# The Sentic Mouse: Developing a tool for Measuring Emotional Valence

by

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## Abstract

This paper provides a discussion of the results from three experimental studies on emotion, and presents a new experiment inspired by them, that is a first step toward designing a tool to measure a subject's valenced response. Peter J. Lang and others showed subjects a series of pictures and asked them to self-rate their emotional response. Ward Winton, Lois Putnam, and Robert Krauss measured heart rate and skin conductance while subjects viewed emotionally evocative stimuli. Dr. Manfred Clynes conducted a series of sentic experiments, gathering data from the vertical and horizontal components of finger pressure. Each of these experiments attempted to quantify emotions and map them into a predictive model of emotion theory. Under the auspices of affective computing, these three models are applied to the interaction between humans and computers. Using a computer to provide the affective stimulus to the human subject, an experiment is conducted which combines all three emotion studies. An ordinary computer mouse was augmented with a sensor to collect sentic data as in Dr. Clynes experiments. Subjects were hooked up to various other bio sensors as in the Winton, Putnam, and Krauss tests and viewed the affective picture database from Lang's work. The three measured results: sentic data, heart rate, and self-assessment, are then readily compared against each other as well as the theory predicted results and the valence for each slide. The results show that a strong correlation between the self-reported valence assessment of our subjects and the results from Lang's numerous experiments exists. The data collected from the sentic mouse also significantly correlated to the self-reported information. Valence information can be captured by the sentic mouse.

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# Chapter 1

# Introduction

A new technique for measuring the valence of a stimulus was designed and tested. After examining the work of five prominent emotion researchers, Peter Lang, Ward Winton, Lois Putnam, Robert Krauss, and Dr. Manfred Clynes, a new experimental apparatus was built to quantify the valence of a stimulus. Dr. Clynes suggests that valence can be extracted from sentic data, while Winton, Putnam, and Krauss have found valence information in the acceleration of HR. An experiment was designed and conducted which combined these two valence assessment techniques utilizing a new sentic detector, the sentic mouse. The rest of this chapter describes the motivation behind building the sentic mouse.

Chapter two presents the three relevant research experiments, by Lang, Winton, Putnam, Krauss, and Dr. Clynes.

Chapter three details the design of the experiment, its results, and implications. It concludes with some discussion remarks and suggestions for future work.

## 1.1 Motivation for the Sentic Mouse Experiment

Our instincts have taught us rules for and responses to emotional cues from other humans. This often unconscious form of communication has not made the leap into our technology. This results in a problem when people express emotions to a computer that cannot recognize the emotions. The proposed solution is a device that can begin to record some of these signals in a natural way (Picard, 1995).

Computers currently lack emotional intelligence, especially awareness of others emotions. There is evidence (Reeves and Nass, 1996) that despite this fact, humans interact with their computer as if it was capable of understanding and responding to emotion signals. Threatening, pounding on, coaxing, patting on the monitor, these are behaviors exhibited by computer users to express to their machine something of the user's emotional state. This is a natural form of communication that is wasted on the computer because it can not detect or interpret this input. The more frustrated the user becomes with the equipment, the more frustrating it becomes that the computer is not receiving this drastic form of expression. Because the computer can not detect or use the expression information, it can not take action to try to rectify the current state of tension.

One step in enabling computers to recognize the emotional cues from the user is to study and understand how the autonomic system behaves for various emotional situations. The specific autonomic response signals being recorded are chosen for the availability of non invasive bio sensors that can be used in conjunction with a wearable computer for real time portable signal acquisition (Thad Starner, et al., 1997). Such measurements as blood volume (BVP), heart rate (EKG), galvanic skin conductance (SC), and respiratory rate are commonly used in emotion research experiments. For these particular signals characteristic patterns have been found which correlate with different self reported emotional states. The most widely accepted axes for the categorization of emotions are valence, the discrimination between positive and negative experiences, and arousal, the intensity with which the emotion is experienced. These two axes have been widely accepted in many diverse theories and research studies.[1]

### 1.1.1 Valence Extraction

The three studies explored here are different attempts to quantify emotions. Peter Lang explored the use of slides to induce emotions in subjects. He then assigned va-

[1]The labeling and categorization of emotions is a complex set of research that I will not get into here. For a discussion of several emotion models see (Velasquez, 1996).

lence and arousal coordinates to each picture and mapped them in a two-dimensional space. Ward Winton, Lois Putnam, and Robert Krauss added heart rate sensors (HR) and galvanic skin conduction detectors (SC) to subjects viewing similarly evocative slides. Winton, Putnam, and Krauss correlated their slides' pleasantness against the measured HR and SC of the subject. Dr. Manfred Clynes asked his subjects to remember and re-live past emotional experiences while collecting sentic data from his subjects.

Combining the tests of all five of these researchers will provide a new technique for measuring the valence of the stimulus. The work of Dr. Clynes illustrates that valence can readily be extracted from sentic data, and the work of Winton, Putnam, and Krauss demonstrates that valence information exists in the acceleration of HR. To verify this an ordinary computer mouse button was augmented with a force resistor to detect the dynamic finger pressure of the user. The user, wearing EKG, HR, SC, and BVP sensors, used this mouse while viewing the affective database from Lang's experiments. With the measured heart rate and sentic data, the validity of a predictive correlation between these signals and the valence of the stimulus will be assessed.

# Chapter 2

# Background

A discussion of the relevant experiments and their results from five prominent emotion researchers follows.

## 2.1 The International Affective Picture System

Peter J. Lang conducted a series of experiments (P. Lang, 1988) using a database of photographs (IAPS) as the emotional stimulus. Slides of diverse content were collected into this study, 480 in all. The content ranged from sexually explicit material, to human injury and surgical slides, to pleasant images of children and wildlife.

For each slide a measure of valence and arousal was assessed and plotted in a two-dimensional space. The quantification of valence and arousal was conducted by subjects using a Self-assessment Manikin (SAM) (Lang and Bradley, 1994). Each subject was asked to view the slide and mark down on paper their assessment of the valence and arousal. The mean response was plotted on the two axes, see figure 2-1. Over hundreds of subjects, this technique yielded a high correlation between subjects and a low standard of deviation.

After mapping out the valence-arousal space, Lang assigned emotionally descriptive labels, based on the content of the pictures, to several key areas of the space. The first quadrant contains the positive valence, high arousal stimuli that he called "joyful" or "excited". The second quadrant (low valence high arousal) included areas

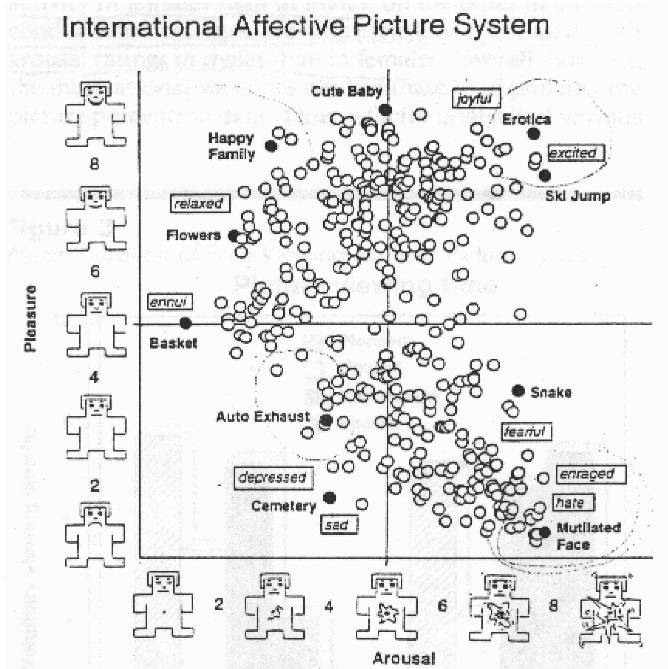


Figure 2-1: Lang used pictorial images to represent the axis of valence and arousal to compensate for language connotation confusion or misunderstanding.

of “hate”, “enraged”, and “fearful”.

This experiment has been verified numerous times. Three researchers in particular, Ward Winton, Lois Putnam and Robert Krauss, conducted a similar slide viewing self-assessment experiment (Ward Winton, Lois Putnam, and Robert Krauss, 1984) using sensors to monitor heart rate (HR) and skin conductance (SC). The introduction of these sensors provided a method for ascertaining the relationship between autonomic responses and the slide induced emotional experiences.

## 2.2 The Physiological Response of Affect

By examining the correlation between autonomic signals and self reported pleasantness, Winton, Putnam, and Krauss set out to discover the relationship of valence to the physiological responses of HR and SC. They selected five categories of emotionally evocative photographs to use as stimuli – Scenic, Erotic, Food, Unusual, and Morbid.

