CHAPTER 1

INTRODUCTION

During a radio broadcast [1] Dr. Kary Mullis described an experiment he believed showed that a person's skin impedance indicated their future emotional response to a randomized stimulus. The experiment he described was first performed by Dr. Dean Radin [2] and later reported confirmed by Dr. D. J. Bierman. The experiment involved a data recorder for skin impedance and followed this sequence:

- The experimental subject presses a button to begin the test.
- After a 3 second delay, a randomly chosen calm or emotional image is briefly presented to the subject.
- There is a 16 second delay before the subject has the opportunity to press the button to begin a new test.

The hypothesis is that measurements of skin impedance not only show the subject's response after the image is shown, but that they indicate the subject's future response before the image is shown. By using statistical analysis on many test runs, Dr.'s Radin and Bierman claim to have proved this hypothesis to a high degree of certainty. While quantum mechanics offers some possibility for this kind of time relationship via the EPR theorem, and there is a theory of mind by Dr. Stuart Hameroff and Dr. Roger Penrose [3] that relies upon this type of relation which has received at least some experimental support, [6] it is unclear how this type of phenomenon could move beyond the nano-second realm and be observable on the timescale of seconds.

Taking into account the poor progress made in understanding consciousness and intelligence, the fact that this experiment would require the design and construction of electronic instrumentation, and the author’s belief that a student’s research provides the opportunity to pursue relatively risky projects, it was decided to perform a replication of this experiment as a Masters Thesis in Electrical Engineering.

CHAPTER 2

EXPERIMENTAL DESIGN

The experimental design closely follows that of Dr.'s Radin and Bierman. It is performed with the subject sitting alone at a table in a conference room. Subjects were chosen randomly from friends, family, and fellow students. The sequence of events is shown in figure 2.1 and is as follows:

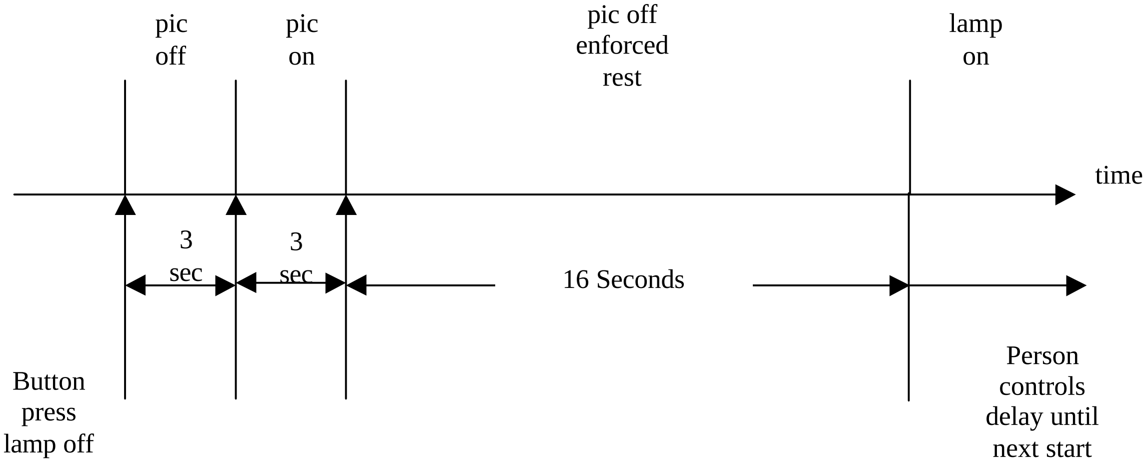


Figure 2.1. Experimental diagram.

- The overall process of the experiment is described to the subject. The purpose is explained as an investigation of biological response to stimulus as part of the researcher's masters degree program

- A university human experiment informed consent form (appendix 2) is read and signed by the subject and any questions about the process are answered.

- The subject completes a written Kiersey personality profile questionnaire.

- The subject is seated at the table and their left hand including approximately 40 cm of the forearm is strapped palm-up to a foam pad using a combination of cloth and Velcro fasteners. The straps are tight enough to somewhat constrain movement, but not so tight as to be uncomfortable. The subject is asked to avoid movement during image viewing and is told that their arm (with attached foam pad) may be held in their lap or on the table, whichever is most comfortable for them.

- Silver electrodes are attached to the pads of the two fingers closest to the thumb on the left hand. They are held in place with foam padded clips and conductive gel is used to ensure good electrical contact is maintained. The impedance measuring wheatstone bridge is adjusted to null the subjects constant impedance level.

