>
<td>2.66 2.35</td>
<td>2.32 1.83</td>
<td>.290</td>
<td>n.s.</td>
<td>.007</td>
<td>.082</td>
</tr>
</tbody>
</table>

Table 3.4 Post-scan HRV descriptive statistics by LEAS Group with MANOVA LEAS effects.
Table 3.5 Post-scan HRV descriptive statistics by Sex with MANOVA Sex effects.

### 3.3 Post-scan Baseline Heart Rate Variability

To examine the stability of the effects of Sex and LEAS Group on baseline HRV variables a MANOVA was performed on post-scan baseline HRV data for MEAN_RR_BASE2, STD_RR_BASE2, RMSSD_BASE2, PNN50_BASE2, LogLF_BASE2, LogHF_BASE2, REL_LF_BASE2, REL_HF_BASE2, and NORM_LFHF_BASE2. Between-subjects factors were Sex and LEAS Group. In congruence with the pre-scan analysis, post-scan data reflect higher HRV baseline levels and a lower resting heart rate in males as compared to females. This difference was reflected in the marginally significant multivariate effect of Sex, $F(9,32) = 1.972$, $p = .077$, $\eta^2_p = .357$, $(1-\beta) = .739$. Similar to previous findings, significant between-subjects effects of Sex were observed for MEAN_RR_BASE2, STD_RR_BASE2, RMSSD_BASE2, PNN50_BASE2, LogLF_BASE2, and LogHF_BASE2 (see Table 3.5), with males obtaining larger values than females.
Table 3.6 Skin conductance response descriptive statistics by Sex and LEAS Group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (N = 20)</th>
<th>Males (N = 19)</th>
<th>Low LEAS (N = 18)</th>
<th>High LEAS (N = 21)</th>
<th>Total (N = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>High Arousal Pleasant SCR</td>
<td>.118</td>
<td>.148</td>
<td>.140</td>
<td>.130</td>
<td>.108</td>
</tr>
<tr>
<td>Low Arousal Pleasant SCR</td>
<td>.040</td>
<td>.052</td>
<td>.043</td>
<td>.051</td>
<td>.034</td>
</tr>
<tr>
<td>High Arousal Unpleasant SCR</td>
<td>.139</td>
<td>.161</td>
<td>.161</td>
<td>.166</td>
<td>.111</td>
</tr>
<tr>
<td>Low Arousal Unpleasant SCR</td>
<td>.070</td>
<td>.112</td>
<td>.098</td>
<td>.090</td>
<td>.073</td>
</tr>
</tbody>
</table>

Skin conductance response (SCR)

3.4 Skin Conductance

To investigate effects of Sex and LEAS Group on skin conductance a repeated measures ANOVA was performed. Within-subjects factors included Valence and Arousal with LEAS Group and Sex as between-subjects factors. Increased SCR was observed in unpleasant as compared to pleasant Valence conditions, resulting in a significant multivariate effect of Valence F(1,35) = 4.608, p = .039, $\eta^2_p = .116$, (1-$\beta$) = .551 (see Figure 1). A significant multivariate effect of Arousal, F(1,35) = 20.822, p = .000, $\eta^2_p = .373$, (1-$\beta$) = .993 (see Figure 2), was also observed, with greater SCR observed in high as opposed to low Arousal conditions. No significant effects of Sex or LEAS Group were observed.
Table 3.7 EMG descriptive statistics by Sex.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>High Arousal Pleasant EMG – Zygomaticus</td>
<td>.005</td>
<td>.002</td>
<td>19</td>
<td>.003</td>
</tr>
<tr>
<td>Low Arousal Pleasant EMG - Zygomaticus</td>
<td>.006</td>
<td>.002</td>
<td>19</td>
<td>.005</td>
</tr>
<tr>
<td>High Arousal Unpleasant EMG - Corrugator</td>
<td>.032</td>
<td>.008</td>
<td>20</td>
<td>.008</td>
</tr>
<tr>
<td>Low Arousal Unpleasant EMG - Corrugator</td>
<td>.032</td>
<td>.008</td>
<td>20</td>
<td>.008</td>
</tr>
</tbody>
</table>

Electromyography response (EMG)