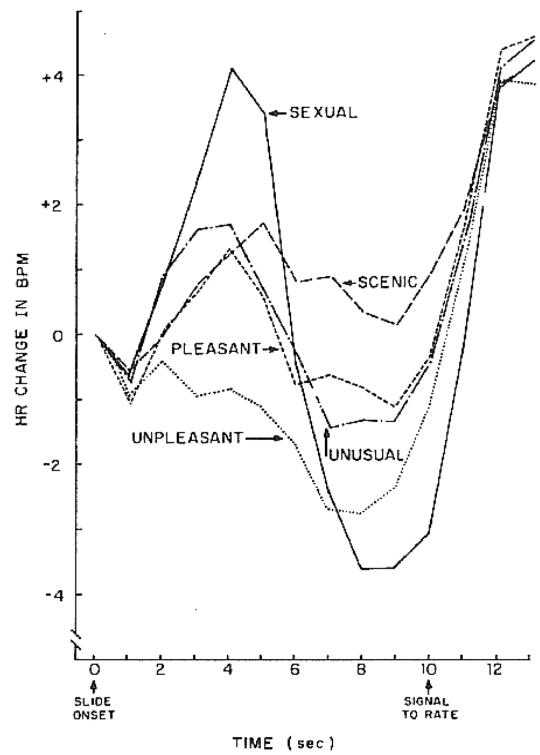


Figure 2-2: Second-by second changes in HR as a function of slide category.

Subjects viewed the slide and rated it; all the while their HR and SC were being recorded. The results from the Lang experiment validated the self reported responses Winton, Putnam, and Krauss collected.

By comparing the measured signals to the Lang category and self-reported ratings, Winton, Putnam and Krauss discovered that valence predicted HR response. The unpleasant categories were characterized by a significantly lower HR (in beats per minute) than other categories. The pleasant slides were succeeded by a marked increase in HR beats per minute, see figures 2-2 and 2-3.

From this experiment it was clear that by monitoring the HR of a subject viewing a slide, an observer could determine the valence of the stimulus. This is especially interesting since valence may differ from subject to subject for the same stimulus, yet the HR monitor could differentiate between a subject who was enjoying the experience and one who may have been thinking of something else or simply not liked the slide.

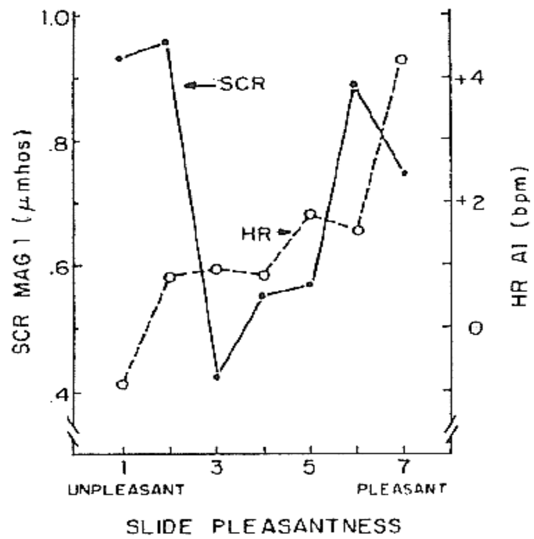


Figure 2-3: HR change at post-slide 4 sec as a function of self-reported slide pleasantness.

There are many applications where assessment of an individual's valence might be useful, the most obvious being to supply the computer with this information so it can learn how to adapt its responses to better serve the user.

Putnam and Krauss also discovered the existence of a discrepancy between the physiological responses of men and women (Putnam and Krauss, 1991). Where women have in general faster HR signals, men show a stronger SC response. This discrepancy has been verified in many subsequent experiments. The results of Dr. Manfred Clynes sentics experiments, using a different approach for monitoring and assessing subject's valence response, found characteristic signal patterns that did not differ between the sexes.

## 2.3 The Sentic Experiment

The sentics research published in Dr. Clynes' book Sentics (Clynes, 1986) has revealed, among other things, a correlation between emotional valence and the dynamic finger pressure of a subject pushing a button. His research has focused on identifying emotions based on the characteristic signal pattern of finger pressure. To this end, Dr. Clynes has traveled the globe testing subjects on his sentograph and found that there are distinct patterns that arise for similar emotions across all subjects. The specific emotions Dr. Clynes had his subjects elicit and their characteristic signals correlated strongly, see figure 2-4.

His experiments had right-handed subjects sit in a prescribed manner (to eliminate non-essential movement) with their finger on the sentograph. At the tone the subject, imagining, fantasizing, or remembering themselves in a pre-specified state, tried to express the emotion by pushing on the sentograph button. The specific emotions Dr. Clynes studied included – Anger, Hate, Grief, Love, Sex, Joy, and Reverence.[1] Although he found that many cultures did not have the words for all these emotions, the specific emotions he wanted to elicit were very familiar to the subjects.

Dr. Clynes' experiments support the hypothesis that it is an innate unconscious human tendency to pull positive stimuli towards the self, and to push negative stimuli away. He found that emotions like love and joy were accompanied by less dramatic horizontal deflection than anger and hate. By measuring the pressure of the finger in the horizontal plane, towards verses away from the subject, valence information can be extracted.

[1] see Appendix B: Emotion definitions

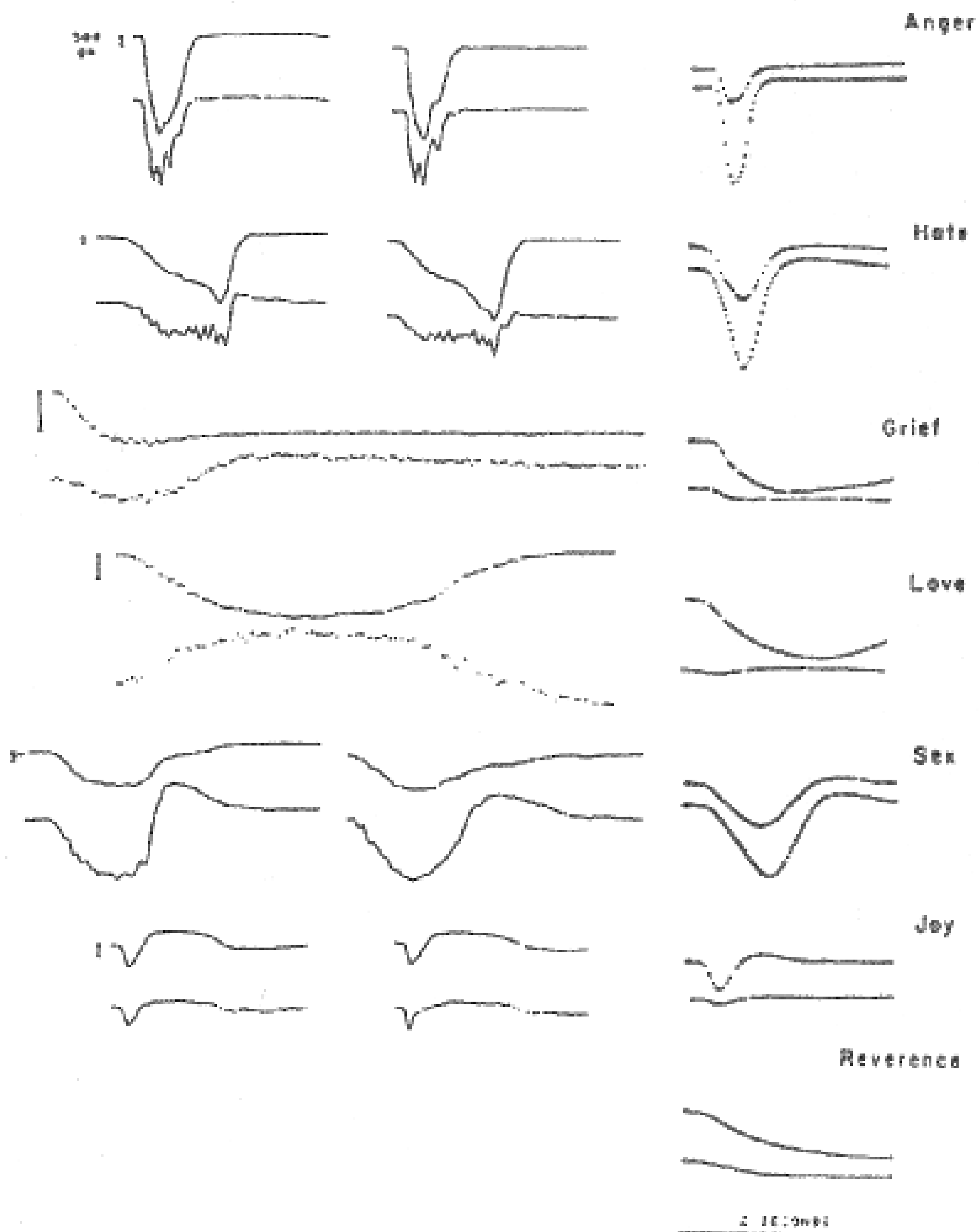


Figure 2-4: The top line reflects vertical pressure and the bottom trace is horizontal deflection.