- The mechanical process of pressing the button to begin image viewing is explained to the subject, and the button is fixed to the table at a comfortable distance from the subject's right hand. The laptop computer on which the images will appear is placed on the table facing the subject. A headset incorporating active noise cancellation connected to a CD player providing recorded white noise is placed on the subject, and instructions on adjusting the volume to a comfortable level are given. The data-recorder and sequencer are started and a dark cloth is placed over the apparatus leaving only the button and laptop screen visible. The subject is left alone in the room for the duration of the experimental run.

- After an approximate two minute self-calibration of the random number generator, the button lights up. The subject presses the button at a time of their choosing, whereupon the light extinguishes. There is a three second delay, then an image is shown on the computer screen for three seconds. All images were selected from the International Affective Picture System [5], a calm/emotional image database developed under a grant from the National Institute for Mental Health, as in Dr. Radin's original experiment. After the image there is a 16-second period before the button lights up again during which the button is inoperative. After 20 images are viewed, the light on the button flashes, indicating the end of the session. The subject toggles a switch, sounding a buzzer outside the conference room, which marks the end of the experiment.

Dr. Hammeroff and Penrose's theory of mind predicts that consciousness should occur in brains down to the size found in worms. Since change in skin impedance is thought to be related to internal mental state, an interesting question is whether responses such as those in the above experiment could be observed in lesser species. With this in mind, an additional series of tests was conducted on earthworms. In place of the electrodes in the human tests there was a test cell, in place of the button presses was a randomly generated time interval of from 3 to 5 minutes between events, and in place of images the test cell was physically vibrated using an audio speaker cone. Due to the overall length of the tests only 15 runs per worm were done. The worms were chilled to 40 degrees F to minimize movement artifacts in the signal.

CHAPTER 3

EQUIPMENT

The equipment for the experiment consists of four major components: the laptop computer, the impedance bridge, the random number generator, and the system controller, as shown in figure 3.1. First, an overview of the purpose and operation of each component is given. Next, a detailed analysis, including design details, is given, and lastly the total system specifications, capabilities, and limitations are presented.

Laptop Computer

The laptop computer is an IBM model 380Z and serves the purposes of image display and data recording. Image display is via a purpose-built Windows slide-viewing program. The data is recorded as a modulated audio signal using a commercial sound recording program. The laptop is also used for post-experiment digital signal processing using Matlab.

Impedance Bridge

Simple AC and DC measurements suggest that human body impedance be modeled as shown in figure 3.2. The impedance bridge circuit is designed to detect small changes in skin impedance. It injects a 2Khz tone into the subject via a wheatstone bridge, the upper legs of which are matched 10K Ohm resistors, and the lower legs of which consist of the subject on one side and a parallel variable resistor and variable capacitor on the other side. By properly adjusting the variable resistor and capacitor, it is possible to null out the subject’s large constant impedance and make small impedance variations observable. This component also contains amplifiers and filters to properly condition the signal for recording by the laptop computer.

Random Number Generator

Computer generated random numbers are not truly random, but are only pseudorandom. Given the unlikely nature of the hypothesis, it was decided that a hardware random number generator should be constructed, thereby minimizing the possibility of any hidden determinism in the experiment’s random variables. The hardware random number generator feeds broadband white noise into the A/D port of the system controller.

System Controller

This component orchestrates the operation of the system. It reads the button to determine when to begin a test run, lights the button lamp to indicate a test run may be initiated, reads the random number generator to determine selection of emotional or calm images, sends signals to the laptop to control display of the images, and sends a signal to the impedance bridge to mark the data set as an emotional or calm trial. The controller also calibrates the random number generator at the beginning of the test run and records the number of emotional and calm images displayed.

Detailed Analysis

Laptop Computer

The laptop was used as-is with no hardware modifications. Internal operations such as reading the hard drive were observed to induce noise into the audio signal. To minimize this type problem all images were loaded into RAM before the beginning of an experiment, all automatic system management features in the operating system were disabled including screen clock display, and the unit was run only on battery power during the test runs. The sound card has 16 bits of resolution, which gives an impedance resolution of approximately 4 milli-Ohms. Quantization noise is not a limiting factor in this system since the data signal is typically averaged over a three-second window. The –3 dB frequency limits are