Table 3.8 EMG descriptive statistics by LEAS Group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low LEAS</th>
<th></th>
<th>High LEAS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>High Arousal Pleasant EMG - Zygomaticus</td>
<td>.003</td>
<td>.002</td>
<td>19</td>
<td>.005</td>
</tr>
<tr>
<td>Low Arousal Pleasant EMG - Zygomaticus</td>
<td>.005</td>
<td>.002</td>
<td>19</td>
<td>.006</td>
</tr>
<tr>
<td>High Arousal Unpleasant EMG - Corrugator</td>
<td>.015</td>
<td>.009</td>
<td>18</td>
<td>.024</td>
</tr>
<tr>
<td>Low Arousal Unpleasant EMG - Corrugator</td>
<td>.018</td>
<td>.009</td>
<td>18</td>
<td>.021</td>
</tr>
</tbody>
</table>

Electromyography response (EMG)

3.5 Electromyography

To examine effects of Sex and LEAS Group on EMG response a repeated measures ANOVA was employed for Zygomaticus Major and Corrugator Superficial data separately. Zygomaticus Major data were examined solely for Pleasant conditions and Corrugator Superficial data were examined solely for Unpleasant conditions as changes in activity for each muscle is predicted only for the respective Valence condition.

No multivariate or between-subject effects were observed for the Zygomaticus analysis. Analysis of Corrugator EMG response revealed higher levels of Corrugator
activity for females than for males in both high and low Arousal unpleasant conditions. This difference was reflected by a significant between-subjects Sex effect, $F(1,35) = 4.231, p = .047, \eta^2_p = .108 (1-\beta) = .516$ (see Figure 5).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (N = 19)</th>
<th>Males (N = 19)</th>
<th>Low LEAS (N = 18)</th>
<th>High LEAS (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasant</td>
<td>827.72</td>
<td>933.37</td>
<td>915.98</td>
<td>845.11</td>
</tr>
<tr>
<td>Unpleasant</td>
<td>852.29</td>
<td>968.60</td>
<td>947.18</td>
<td>873.71</td>
</tr>
<tr>
<td>High Arousal</td>
<td>843.63</td>
<td>946.99</td>
<td>935.23</td>
<td>855.39</td>
</tr>
<tr>
<td>Low Arousal</td>
<td>836.39</td>
<td>954.98</td>
<td>927.93</td>
<td>863.44</td>
</tr>
</tbody>
</table>

Mean Phasic IBI

Table 3.9 Phasic HR response descriptive statistics of Valence and Arousal conditions by Sex and LEAS Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (N = 19)</th>
<th>Males (N = 19)</th>
<th>Low LEAS (N = 18)</th>
<th>High LEAS (N = 20)</th>
<th>Total (N = 38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBI_1</td>
<td>847.60</td>
<td>952.67</td>
<td>933.45</td>
<td>866.82</td>
<td>900.13</td>
</tr>
<tr>
<td>IBI_2</td>
<td>839.55</td>
<td>955.31</td>
<td>935.71</td>
<td>859.15</td>
<td>897.43</td>
</tr>
<tr>
<td>IBI_3</td>
<td>838.84</td>
<td>952.93</td>
<td>933.98</td>
<td>857.78</td>
<td>895.88</td>
</tr>
<tr>
<td>IBI_4</td>
<td>839.23</td>
<td>950.53</td>
<td>931.38</td>
<td>858.38</td>
<td>894.88</td>
</tr>
<tr>
<td>IBI_5</td>
<td>839.79</td>
<td>950.65</td>
<td>930.70</td>
<td>859.73</td>
<td>895.22</td>
</tr>
<tr>
<td>IBI_6</td>
<td>835.06</td>
<td>943.82</td>
<td>924.26</td>
<td>854.62</td>
<td>889.44</td>
</tr>
</tbody>
</table>

Interbeat Interval Number (IBI#), Level of Emotional Awareness Scale (LEAS)

Table 3.10 Phasic HR response descriptive statistics of IBI by Sex and LEAS Group
3.6 Phasic Heart Rate Data

To examine differences in phasic IBI values by Sex and LEAS Group a repeated measures ANOVA was performed. Within-subjects factors were Valence, Arousal, and IBI. Between-subjects factors were LEAS Group and Sex. Males obtained a higher average IBI value than Females as reflected by a significant between-subjects effect of Sex, $F(1,34) = 8.631, p = .006, \eta^2_p = .202, (1-\beta) = .814$ (see Figure 6). A marginally significant between-subjects effect of LEAS Group, $F(1,34) = 3.650, p = .065, \eta^2_p = .097, (1-\beta) = .459$ (see Figure 7), was also found, with the High LEAS Group obtaining a shorter average IBI as compared the Low LEAS Group. The multivariate solution reflected a significant effect of Valence, $F(1,34) = 49.039, p = .000, \eta^2_p = .591, (1-\beta) = 1.00$, associating shorter average IBIs with pleasant conditions as compared to unpleasant conditions (see Figure 8).