# Chapter 3

# The Sentic Mouse Experiment

Dr. Clynes found a correlation between horizontal pressure deflection and valence. Winton, Putnam, and Krauss discovered a relationship between HR and valence. This new experiment tries to discover the relationship between a new sentic sensor and valence, using HR and the IAPS database as corroborating qualifiers against a self-reported assessment.

Dr. Clynes prescribes an exact positioning of the subject's body with respect to the sentograph to minimize the noise of the signal and maximize repeatability. It is hypothesized that humans naturally and unconsciously express their like or dislike through many pathways including HR, SC and sentic touch. Therefore these stringent lab conditions may not be strictly necessary. However, the conservation of right handed mouse use is still necessary both because of the nature of sentic data and the hardware used for its collection.

This is essentially a sentics experiment conducted in a more natural setting. A sentograph detector embedded in the mouse button allows detection of sentic tendencies during the presentation of emotionally affective slides. While inducing an emotional reaction through the subject's exposure to the IAPS database slides, the sentic data from the subject is monitored and compared against the self-reported data.

## 3.1 Method

Thirteen subjects were shown a sequence of emotion eliciting pictures while hooked up to EKG, BVP, and a SC sensor. Each subject was instructed to look at the image for what they estimated to be twenty seconds before clicking on the button marked "Next" using the sentic mouse. After the presentation of the stimulus slide, the subject rated their emotional experience with that slide, by manipulating slider bars corresponding to valence and arousal.

### 3.1.1 Subjects

Fourteen fellow classmates of the Affective Computing Seminar volunteered to participate in our study. Along with other random student volunteers working at the MIT Media lab over the weekend, all subjects willingly took part in the experiment. They were all students at MIT and ranged from ∼20-40 years in age. Only the last three, two women and one man, produced sentic signals that could be analyzed due to the failure of the experimenter to record a timing marker. Of the fourteen subjects, three trials had to be eliminated because of software failure, and one experiment was interrupted.

### 3.1.2 Stimuli

Of the 480 pictures currently in the International Affective Picture System (IAPS) only twenty-three were selected as representative of the extremes of Lang's four emotional quadrants. Seven more were chosen as neutral stimuli to pad the experiment and to provide contrast to these extremes. Two different collections of pictures were compiled, one for men and another for women.[1] Although a great deal of overlap exists, subject material was chosen for equal opportunity as well as emotional index. Many photos of nude women ranked highly in the men's subset. Therefore, despite their low index, photos of nude males were included in the women's collection.

[1] See Appendix A: IAPS data


Figure 3-1: The sentic mouse uses a force sensor on the index button to measure the dynamic finger pressure of a user.

### 3.1.3 Apparatus

A four quadrant Multipath ™ force resistor was embedded into the button of a Logictech mouse, see figure 3-1. The resistance of the front sensor can be compared to that of the back one to yield the force and direction information found in a sentograph. This signal and the data from the other bio sensors were collected on a Toshiba Satellite ™ laptop computer, using a Thought Technology Ltd. FlexComp signal sampler and software. The force sensor was connected to the FlexComp with two Thought Technology GSR sensors. The numerical computation package MATLAB ™ was used for graphing, and the SPSS 7.5 for Windows ™ for the statistical data analysis.

Affective images were displayed on a 700 series HP machine with a 24 inch monitor running TCL. The TCL script[2] provided a GUI interface for the user to manipulate. With each photo, the largest being 1024 x 768 pixels, there was a button for the user to click marked "Next". After viewing the picture, the user was presented with two

[2]See Appendix B: TCL Code

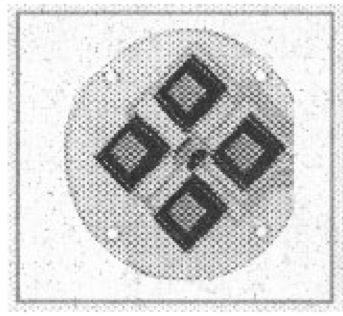

Figure 3-2: The sensor is a four quadrant force resistor.

slider widgets labeled – "Did you like this picture?" to measure valence, and "How intensely did you feel like/dislike?" to measure arousal. The sliders were scaled from $-3$ to $+3$ for valence, and 0 through 6 for intensity. The manipulation of these sliders by the subject formed the basis for our self-reported reports.

**The Sentic Mouse**

An off the shelf Logictech three button mouse, with a serial connector, was selected as the sentic mouse because of its ease of disassembly. Removing the three screws on the underside, the shell separated easily from the logic board. The force resistor, see figure 3-2 was affixed to the index button with silicon sealant, and the MediaPoint ™ rubber joystick affixed on top of the sensor using the same sealant. Due to the fragility of the plastic sensor, silicon sealant was chosen over many other forms of adhesion including solder, tape, and many kinds of glue. An eight strand ISDN phone cord was soldered to the sensor connector, and secured inside the shell of the mouse. For this experiment only the front and the back quadrants of the resistor are monitored to provide horizontal and vertical data signals. However, the prototype was built to permit future use of all four quadrants in the event that the recording of the side to side motion becomes desirable.

### 3.1.4 Design

The valence self-reported data was collected following each slide presentation. The subject manipulation of the sliders was compared against the HR signals and sentic information to determine if a valid relationship existed. The pictures, and their order of presentation that was randomized for valence and intensity content, had a distinct set for men and another for women. This differentiation was necessary because of the erotic content in the first quadrant for male subjects. Each subject was given the opportunity to view both collections of pictures if they so chose.

Subjects were pre-screened for right handedness and allowed to experience the IAPS slides in privacy. We used a dark office with the door shut and the blinds down. Ideally, the experimenter should not be in the room with the subject, so they are free to express themselves in private. Unfortunately, our data collection required the experimenter to be in the room to click a button every time the picture stimulus came up. This was needed as a timing reference for the bio sensor signals. However, the experimenter sat behind the subject facing a computer screen that displayed the subject's bio signal in real time. The subjects were informed that the experimenter was not looking at them, but was there for timing purposes only. Subjects were strongly urged to respond fully to each slide, and not to repress their signals because of the presence of the experimenter.

### 3.1.5 Procedures

Subjects were fully informed at the outset of the experiment of the nature of the trials about to occur. They were given three EKG electrodes and the experimenter described their proper placement. The subject was instructed to take a diagram with them into the bathroom to put the electrodes on in private. Upon their return, the experimenter assisted the subject in properly putting on the GSR (the electrodes were attached to the distal phalanges of the index and middle fingers of the left hand) and BVP (secured to the ring finger of the left hand) sensor. After verifying that the signals being received were good, the experimenter started the program that presented a screen of consent to the subject. The screen of consent informed the subject that if they did not want their data used in the experiment they could retract it at any time, or abort the session if they so desired. All subjects freely consented.[3]

All questions regarding the experiment, the sensors, or the instructions were answered before beginning the test. The experimenter reminded the subject again to remain still and not vocalize for the duration of the experiment, and to press the mouse firmly after each slide. They were informed of the 3 second blank screen delay before the appearance of each slide and instructed to relax and let their signals return to their baseline during this pause. Subjects were also reminded to allow themselves to feel the power of each emotional response before proceeding to the next slide.[4]

Three seconds of blank screen followed the slider question page, and preceded the next stimulus. This was required to allow the time dependent body responses, namely HR and SC, to re-stabilize between slides. Additionally, only the first ten seconds of the signals for each slide was used in the HR and SC analysis, because the signal response dampened as the subject became de-sensitized to the stimulus.

The measured sentic data for each subject was compared against the collected self-reported data. In future work it should also be compared against theoretical IAPS results for each slide stimulus and against measured and theoretical HR acceleration. Comparing, sentic data against the Lang database would provide a method to corroborate the subject's self-reported measure of valence.

The null hypothesis, that there exists no relation between sentic data and valence, can be rejected if there exists a correlation.

## 3.2 Results

Allowing the subject in this experiment more freedom than Dr. Clynes permitted will both introduce significant noise into the data and simulate more realistic conditions for the natural expression of emotions. The use of a mouse rather than a formal

[3]see Appendix C: Instructions

[4]In future work, the above reminders should be turned into a checklist for the experimenter to follow for every trial.

sentograph offers an interesting mix of strongly adhering to and vastly straying from the guidelines set forth by Dr. Clynes in his experiments (see Sentics Chapter 4). Constraints such as arm and finger position as well as handedness are maintained while others like back posture and rigidity of body movement are sacrificed. Additionally, since the goal of the experiment is simply to extract positive versus negative reactions, and not to try to replicate the emotion patterns discovered by Dr. Clynes, the training period will be eliminated in favor of an untrained naturally occurring expression of emotion.