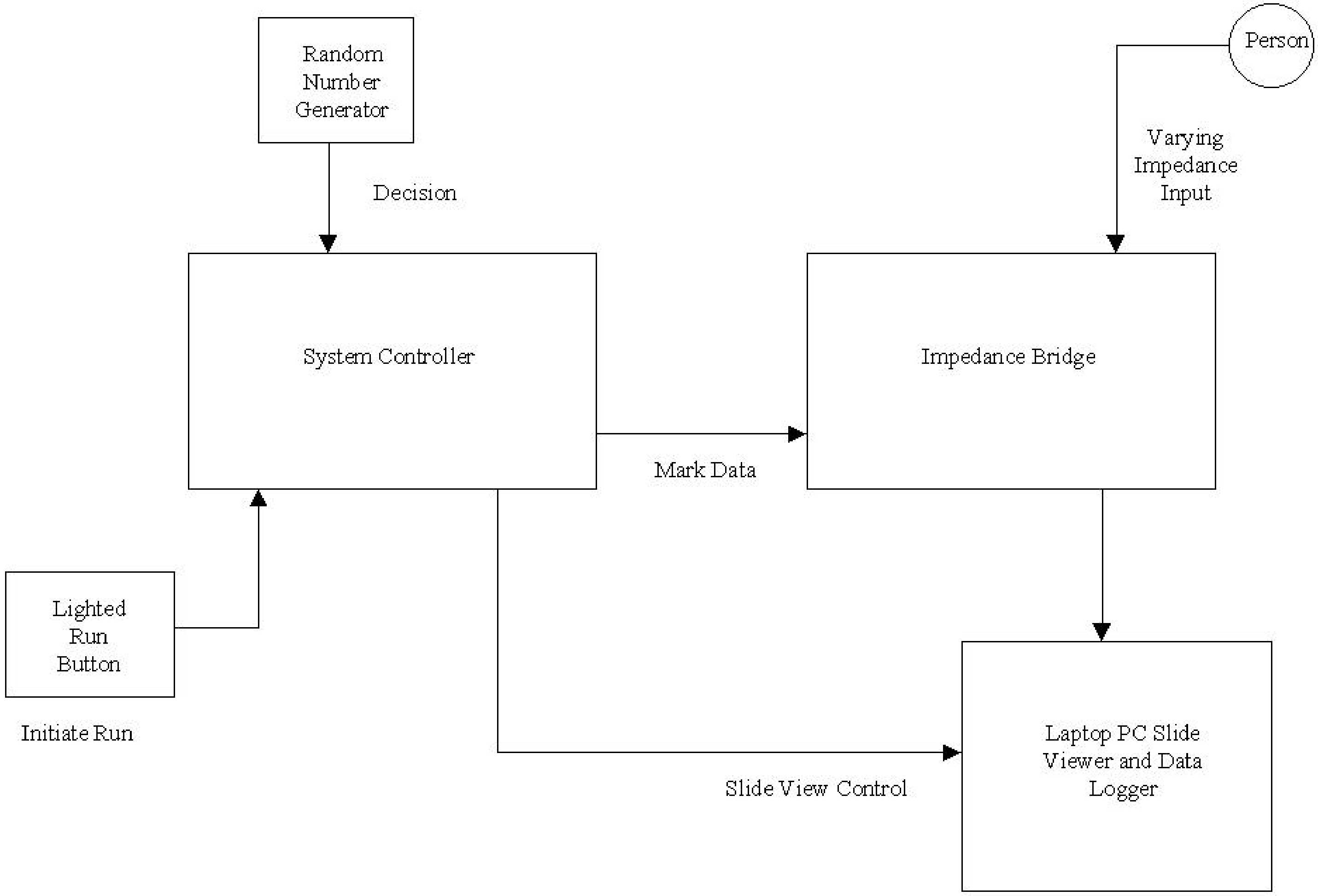


Figure 3.1. System block diagram.

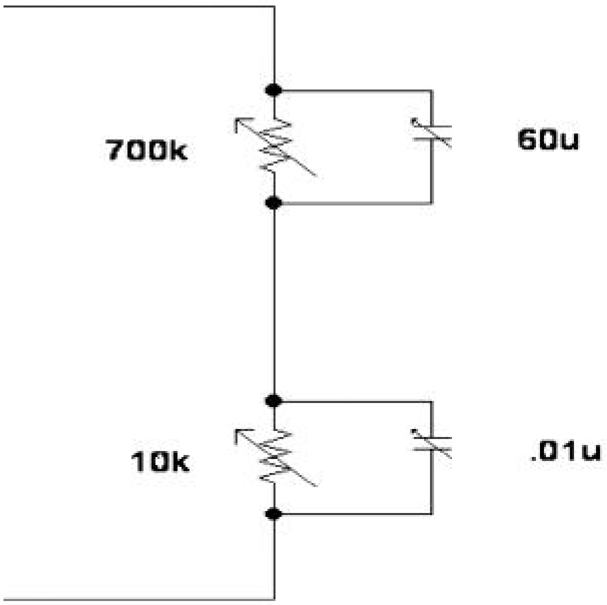


Figure 3.2. Human equivalent circuit.

approximately 30Hz and 21 kHz. Sampling is at 8 kHz and an anti-aliasing filter in the impedance bridge limits energy above 4 kHz to approximately 50 dB below typical signal levels.