Several significant interactions were observed in the multivariate solution of the repeated measures ANOVA, including a Valence x Arousal x Sex interaction, $F(1,34) = 6.703, p = .014, \eta^2_p = .165, (1-\beta) = .711$ (see Figure 9), a Valence x IBI interaction, $F(5,30) = 14.175, p = .033, \eta^2_p = .321, (1-\beta) = .762$ (see Figure 10), and a Valence x IBI x Sex x LEAS Group interaction, $F(1,34) = 3.093, p = .023, \eta^2_p = .340, (1-\beta) = .803$ (see Figures 11 & 12). A marginally significant interaction of Arousal x IBI x LEAS Group x Sex, $F(5,30) = 11.847, p = .063, \eta^2_p = .283, = .672$, (see Figure 13 & 14) was also observed.

To explore trends of these interactions orthogonal polynomial contrasts were employed. Cubic contrasts were used, as previous data has found tri-phasic IBI patterns in response to visual stimuli (Sokolov & Cacioppo, 1997; Graham & Clifton, 1966;
Sokolov, 1963). These contrasts were applied to the Valence x IBI x Sex x LEAS Group interaction to explore the IBI trends associated with the other factors. An effect of Sex was observed with a significant cubic trend of IBI found for males, $F(1,34) = 4.908$, $p = .033$, (see Figure 17), but not for females. Further analyses revealed an influence of LEAS Group on this effect, with a significant cubic trend of IBI observed for males in the Low LEAS Group, $F(1,34) = 6.367$, $p = .016$, (see Figure 17), but not for males in the High LEAS Group. This cubic trend for Low LEAS males was then compared by Valence. A marginally significant cubic trend of IBI was observed for Low LEAS Group males in unpleasant conditions, $F(1,34) = 3.694$, $p = .063$, (see Figure 17), but not in pleasant conditions.

Although a significant cubic trend of IBI was not observed for females in the Valence x IBI x Sex x LEAS Group interaction, contrasts were still used to explore potential trends relating to Valence and LEAS Group for females. Effects of Valence and LEAS Group were identified in females with a significant cubic trend of IBI found for High LEAS Group females during pleasant Valence conditions, $F(1,34) = 9.486$, $p = .004$, (see Figure 16).
CHAPTER 4
DISCUSSION

This study sought to explore the influence of emotional awareness level and sex on psychophysiological responding to emotional stimuli. It was found that 1) Levels of Emotional Awareness Scale (LEAS) Group did not show any significant associations with Skin Conductance Responses (SCR), Electromyography (EMG) responses, or baseline Heart Rate Variability (HRV) data. However, significant differences by Sex were observed in baseline HRV data and EMG responses. For phasic Heart Rate (HR) data, it was found that 2) LEAS Group had marginally significant predictive power for overall average phasic IBI values. It was also found that LEAS scores were associated with significantly different phasic IBI patterns and that this difference interacted with Valence and Sex.

Chosen stimuli produced expected effects of arousal in SCR data, but not in EMG data. As found in previous research using the International Affective Picture System (IAPS), low and high arousal images produced significantly different levels of psychophysiological responding in SCR data, with increased conductivity observed during high arousal conditions (Lang, Bradley, & Cuthbert, 1999; Lang et al., 1993; Bradley et al., 2001). While previous research has also found similar effects of arousal in electromyography (EMG) response, this difference was not detected for this sample (Cacioppo, Petty, Losch & Kim, 1986; Lang, Greenwald, Bradley & Hamm, 1993; Lang,
Bradley, & Cuthbert, 1998). It is possible that differentiation of arousal level between low and high conditions in this study was great enough to show this effect in SCR, but not in EMG data. A subtle, socially driven response, such as EMG, may require larger differentiation of arousal level to show significant response differences than is required for differences to be observed in the rapid, global changes in sympathetic activity measured by SCR.