The self-reported data collected and the SAM data collected through the IAPS project are the benchmarks against which the sentic data were processed. If the sensor data correlates with valence than success has been achieved, we can reject the null hypothesis. In our setup we found that our subject's responses had highly significant correlation to those in the Lang study.[5] The female data demonstrated a Pearson correlation of 0.885 ($p<.001$) to the Lang results, and the men's 0.757 ($p<.001$). This significance supports the validity of our experimental setup.

By taking the difference of the front sensor signal from the back a measure of valence is derived. It is this difference that holds the sentic information. A person reacting to a negative valence stimulus, pushing away on the sensor, showed a positive bump in this new signal. Similarly, positive valence resulted in a dip in the new signal, as predicted by Dr. Clynes. The sentic data collected correlated significantly within as well as between subjects.[6] It is noteworthy to mention that simply taking the sum of the data streams would yield intensity information.

The results from the Winton, Putnam, and Krauss experiment concerning the relation between HR and valence were not verified here, both because we did not have access to the exact EKG sensor positioning used in that experiment, and because we could not replicate the signal processing Winton, Putnam, and Krauss conducted. We did not get a chance to compare our data collected by the HR monitor against either the self-reported data or the sentic detector, due to technical and time constraints.

[5]see Appendix D: Self-Reported Results

[6]see Appendix E: Subjects Sentic Data

This is left open as an avenue for future work.[7]

## 3.3 Error Analysis

*Hardware* One source of error came from the fact that we were measuring the conductance of the force resistor. The FlexComp sampler used to collect the signal did not have a setting for potential. The signals acquired are therefore the inverse of what a resistance signal would look like. The use of a voltage isolator as an interface between the FlexComp and the resistor sensor, might provide a cleaner signal.

The FlexComp software was programmed to sample the EKG at 1000Hz and the sentic mouse at 31Hz but we discovered upon analysis that it was actually sampling everything at 31Hz.

The construction of the sentic mouse was plagued with technical problems. The result is bulky, odd-looking, and uncomfortable. Subjects often asked how to work the mouse before the trials began. Although the experimenter instructed them to use it as a natural mouse, clearly they were aware of the presence of the sensor and that effected the way they used the mouse. Future work to make this device more robust and to hide the sensor within the button on the mouse would benefit the collected data greatly.

*Design* After briefly reviewing the data collected from the first ten subjects, it was decided that a signal marker was needed for the sentic signal. The lack of a timing apparatus and the freedom of the user to move the mouse made the sentic click impossible to find in most trials. For the future, either an auditory tone as is used in Dr. Clynes work, or better yet the embedding of a switch in the button of the sentic mouse should be implemented. The switch will close a circuit sending an accurate timing impulse to the FlexComp. At the time of data analysis, this impulse signal can be used to extract the relevant mouse activity and sentic patterns.

The same random order of slides was presented to each subject. This was due to

[7]The HR and SC experiments are being conducted by Jennifer Healey and the data analysis correlating these signals with the sentic data has not yet begun.

time restrictions. In future incarnations of this experiment, the order of slides should be shuffled for each subject to compensate for priming effects. For example in our study, the picture of the sky happened to fall after an especially gruesome face. The overall ranking of the sky was inflated due to the negative priming of the mutilation slide.

The slider bars used in the experiment always reset to zero. Thus if the subject failed to respond, they would tend to leave the measure at the zero mark. The impact of this is a dampening of the self-reported data as compared to the Lang database. Another contributor to the dampening effect is that the Lang pictorial scale is a nine-point scale, whereas the slider bars only measured seven points.

## 3.4 Discussion

In the field of emotion detection and interpretation, determining the valence of the stimulus has proven one of the most difficult obstacles to overcome. Measuring intensity is easier than valence. Although humans are good at recognizing valence in the facial expression of others (Ward Winton, Lois Putnam, and Robert Krauss, 1984), cameras and computer vision are not yet capable of this extrapolation. The trend towards portable computing also currently inhibits the use of vision recognition, as vision systems are generally bulky, heavy, fragile, and it is hard to wear a camera that looks at your face.

The external method of emotion stimulus employed by the IAPS database over an internally generated emotion routine, as employed by Dr. Clynes, helps us explore naturally occurring emotions. The use of a computer as the source of the stimulus allows us to observe the kinds of emotions that can be induced by a computer in ordinary situations. This natural setting where the computer provokes the user does not provide an exhaustive set of all the variants on emotions capable in a human computer interaction. The draw back to using slides is that low level arousal images are difficult to manufacture. There is a significant deficit in the IAPS database in these categories. One possible reason for this is the goal of advertising to produce a high arousal response in the viewer has caused a flood of high arousal pictures.

Language and labeling are big obstacles for emotion research. Peter Lang avoided language barriers by using pictorial cues. Dr. Manfred Clynes described in explicit detail exactly what he wanted the subject to feel for each emotion label. Many subjects in this experiment remarked after the fact that they had difficulty deciding if they "liked" or "disliked" some stimuli. They also talked about their inner struggle extracting what they really felt from what they thought they were supposed to feel. In the next incarnation of this experiment, the pictorial representations from Lang's work should be used rather than the verbal labeling of the slider bars.

The internal sense of time that each subject experiences will presumably change for the different stimuli. The relationship between duration and valence, is not studied here, but is an avenue for future exploration.

It has been shown in this pilot study, that valence information can be captured by a pressure sensitive mouse. Future research will produce a reliable, non-invasive, method for detecting the valence of a stimulus. Building an agent to monitor and interpret these signals in real-time could yield a valence aware program. Such a pattern recognition program would enable computers to be more responsive to the user's likes and dislikes. Finally, by adding intensity information to this agent, by means of further data manipulation, it can map the valence arousal space and learn how to respond to a variety of emotional states.

# Appendix A

# IAPS data for women and men

Table A.1: The IAPS data: **Female Subjects**

| Slide | No. | Valence Mean | Valence (SD) | Arousal Mean | Arousal (SD) |
|---|---|---|---|---|---|
| High Valence(>7.00)/High Arousal(>6.50) | | | | | |
| Ski Jump | 8030 | 7.35 | (1.86) | 7.38 | (1.91) |
| Sky-divers | 5621 | 7.80 | (1.54) | 7.00 | (2.13) |
| Sailing | 8080 | 7.73 | (1.43) | 6.25 | (2.34) |
| Skier | 8034 | 7.19 | (1.63) | 6.38 | (2.10) |
| Male Nude | 4510 | 7.00 | (2.28) | 6.05 | (2.26) |
| Cash | 8501 | 7.67 | (1.97) | 6.02 | (2.50) |
| bogus: | | | | | |
| Male Nude | 4490 | 6.27 | (1.95) | 6.06 | (1.71) |
| Couple | 4659 | 6.15 | (2.01) | 6.47 | (2.18) |
| food: | | | | | |
| ChocoDrink | 7270 | 7.77 | (1.68) | 5.85 | (2.11) |
| Ice cream | 7330 | 7.96 | (1.49) | 5.54 | (2.53) |
| Brownie | 7200 | 7.77 | (1.71) | 4.85 | (2.55) |
| Low Valence(<1.50)/High Arousal(>7.50) | | | | | |
| Mangled face | 3080 | 1.33 | (0.75) | 7.61 | (1.81) |
| Baby tumor | 3170 | 1.20 | (0.57) | 7.55 | (1.98) |
| Soldier | 9410 | 1.20 | (0.58) | 7.54 | (1.78) |
| Burn victim | 3053 | 1.15 | (0.73) | 7.51 | (2.29) |
| Knife | 6350 | 1.44 | (0.95) | 7.52 | (1.99) |
| Mangled face | 3060 | 1.66 | (1.71) | 7.34 | (2.10) |
| bogus: | | | | | |
| Child | 9040 | 1.50 | (0.97) | 6.44 | (2.00) |
| High Valence(>7.00)/Low Arousal(<3.25) | | | | | |
| flowers | 5200 | 7.69 | (1.37) | 2.98 | (2.22) |
| Flower | 5000 | 7.59 | (1.63) | 2.90 | (1.92) |
| Tuxedos | 2370 | 7.43 | (1.49) | 2.93 | (2.20) |
| Flower | 5030 | 7.18 | (1.56) | 3.08 | (2.24) |
| Clouds | 5891 | 7.58 | (1.54) | 3.14 | (2.60) |
| Flower | 5010 | 7.55 | (1.39) | 3.24 | (2.43) |
| Sprgbok | 1620 | 7.95 | (1.19) | 3.49 | (2.36) |
| Low Valence/Low Arousal | | | | | |
| Basket | 7010 | 4.92 | (0.48) | 1.97 | (1.58) |
| Trash Can | 7060 | 4.29 | (1.35) | 2.42 | (1.80) |
| Ironing board | 7234 | 4.12 | (1.73) | 3.05 | (1.99) |
| Cemetery | 9000 | 2.33 | (1.45) | 4.19 | (2.37) |
| Cemetery | 9001 | 2.82 | (1.88) | 3.60 | (2.27) |
| bogus: | | | | | |
| Female nude | 4001 | 3.58 | (1.74) | 3.88 | (2.13) |