Impedance Bridge

The two kHz signal is derived from a one MHz crystal oscillator divided by 256 by cascaded 40193 counters. The signal is further divided by two with half of a 74LS74 flip-flop yielding an operating frequency of 1953.125 Hz. This signal is routed through a 7413 schmidt trigger for minimum rise and fall times. The square wave is fed into a four pole butterworth low pass filter built using OP-27GP operational amplifiers. The frequency selective components for this filter were hand matched for optimum performance. The filter output feeds into the wheatstone bridge through a 39 K Ohm isolation resistor.

Balance of the bridge is accomplished by tuning a 10 turn wire-wound 50 K Ohm potentiometer and a 0 to 0.1 uF switch-box type capacitor bank. The person is isolated from

DC currents using low-leakage capacitors to improve stability. The output of the bridge is read by a standard 3 op-amp instrumentation amplifier also using the OP-27GP. The final stage is a Delviannis-Friend band pass filter whose components were hand matched and whose transfer function is shown in figure 3.3. The spectral output of the impedance bridge is shown in figure 3.4.

All analog signals were routed using shielded, twisted pair wiring and separate power supplies were provided for the analog and digital sections. Further noise isolation was provided by a dedicated metal enclosure. A mechanical relay powered by the system controller provides for embedding a mark indicating emotional or calm runs directly in the data set. The relay switches a 1,000 Ohm load in parallel with the output of the amplifier, producing a spike in the output data signal. The mark in the data is produced concurrent with the image being shown on the computer and provides registration of +/- 125 microseconds.

Random Number Generator

The random number generator amplifies noise from a zener diode. The output is DC biased and feeds the A/D converter of the system controller. There was a problem with noise spikes occasionally latching the amplifiers. This was resolved with the addition of back to back diode limiters on the amplifier input. Figure 3.5 shows the time domain and frequency domain signals from the generator as well as a histogram of 100,000 samples from the output.

The maximum sampling rate of the system controller is approximately 30 Hz. A separate power supply is provided for the random number generator. The circuit is shielded by grounded copper foil. Temperature dependence is canceled by performing a short calibration at the beginning of each run.