Effects of Sex and LEAS Group were different for each psychophysiological measure. Baseline HRV data revealed effects of Sex, but no effects of LEAS Group. Cardiac activity data obtained before experiment participation revealed lower resting heart rates and increased heart rate variability (HRV) in males. To assess stability of these trends, HRV recordings were also taken after image viewing. Males again demonstrated slower average heart rates and increased HRV as compared to females. Low resting heart rate and increased HRV are indicative of efficient and effective use of biological resources.

Phasic HR response data revealed significant effects of both Sex and LEAS Group. Males obtained significantly longer average phasic IBI values as compared to females, reflecting a slower average heart rate. A marginally significant effect of LEAS Group was also observed in the phasic HR response data. Low LEAS Group individuals obtained longer average IBIs, resulting in a slower heart rate, in comparison to participants in the High LEAS Group. While a slower resting heart rate requires less energy to maintain and is considered to be adaptive when an organism is at baseline, slower heart rates may not be beneficial when responding to emotionally inducing stimuli. A faster heart rate helps to quickly deliver resources to the body that may be
necessary when reacting to changes in the environment (Lang, 1987). Faster HRs found in females and High LEAS Group participants suggest that these individuals may be better prepared physiologically to respond to environmental demands.

A main effect of Valence was also observed in the phasic HR response data, with shorter average IBIs observed in pleasant conditions as compared to unpleasant conditions. While an increased HR may seem unnecessary for pleasant situations, it is important to point out that avoiding threat is not the only environmental response important to our survival. Expending energy towards attainment of desired goals is equally necessary for survival. Pursuit of food, attracting a mate, and even the preparation for, and act of sex are all examples of pleasant environmental conditions that require more energy than necessary at baseline. With this in mind, conditions of both pleasant and unpleasant valence levels could result in appropriate increases in HR, and these changes would be expected to vary as a function of arousal level, rather than valence (Cook et al., 1991; Fiorito & Simmons, 1994; von Oyen, Witvliet, & Vrana, 1995). The difference in IBI by Valence observed in this study may actually reflect a difference in arousal level, with pleasant images attaining higher overall arousal levels than unpleasant images. Simultaneous influence of Valence, Sex, and LEAS group resulted in several significant interactions in the multivariate solution, including the Valence x Arousal x Sex interaction, the Valence x IBI interaction, and the Valence x IBI x Sex x LEAS Group interaction.

To investigate trends of the different factors in these interactions, orthogonal polynomial contrasts were applied to the highest order interaction reaching significance: Valence x IBI x Sex x LEAS Group. To examine patterns of each level of every factor,
weights of the contrast factors were systematically varied in successive trend analyses. As previous research has reported triphasic IBI patterns in response to emotional stimuli, cubic contrasts were applied for the trend analyses (Sokolov & Cacioppo, 1997; Graham & Clifton, 1966; Sokolov, 1963). A significant cubic trend of IBI was observed for Low LEAS Group males during unpleasant conditions and for High LEAS Group females during pleasant conditions. Graphs of phasic IBI by Valence by LEAS Group by Sex (Figures 16 & 17) were inspected to assess directions of the different trends. A triphasic response pattern, comprised of an initial deceleration, followed by acceleration and a second deceleration was observed in Low LEAS Group males during the unpleasant conditions. This is the typical response pattern observed for positive and neutral images, and not typically found for unpleasant images (Sokolov & Cacioppo, 1997; Graham & Clifton, 1966; Sokolov, 1963). Unpleasant stimuli are usually associated with an initial deceleration that continues until the end of image presentation (Bradley et al., 2001). During pleasant conditions the Low Leas Group males show a slight overall acceleration in HR, which is also unexpected, as pleasant images are expected to produce the typical triphasic waveform. High LEAS Group male counterparts show relatively flat response patterns in both pleasant and unpleasant conditions.