Table A.2: The IAPS data: **Male Subjects**

| | | Valence | | Arousal | |
|---|---|---|---|---|---|
| Slide | No. | Mean | (SD) | Mean | (SD) |
| High Valence(>7.70)/High Arousal(>7.20) | | | | | |
| Female Nude | 4180 | 8.21 | (1.34) | 7.43 | (1.97) |
| Couple | 4664 | 7.99 | (1.25) | 7.72 | (1.45) |
| Couple | 4659 | 7.70 | (1.64) | 7.43 | (1.80) |
| Couple | 4607 | 7.99 | (1.09) | 7.19 | (1.88) |
| Female Erotic | 4220 | 8.02 | (1.37) | 7.17 | (1.76) |
| Ski Jump | 8030 | 7.29 | (1.66) | 7.32 | (2.16) |
| Sailing | 8080 | 7.73 | (1.25) | 7.12 | (1.95) |
| bogus: | | | | | |
| Cash | 8501 | 8.14 | (1.24) | 6.86 | (2.00) |
| Sky-divers | 5621 | 7.28 | (1.22) | 6.96 | (1.72) |
| food: | | | | | |
| Turkey | 7230 | 7.42 | (1.47) | 5.81 | (2.25) |
| Brownie | 7200 | 7.50 | (1.78) | 4.90 | (2.67) |
| ChocoDrink | 7270 | 7.24 | (1.76) | 5.66 | (2.33) |
| Low Valence(<2.20)/High Arousal(>6.35) | | | | | |
| Mangled face | 3060 | 1.94 | (1.39) | 6.89 | (2.08) |
| Mangled face | 3080 | 1.63 | (1.11) | 6.84 | (2.06) |
| Baby tumor | 3170 | 1.77 | (1.31) | 6.79 | (1.93) |
| Mutilation | 3000 | 1.69 | (1.47) | 6.74 | (2.37) |
| Soldier | 9410 | 1.96 | (1.56) | 6.38 | (2.26) |
| Throat slash | 3071 | 2.06 | (1.59) | 6.61 | (2.13) |
| bogus: | | | | | |
| Child | 9040 | 1.88 | (1.17) | 5.10 | (2.11) |
| High Valence(>6.50)/Low Arousal(<3.00) | | | | | |
| Outdoors | 5760 | 7.69 | (1.28) | 2.77 | (2.16) |
| Rabbit | 1610 | 7.28 | (1.47) | 2.82 | (2.01) |
| Tuxedos | 2370 | 6.71 | (1.32) | 2.85 | (2.07) |
| Flower | 5010 | 6.75 | (1.52) | 2.78 | (2.07) |
| Bass violin | 7900 | 6.50 | (1.79) | 2.94 | (2.17) |
| Flower | 5000 | 6.58 | (1.77) | 2.44 | (2.06) |
| Low Valence/Low Arousal | | | | | |
| Male Nude | 4510 | 4.05 | (1.72) | 1.78 | (1.48) |
| Basket | 7010 | 4.95 | (1.43) | 1.55 | (1.36) |
| Stool | 7025 | 4.46 | (1.23) | 2.44 | (2.27) |
| Cemetery | 9001 | 3.41 | (2.15) | 3.74 | (2.35) |
| Cemetery | 9000 | 2.81 | (1.65) | 3.90 | (2.12) |
| bogus: | | | | | |
| Male Nude | 4490 | 4.29 | (1.31) | 2.85 | (1.96) |

# Appendix B

# Tcl Code

```
#!/bin/sh
#\
exec /mas/vision/bin/hp700/wish4.1 slider
#setenv _RLD_ARGS -ignore_unresolved
#An experiment on emotional response
source ~ tpminka/lib/common/util.tcl
load-formats

# 1. Set up initial window.

wm title . "Click on Next to continue"
wm geometry . 2000x1000
wm geometry . +0+0
frame .slider
frame .window
frame .intro
pack .intro

# 2. The pictures used in this experiment are listed in a file index.txt.
```

```
cd /mas/vision/projects/TextureHeads.3/AffectPics/images
set i [open index.txt r+]
set f [open ~/file a+]
wm protocol . WM_DELETE_WINDOW {
    .window configure -text "I don't want to die"
}

# 3. A procedure for loading the next picture

proc load_picture {} {
    upvar i index
    upvar f file
    set tmp [gets $index]
    if [eof $index] {
        flush $file
        close $index
        close $file
        destroy .
    }
    if ![eof $index] {
        pack forget .slider
        pack .window
        image1 blank
        .window.b configure -state disabled
        update
        after 3000
        image1 read $tmp
        update
        after 10000 {.window.b configure -state active}
    }
```

```
}

proc raise_slider {} {
    reset
    pack forget .window
    pack .slider
    return
}

# 4. A proceedure to get the values of the slider bars
# and return them to a file called file. Also resets
# the sliders just before displaying the slider page.

proc reset {} {
    upvar 2 f file
    set data(valence) [.slider.valence get]
    set data(intensity) [.slider.intensity get]
    proc search a {
        upvar $a data
        foreach x [array names data] {
            lappend list ($x)
            lappend list [set data($x)]
        }
        return $list
    }
    puts $file [search data]
    flush $file
    .slider.valence set 0
    .slider.intensity set 0
}
```

# 5. Create the button and the pictures.

```
image create photo -height 955
label .window.picture -image image1
image1 read [gets $i]
button .window.b -text Next -command raise_slider
pack .window.picture -side top -in .window
pack .window.b -side bottom -anchor e -in .window
```

# 6. Create the sliders and the button

```
frame .slider.pad1
pack .slider.pad1 -pady 125
scale .slider.valence -label “Did you like this picture?” \
    -from -3 -to 3 -length 10c -width 0.75c -orient horizontal \
    -tickinterval 1
scale .slider.intensity -label “How intensely did you feel ike/dislike?” \
    -from 0 -to 6 -length 10c -width 0.75c -orient horizontal \
    -tickinterval 1
pack .slider.valence .slider.intensity -in .slider -pady 50 -padx 323
frame .slider.pad2
pack .slider.pad2 -pady 149
button .slider.b -text Next -command load_picture
pack .slider.b -side bottom -anchor e -in .slider
```

# 7. Introduction page.

```
text .intro.text -font -*-helvetica-bold-r-normal-*-*-200-*-*-*-*-*-*
.intro.text insert end “You are about to see a series of pictures.
```

Look at each picture for approximatley 20 seconds before clicking on
the \“Next\” button to continue. Following each photo you will be asked
to rate how much you \“liked\” the picture, and how \“intensely\” you felt that
response.

You have a right to privacy. Your name will not be released.
If at any time you want to discontinue the experiment, or if at the
conclusion you wish that your data be retracted from the experiment,
simply mention it to the experimenter.

Click on \“I Agree\” to continue.”

```
pack .intro.text
proc accept {} {
    pack forget .intro
    pack .window
}
button .intro.b -text “I Agree” -command accept
pack .intro.b -side bottom -anchor e -in .intro

bind .intro.b <Button-2> {
exit
}
bind .window.b <Button-2> {
exit
}
```

# Appendix C

# Instructions presented on the Computer Screen

You are about to see a series of pictures. Look at each picture for approximately 20 seconds before clicking on the "Next" button to continue. Following each photo you will be asked to rate how much you "liked" the picture, and how "intensely" you felt that emotion.

You have a right to privacy. Your name will not be released. If at any time you want to discontinue the experiment, or if at the conclusion you wish that your data be retracted from the experiment, feel free to do so.

Click on "I Agree" to continue.