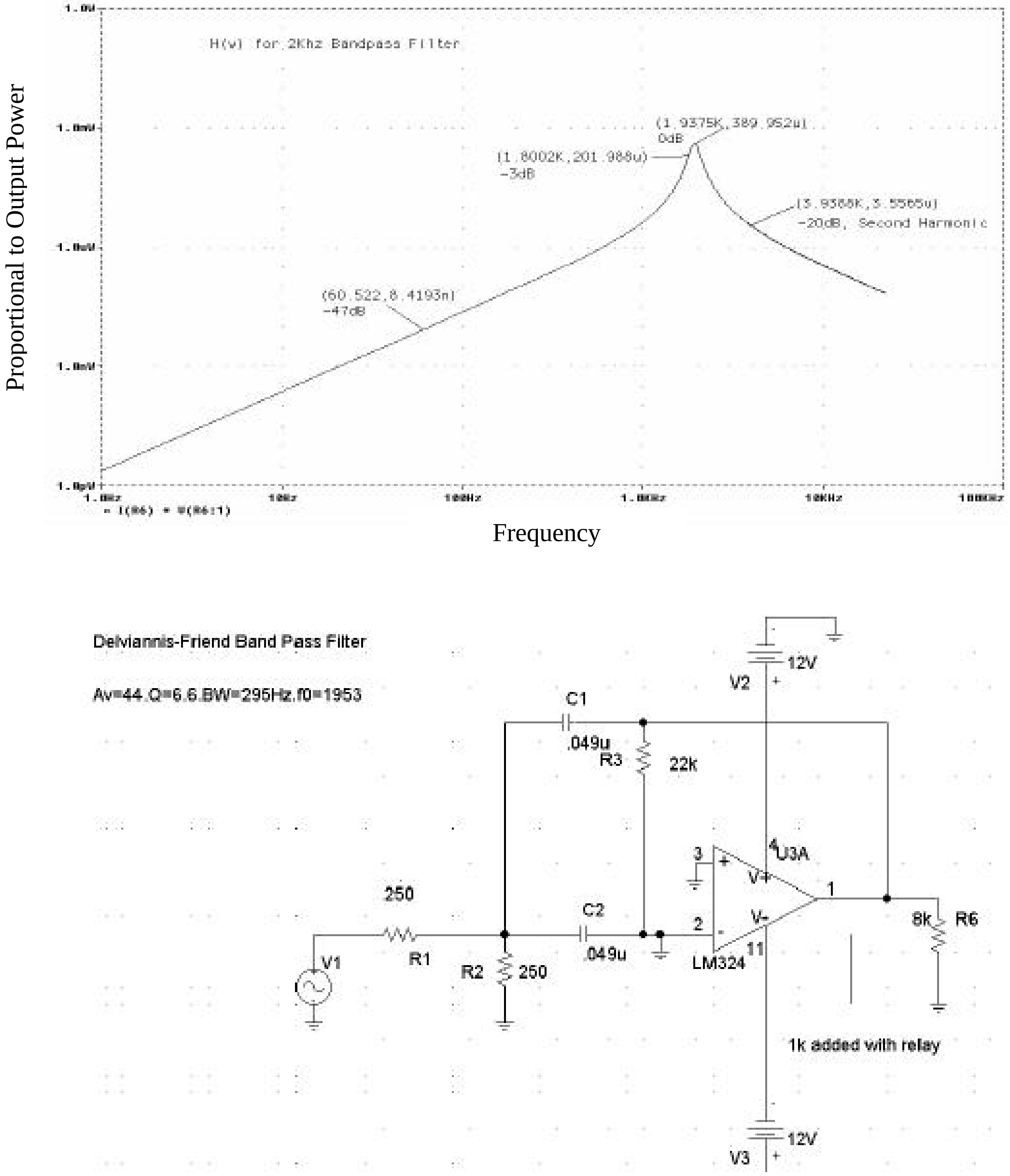


Figure 3.3. Circuit and transfer function for Delviannis-Friend filter.

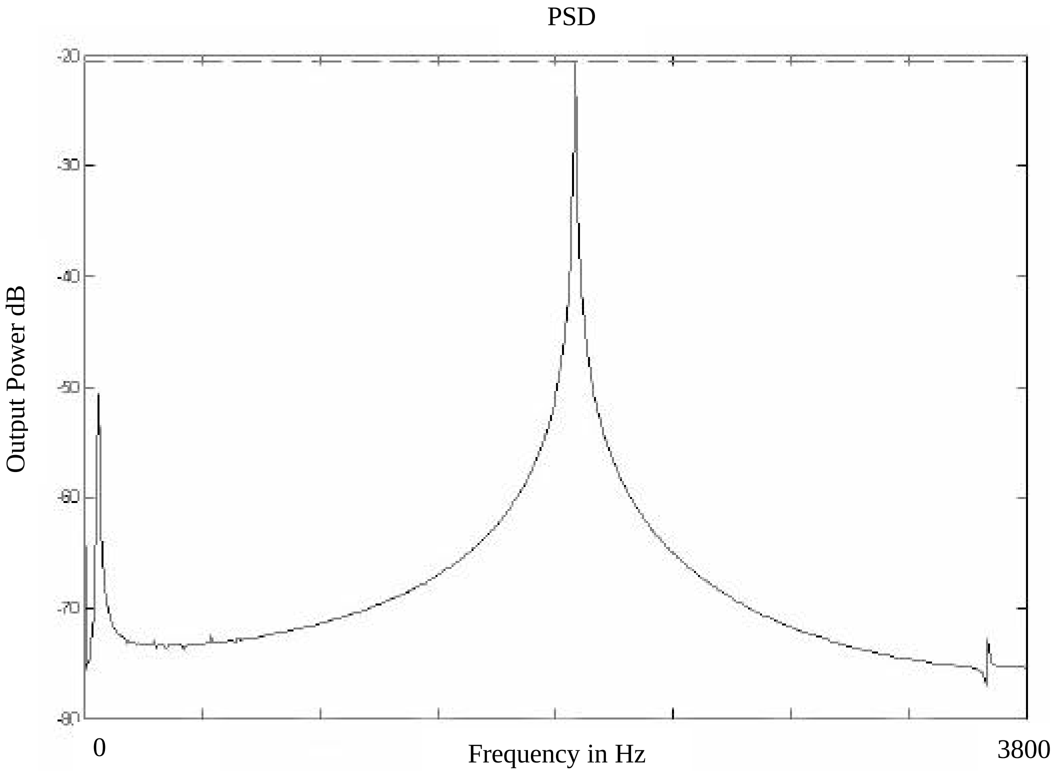


Figure 3.4. Power spectral density of output of impedance bridge.

System Controller

The system controller is a single board computer model Vitrax IX manufactured by Aries Electronics. Programming is via remote terminal and RS232 port. The unit features onboard digital I/O, 10 bit A/D and BASIC language interpreter ROM.