High LEAS Group females demonstrated a significant cubic trend of IBI during pleasant conditions, but this trend does not follow the typically expected directions. Inspection of the graph (Figure 16) of this effect reveals a fairly strong initial acceleration, followed by a slight deceleration and a slight second acceleration. This is in exact contrast to the expected pattern, which is comprised of an initial deceleration, followed by an acceleration and a second deceleration (Sokolov & Cacioppo, 1997;
Graham & Clifton, 1966; Sokolov, 1963). High LEAS Group females also show a slight initial acceleration during unpleasant conditions, but the pattern is relatively flat overall. Low LEAS Group females show a slight initial deceleration, no changes in the middle of the response, and end with a moderate acceleration. During pleasant conditions High LEAS Group females show a slight acceleration followed by a relatively flat response pattern. LEAS Group appears to modulate phasic HR response, but the effect is not consistent across Sex or Valence. Expected response patterns were not observed in any condition, with the majority of response patterns showing relatively flat responses. It appears that during the majority of conditions participants did not find the stimuli arousing enough to elicit a response at the cardiac level. However, conditions that did elicit a change in phasic HR response patterns did so in an unexpected manner. Reason for these unexpected patterns is unclear.

SCR and EMG data did not reflect any significant influence from LEAS Group. Sex effects were only observed in EMG data. Females showed higher levels of Corrugator Supercilli activity as compared to males during unpleasant conditions. No differences by sex were observed for Zygomaticus Major data. These results reflect an increased sensitivity to unpleasant stimuli in women. SCR and EMG measures of psychophysiological activity are less differentiated than those obtained using ECG, making it even more difficult to detect potential effects of LEAS Group. Complexity of the cardiovascular psychophysiological system may help to power the effect, explaining why effects of LEAS Group can be detected by ECG and not by SCR or EMG. Additionally, increasing the size of the sample would also increase chances of observing these effects. A total sample size of 44 is fairly small for a psychophysiological study and
may not provide enough power for effects to reach significance. It is likely that observed influences of Sex and LEAS Group would increase for all of the psychophysiological measures if additional subjects were added to the study.

It is also possible that images used in this study were not arousing enough to elicit effects of Sex and LEAS Group for all psychophysiological measures in every condition. Significant effects of Sex and LEAS Group observed in cardiovascular data suggest that these factors play some sort of role in physiological responding to emotional stimuli. Further studies, using more highly arousing pictures and larger sample sizes, may help to illuminate the effects observed in phasic HR data and may reveal further effects of Sex and LEAS Group in SCR and EMG data as well.
REFERENCES


APPENDIX A

FIGURES
Figure 1. Mean Skin Conductance Response by Valence.

Note: Error bars represent +/- 1 standard error.
Figure 2. Mean Skin Conductance Response by Arousal.

Note: Error bars represent +/- 1 standard error.
Figure 3. Mean Skin Conductance Response values of the LEAS Group x Sex x Valence x Arousal interaction for Low LEAS Group Subjects.
Figure 4. Mean Skin Conductance Response values of the LEAS Group x Sex x Valence x Arousal interaction for High LEAS Group Subjects.
Figure 5. Mean Corrugator electromyography response by Sex.

Note: Error bars represent +/- 1 standard error.
Figure 6. Mean IBI values of the phasic HR response by Sex.

Note: Error bars represent +/- 1 standard error.
Figure 7. Mean IBI values of the phasic HR response by LEAS Group.

Note: Error bars represent +/- 1 standard error.
Figure 8. Mean IBI values of the phasic HR response by Valence.

Note: Error bars represent +/- 1 standard error.
Figure 9. Mean IBI values of the phasic HR response of each condition by Sex.

Note: Error bars represent +/- 1 standard error.
Figure 10. Mean IBI values of the phasic HR response by Valence.
Figure 11. Mean phasic IBI values of the LEAS Group x Sex x Valence x IBI interaction for Low LEAS Group subjects.
Figure 12. Mean phasic IBI values of the LEAS Group x Sex x Valence x IBI interaction for High LEAS Group subjects.
Figure 13. Mean phasic IBI values of the LEAS Group x Sex x Arousal x IBI interaction for Low LEAS Group subjects.
Figure 14. Mean phasic IBI values of the LEAS Group x Sex x Arousal x IBI interaction for High LEAS Group subjects.
Figure 15. Mean phasic IBI values by Valence and Arousal.
VALENCE*IBI*SEX*LEAS Score Group - Females

Figure 16. Mean phasic IBI values by Valence and LEAS Group for Females only.
Figure 17. Mean phasic IBI values by Valence and LEAS Group for Males only.
Figure 18. Mean phasic IBI values by Valence and Arousal.