# Appendix D

# Self-Reported Results

Table D.1: The self-reported means: **Female Subjects**

| | | IAPS | | Sub7 | | Sub15 | | Sub18 | | Sub19 | | Sub20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Slide | Val. | Ar. | Val. | Ar. | Val. | Ar. | Val. | Ar. | Val. | Ar. | Val. | Ar. |
| 1 | Basket | 0.3 | 0.7 | 1 | 0 | 1 | 0 | 1 | 3 | 1 | 2 | 1 | 1 |
| 2 | Tuxedos | 2.5 | 1.6 | 1 | 2 | 0 | 1 | 1 | 2 | 0 | 0 | 1 | 1 |
| 3 | Trash Can | -0.3 | 1.1 | -1 | 2 | -1 | 1 | -1 | 3 | -1 | 1 | 0 | 0 |
| 4 | Male Nude | 2.1 | 4.3 | 2 | 4 | 1 | 2 | 0 | 1 | 1 | 4 | -1 | 1 |
| 5 | Brownie | 2.8 | 3.2 | 1 | 4 | 1 | 1 | 2 | 3 | 2 | 1 | 1 | 2 |
| 6 | Cemetery | -1.5 | 2.1 | 1 | 2 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 3 |
| 7 | Couple | 1.4 | 4.7 | 3 | 6 | 1 | 2 | 3 | 3 | 1 | 2 | -1 | 1 |
| 8 | Flower | 2.6 | 1.8 | 1 | 1 | 1 | 2 | 3 | 4 | 1 | 3 | 1 | 0 |
| 9 | Ironing board | -0.4 | 1.7 | -1 | 2 | -1 | 2 | -1 | 1 | -2 | 2 | 0 | 0 |
| 10 | Mangled face | -2.8 | 5.7 | -3 | 6 | -2 | 5 | -3 | 6 | -3 | 3 | 1 | 1 |
| 11 | Skier | 2.3 | 4.6 | 2 | 5 | 2 | 2 | 3 | 2 | 2 | 4 | 0 | 0 |
| 12 | Female nude | -0.9 | 2.4 | 0 | 3 | 0 | 2 | 1 | 2 | 1 | 2 | 0 | 0 |
| 13 | Ice cream | 3.0 | 3.8 | 2 | 5 | 0 | 2 | 3 | 6 | 2 | 2 | 2 | 1 |
| 14 | Child | -2.7 | 4.6 | -1 | 2 | -2 | 2 | 3 | 6 | -2 | 4 | 0 | 1 |
| 15 | Ski Jump | 2.4 | 5.5 | 3 | 6 | 2 | 2 | 2 | 4 | 2 | 4 | 1 | 2 |
| 16 | Soldier | -3.0 | 5.6 | 1 | 3 | -2 | 2 | -2 | 3 | -3 | 5 | -2 | 1 |
| 17 | ChocoDrink | 2.8 | 4.1 | 3 | 4 | 0 | 1 | 3 | 4 | 2 | 2 | 1 | 0 |
| 18 | flowers | 2.7 | 1.6 | 1 | 6 | 2 | 2 | 2 | 4 | 2 | 2 | 0 | 0 |
| 19 | Male Nude | 1.5 | 4.3 | 1 | 4 | 1 | 2 | 2 | 5 | 2 | 2 | -1 | 1 |
| 20 | Cemetery | -2.0 | 2.7 | 1 | 2 | 0 | 1 | 0 | 1 | -1 | 3 | 2 | 2 |
| 21 | Mangled face | -2.5 | 5.4 | -3 | 6 | -3 | 4 | 3 | 6 | -3 | 6 | -1 | 2 |
| 22 | Clouds | 2.6 | 1.7 | 1 | 2 | 2 | 3 | 1 | 2 | 2 | 4 | 1 | 1 |
| 23 | Cash | 2.7 | 4.3 | 3 | 6 | 1 | 4 | 1 | 1 | 1 | 6 | 1 | 0 |
| 24 | Baby tumor | -3.0 | 5.6 | 2 | 6 | -3 | 5 | -3 | 5 | -2 | 5 | -1 | 2 |
| 25 | Sprgbok | 3.0 | 2.1 | 1 | 1 | 2 | 2 | 1 | 3 | 2 | 5 | 1 | 0 |
| 26 | Sky-divers | 2.8 | 5.1 | 1 | 4 | 2 | 2 | 2 | 4 | 3 | 4 | 2 | 1 |
| 27 | Sailing | 2.7 | 4.5 | 3 | 5 | 1 | 0 | 1 | 2 | 3 | 6 | 3 | 2 |
| 28 | Knife | -2.7 | 5.6 | -3 | 4 | -2 | 5 | 3 | 4 | -3 | 5 | -1 | 1 |
| 29 | Burn victim | -3.0 | 5.6 | -3 | 2 | -3 | 5 | 3 | 5 | -3 | 6 | -2 | 2 |
| 30 | Flower | 2.6 | 1.5 | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | 0 | 1 |

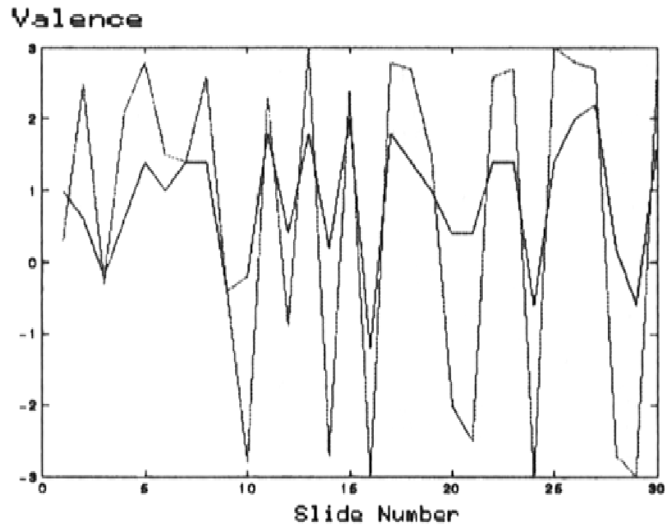


Figure D-1: The Lang *female* valence results are plotted against collected data.

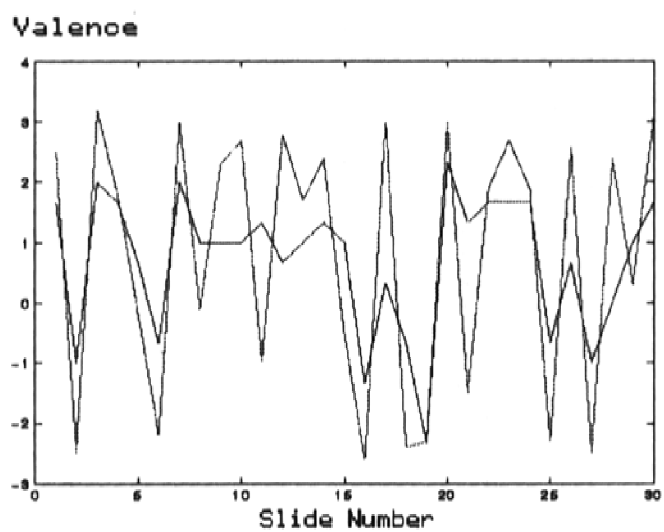


Figure D-2: The Lang *male* valence results are plotted against collected data.