Total System Specifications

This system was designed for the specific task of integrating changes in impedance over multiple 3-second windows. The specifications presented here describe performance limits with this particular purpose in mind. The noise floor was determined by running the experiment 128 times with a resistor/capacitor connected in place of a person. Since the resistor value remained constant during the 3-second data window of each run, any variation

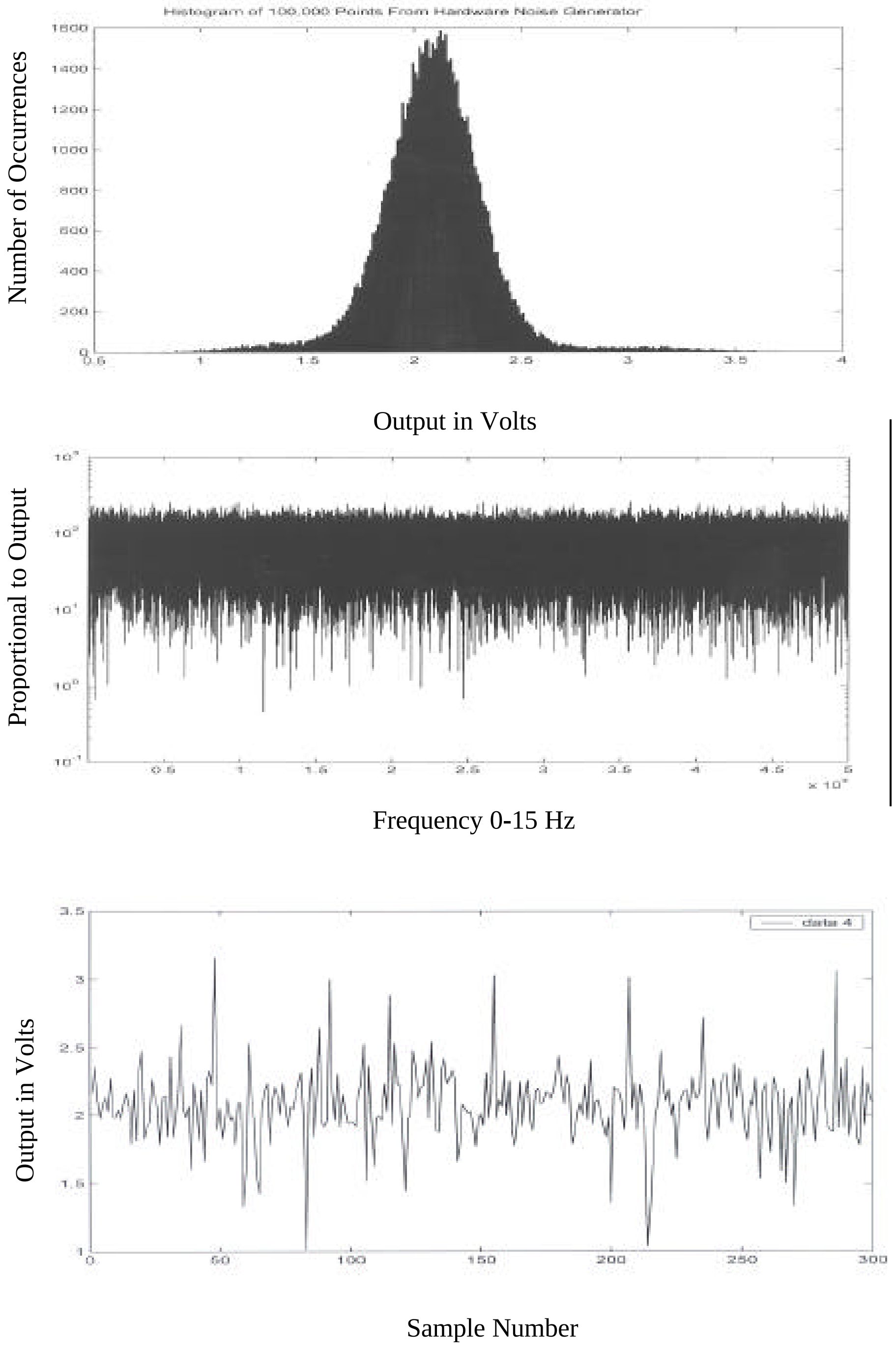


Figure 3.5. Time domain and frequency domain signals from the generator.

may be attributed to total system noise. Total system noise for the average of 128 runs is approximately 2 micro-Ohms. The average change during 128 human trials was measured to be 500 micro-Ohms, giving a SNR of 48 dB. The range of the instrument is approximately 200 Ohms, and assuming a minimum detectable signal of 4 micro-Ohms, the system dynamic range is approximately 154 dB.

A four point calibration was performed in the lab using an Agilent model 34401A, 6 ½ digit 4 wire resistance bridge with a recent calibration as a reference. The residuals from a linear fit were approximately 0.05%. There is a practical problem that prevents this lab-bench specification from applying to the experiment however. Simple measurements of a person's impedance suggest it be modeled as a fairly large, leaky capacitor (approximately 60 uF) in series with a series-parallel resistor/capacitor combination of approximately 10 kOhms and 0.01 uF. The values of these model components have a frequency dependence, and the values also vary with the DC charge on the leaky capacitor. Also, the parameters vary simultaneously. Figure 3.6 shows the transfer function of the system versus changes in person resistance and capacitance at two kHz. The plots show how person R and C changes effect both the magnitude and phase of the output. As can be seen, the system is non-linear, but it is mostly monotonic with respect to changes in these parameters. Since it is only required to measure the relative change in impedance and not the absolute value of the impedance, this system suffices.

The typical operating mode is to null the system, then to offset the balancing pot so the system operates significantly out of balance on the resistance scale. This adjustment allows envelope demodulation to be used to decode the signal. FM demodulation also produces a signal, but since changes in R or C effect both magnitude and phase, the FM encoded information should not be unique. This reasoning and the relative computing cost of FM demodulation eliminated the technique from consideration.

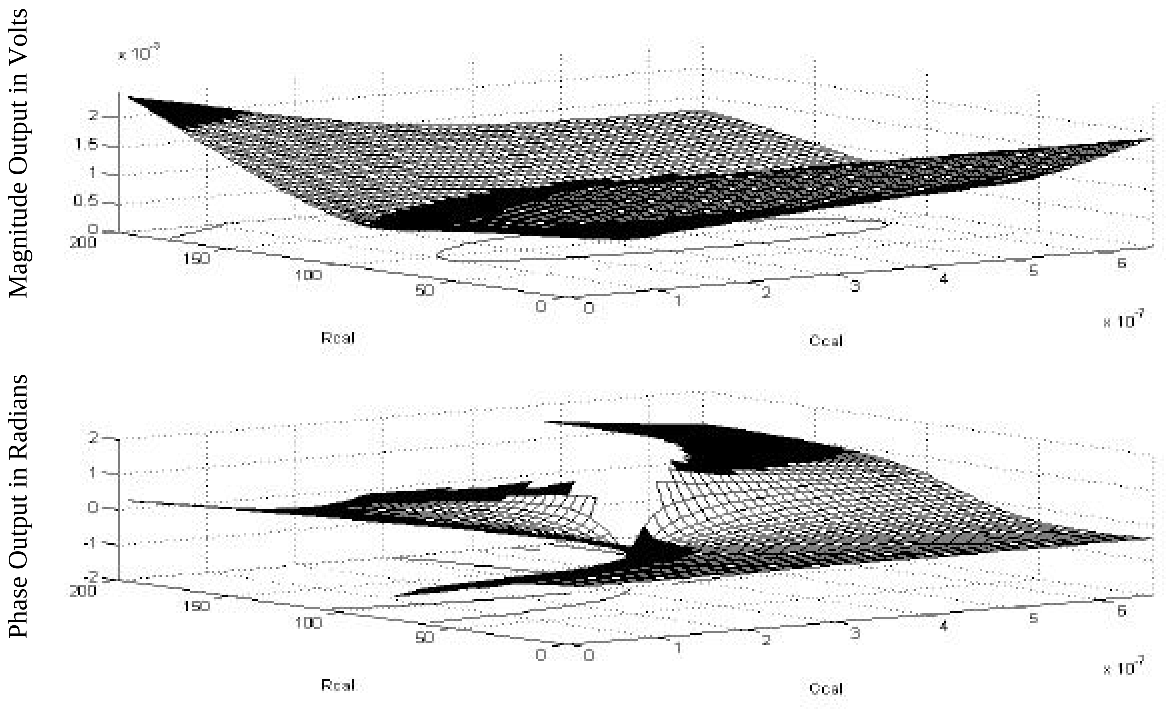
A resistor box using gold contact switches with a resistance of less than 10 milli-Ohms was used to switch calibration resistors in series with the person at the beginning and end of each run. This provided a check of the system and an approximate calibration.

The random number generator, system controller, impedance bridge, and laptop computer each has it's own DC battery-operated power supply. There is a common ground between the equipment but no signals are DC coupled.