Table D.2: The self-reported means: **Male Subjects**

| | | IAPS | | Sub10 | | Sub13 | | Sub17 | |
|---|---|---|---|---|---|---|---|---|---|
| | Slide | Val. | Ar. | Val. | Ar. | Val. | Ar. | Val. | Ar. |
| 1 | Turkey | 2.5 | 4.1 | 2 | 3 | 2 | 2 | 1 | 2 |
| 2 | Baby tumor | -2.5 | 4.9 | -2 | 3 | 1 | 1 | -2 | 5 |
| 3 | Female Nude | 3.2 | 5.5 | 2 | 2 | 2 | 3 | 2 | 4 |
| 4 | Flower | 1.8 | 1.1 | 2 | 2 | 2 | 3 | 1 | 2 |
| 5 | Male Nude | -0.2 | 1.5 | 1 | 3 | 0 | 0 | 1 | 2 |
| 6 | Throat slash | -2.2 | 4.8 | 0 | 1 | -1 | 1 | -1 | 3 |
| 7 | Couple | 3.0 | 5.3 | 2 | 2 | 2 | 2 | 2 | 3 |
| 8 | Stool | -0.1 | 1.1 | -1 | 1 | 2 | 2 | 2 | 1 |
| 9 | ChocoDrink | 2.3 | 4.0 | 0 | 1 | 2 | 2 | 1 | 2 |
| 10 | Outdoors | 2.7 | 1.4 | 1 | 1 | -1 | 1 | 3 | 2 |
| 11 | Cemetery | -1.0 | 2.3 | 2 | 2 | 1 | 1 | 1 | 4 |
| 12 | Sailing | 2.8 | 5.2 | 1 | 1 | 2 | 3 | -1 | 2 |
| 13 | Bass violin | 1.7 | 1.6 | 0 | 0 | 1 | 1 | 2 | 2 |
| 14 | Sky-divers | 2.4 | 5.0 | 1 | 2 | 1 | 3 | 2 | 3 |
| 15 | Male Nude | -0.5 | 0.6 | 1 | 3 | 2 | 3 | 0 | 1 |
| 16 | Mangled face | -2.6 | 5.0 | -2 | 4 | 0 | 0 | -2 | 5 |
| 17 | Couple | 3.0 | 5.6 | 1 | 2 | -1 | 2 | 1 | 6 |
| 18 | Child | -2.4 | 3.5 | -1 | 3 | 2 | 4 | -3 | 5 |
| 19 | Mangled face | -2.3 | 5.0 | -3 | 4 | -1 | 3 | -3 | 6 |
| 20 | Female Erotic | 3.0 | 5.3 | 2 | 2 | 3 | 5 | 2 | 4 |
| 21 | Cemetery | -1.5 | 2.4 | 1 | 2 | 1 | 2 | 2 | 5 |
| 22 | Flower | 1.9 | 1.4 | 2 | 2 | 2 | 3 | 1 | 2 |
| 23 | Couple | 2.7 | 5.5 | 2 | 3 | 1 | 1 | 2 | 4 |
| 24 | Tuxedos | 1.9 | 1.5 | 1 | 1 | 1 | 1 | 3 | 3 |
| 25 | Soldier | -2.3 | 4.6 | 1 | 3 | 0 | 0 | -3 | 3 |
| 26 | Brownie | 2.6 | 3.3 | 2 | 2 | -1 | 1 | 1 | 1 |
| 27 | Mutilation | -2.5 | 4.9 | -2 | 4 | 1 | 0 | -2 | 4 |
| 28 | Rabbit | 2.4 | 1.5 | 1 | 1 | -1 | 2 | 0 | 2 |
| 29 | Basket | 0.3 | 0.4 | 2 | 3 | 0 | 0 | 1 | 2 |
| 30 | Cash | 3.1 | 5.0 | 2 | 2 | 1 | 3 | 2 | 2 |

# Appendix E

# Subject Sentic Results

Table E.1: *Zero* Valence Correlations: *Within subjects* Sub#19

Pearson

| Sub#19 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 1.000 | .580‡ | -.137 | .451‡ | -.467‡ | -.048 | .457‡ |
| 2 | .580‡ | 1.000 | -.360‡ | .028 | -.360‡ | .133 | .225† |
| 3 | -.137 | -.360‡ | 1.000 | .536‡ | .376‡ | .585‡ | .365‡ |
| 4 | .451‡ | .028 | .536‡ | 1.000 | -.082 | .502‡ | .513† |
| 5 | -.467‡ | -.360‡ | .376‡ | -.082 | 1.000 | .306‡ | .372‡ |
| 6 | -.048 | .133 | .585‡ | .502‡ | .306‡ | 1.000 | .385‡ |
| 7 | .457‡ | .225† | .365 | .513‡ | .372‡ | .385‡ | 1.000 |

Significance

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | . | .000 | .150 | .000 | .000 | .617 | .000 |
| 2 | .000 | . | .000 | .771 | .000 | .164 | .018 |
| 3 | .150 | .000 | . | .000 | .000 | .000 | .000 |
| 4 | .000 | .771 | .000 | . | .395 | .000 | .000 |
| 5 | .000 | .000 | .000 | .395 | . | .001 | .000 |
| 6 | .617 | .164 | .000 | .000 | .001 | . | .000 |
| 7 | .000 | .018 | .000 | .000 | .000 | .000 | . |

The sentic data for zero valence had a significant correlation both within and between subjects. Within subjects, for subject #19, the correlation ranged from being significantly negative to significantly positive ($p<0.001$). Between subjects, the zero valence sentic signal also had a highly positive correlation ($p\leq0.002$).

Table E.2: *Zero* Valence Correlations: *Between subjects*

Pearson

| | sub#17 | sub#19 | sub#20 |
|---|---|---|---|
| sub#17 | 1.000 | .319‡ | .295‡ |
| sub#19 | .319‡ | 1.000 | .794‡ |
| sub#20 | .295‡ | .794‡ | 1.000 |

Significance

| | | | |
|---|---|---|---|
| sub#17 | . | .001 | .002 |
| sub#19 | .001 | . | .000 |
| sub#20 | .002 | .000 | . |

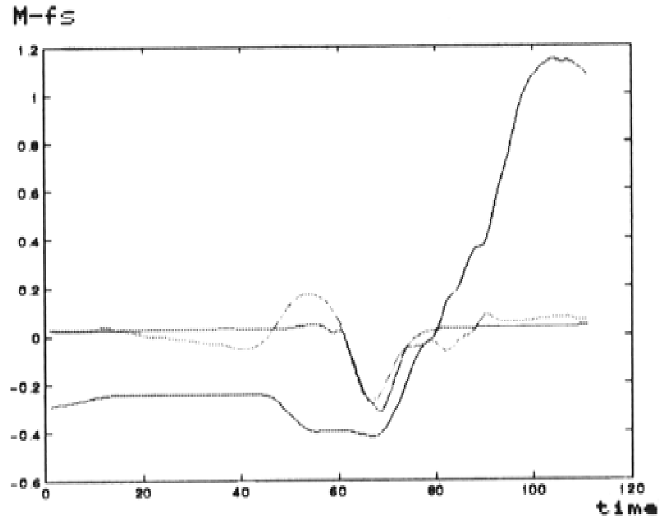


Figure E-1: The mean subject sentic form for *zero* valence for subjects #17, #19, and #20.

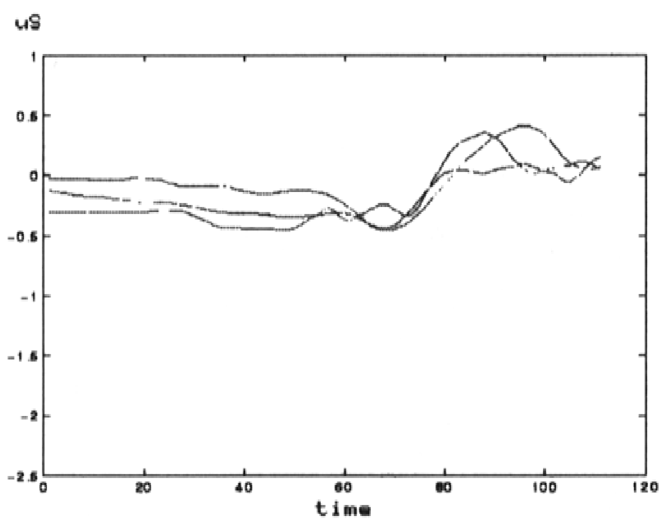


Figure E-2: *Positive* valence subject #17

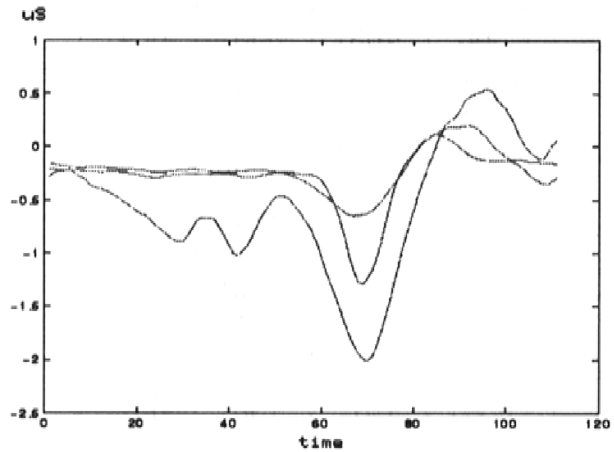


Figure E-3: *Positive* valence subject #19

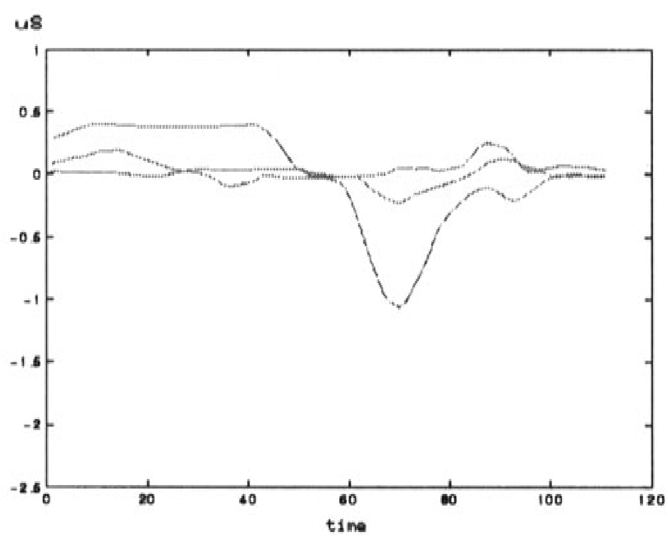


Figure E-4: *Positive* valence subject #20

Table E.3: *Positive* Valence Correlations: *Between subjects*

Pearson

| | 17_1 | 17_2 | 17_3 | 19_1 | 19_2 | 19_3 | 20_1 | 20_2 | 20_3 |
|---|---|---|---|---|---|---|---|---|---|
| 17_1 | 1.000 | .784‡ | .830‡ | .601‡ | .824‡ | .873‡ | .584‡ | .263‡ | -.177 |
| 17_2 | .784‡ | 1.000 | .572‡ | .873‡ | .838‡ | .915‡ | .761‡ | .704‡ | .174 |
| 17_3 | .830‡ | .572‡ | 1.000 | .468‡ | .655‡ | .604‡ | .262‡ | -.057 | -.364‡ |
| 19_1 | .601‡ | .873‡ | .468‡ | 1.000 | .774‡ | .818‡ | .824‡ | .760‡ | 157 |
| 19_2 | .824‡ | .838‡ | .655‡ | .774‡ | 1.000 | .874‡ | .722‡ | .506‡ | 198† |
| 19_3 | .873‡ | .915‡ | .604‡ | .818‡ | .874‡ | 1.000 | .830‡ | .650‡ | .031 |
| 20_1 | .584‡ | .761‡ | .262‡ | .824‡ | .722‡ | .830‡ | 1.000 | .803‡ | .275‡ |
| 20_2 | .263‡ | .704‡ | -.057 | .760‡ | .506‡ | .650‡ | .803‡ | 1.000 | .513‡ |
| 20_3 | -.177 | .174 | -.364‡ | .157 | .198† | .031 | .275‡ | .513‡ | 1.000 |

Significance

| | 17_1 | 17_2 | 17_3 | 19_1 | 19_2 | 19_3 | 20_1 | 20_2 | 20_3 |
|---|---|---|---|---|---|---|---|---|---|
| 17_1 | . | .000 | .000 | .000 | .000 | .000 | .000 | .005 | .063 |
| 17_2 | .000 | . | .000 | .000 | .000 | .000 | .000 | .000 | .067 |
| 17_3 | .000 | .000 | . | .000 | .000 | .000 | .006 | .553 | .000 |
| 19_1 | .000 | .000 | .000 | . | .000 | .000 | .000 | .000 | .100 |
| 19_2 | .000 | .000 | .000 | .000 | . | .000 | .000 | .000 | .037 |
| 19_3 | .000 | .000 | .000 | .000 | .000 | . | .000 | .000 | .745 |
| 20_1 | .000 | .000 | .006 | .000 | .000 | .000 | . | .000 | .004 |
| 20_2 | .005 | .000 | .053 | .000 | .000 | .000 | .000 | . | .000 |
| 20_3 | .063 | .067 | .000 | .100 | .037 | .745 | .004 | .000 | . |

The positive valence sentic data between subjects was also significant ($p<0.001$).

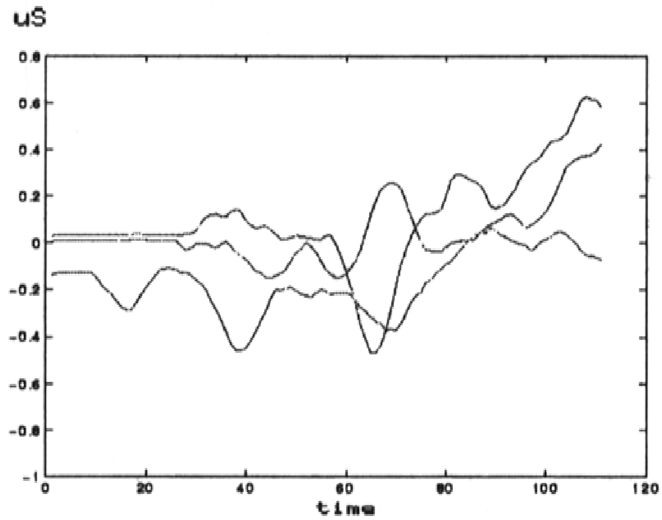


Figure E-5: *Negative* valence subject #17

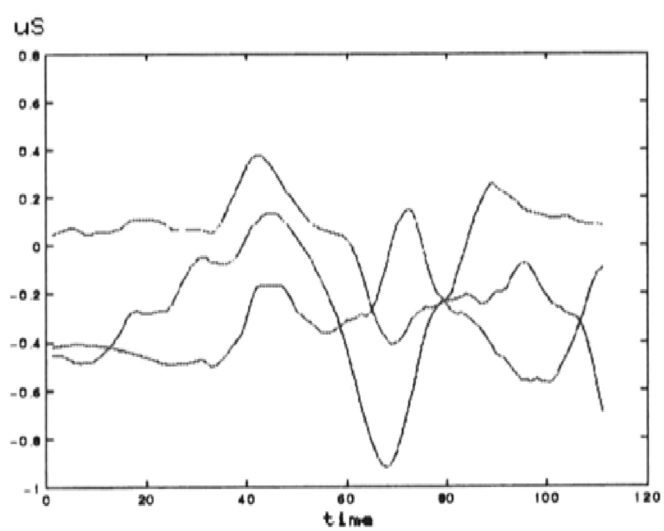


Figure E-6: *Negative* valence subject #19

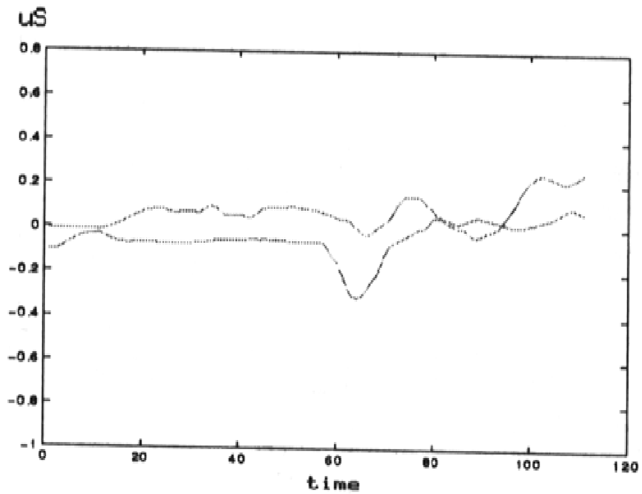


Figure E-7: *Negative* valence subject #20

The negative valence sentic data demonstrated significance with at Pearson from -.507 to .636 with ($p<0.001$).

Table E.4: Negative Valence Correlations: Between subjects

| | 17_n1 | 17_n2 | 17_n3 | 19_n1 | 19_n2 | 19_n3 | 20_n1 | 20_n2 |
|---|---|---|---|---|---|---|---|---|
| 17_n1 | 1.000 | .434‡ | .349‡ | -.277‡ | .126‡ | -.507‡ | -.138 | .528‡ |
| 17_n2 | .434‡ | 1.000 | .644‡ | .395‡ | -.239† | .368‡ | .247‡ | .957‡ |
| 17_n3 | .349‡ | .644‡ | 1.000 | .188† | -.402‡ | .107 | -.051‡ | .636 |
| 19_n1 | -.277‡ | .395‡ | .188† | 1.000 | -.536‡ | .758‡ | -.018‡ | .284‡ |
| 19_n2 | .126‡ | -.239‡ | -.402‡ | -.536‡ | 1.000 | -.386‡ | .348‡ | -.187‡ |
| 19_n3 | -.507‡ | .368‡ | .107 | .758‡ | -.386‡ | 1.000 | .398‡ | .259‡ |
| 20_n1 | -.138 | .247‡ | -.051 | -.018 | .348‡ | .398‡ | 1.000 | .189† |
| 20_n2 | .528‡ | .957‡ | .636‡ | .284‡ | -.187‡ | .259‡ | .189† | 1.000 |
| 17_n1 | . | .000 | .000 | .003 | .188 | .000 | .149 | .000 |
| 17_n2 | .000 | . | .000 | .000 | .012 | .000 | .009 | .000 |
| 17_n3 | .000 | .000 | . | .048 | .000 | .262 | .598 | .000 |
| 19_n1 | .003 | .000 | .048 | . | .000 | .000 | .854 | .003 |
| 19_n2 | .188 | .012 | .000 | .000 | . | .000 | .000 | .050 |
| 19_n3 | .000 | .000 | .262 | .000 | .000 | . | .000 | .006 |
| 20_n1 | .149 | .009 | .598 | .854 | .000 | .000 | . | .047 |
| 20_n2 | .005 | .000 | .000 | .003 | .050 | .006 | .047 | . |

‡Signifies that correlation is significant at the 0.01 level (two-tailed).

†Signifies that correlation is significant at the 0.05 level (two-tailed).

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