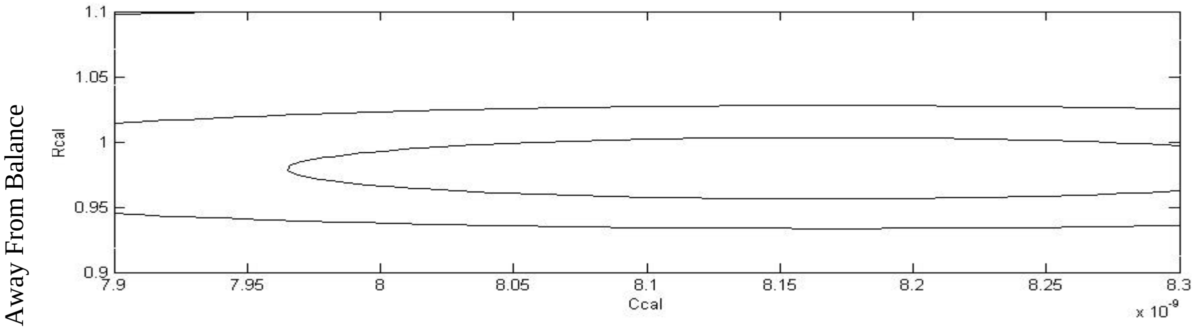
System performance versus a commercial gauge is shown in table 3.1.

Table 3.1. Performance versus commercial gauge

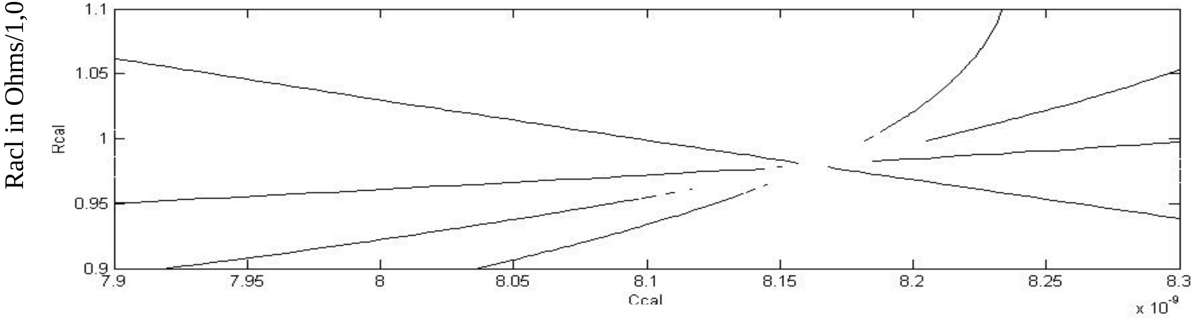
	Impedance Bridge	Commercial Unit
Minimum Detectable Signal	0.000002 Ohms	0.000006 Ohms (theoretical limit) 0.01 Ohms (practical spec)
Bandwidth	DC-900 Hz	DC-10 Hz
SNR	48 dB	38 dB (theoretical limit)
Dynamic Range	154 dB	184 dB (theoretical limit)



Rcal in Ohms away from balance, Ccal in farads away from balance



Equipotential magnitude output in volts



Equipotential phase output in radians

Figure 3.6. System transfer function versus changes in person R and C at two kHz.

CHAPTER 4

DATA, ANALYSIS AND RESULTS

Three hundred fourteen trials were done on 15 human subjects with 157 being emotional and 157 being calm. Two hundred thirty-one trials were done on worms with 114 having mechanical vibration and 117 having no stimulus. All data were considered in the analysis with no outliers being discarded. Figure 4.1 shows the modulated signal for a series of 20 runs on a human subject along with the demodulated signal for the same experiment. The step variations at either end of the data set are calibration points where resistors were switched in series with the subject at the beginning and end of the trials. The large sawtooth variations are due to factors such as deep respiration and movement and sometimes are observed to occur spontaneously. These variations can have very low frequency components with periods on the order of tens of seconds or even minutes. The spikes in the data indicate the time indexes where the images were shown. This figure shows an overview of the entire data set but lacks the resolution to see much response to the applied stimulus.

The data processing utilized Matlab scripts. The approach was to first apply a 2 kHz band pass filter; second to envelope demodulate the signal; third to apply a 2 Hz low pass filter, and lastly to down-sample to 200 Hz. At this point, the signals were stored in files for later analysis.

All the human calm trials were averaged, as were the emotional trials, and these results are shown in figure 4.2. The time scale is for a period of 25 seconds before to 25 seconds after the image was shown and the magnitude scale is decreased to show subtle variations. The large offset in the means of the two averaged signals results from very low frequency variations which could not average out given this sample size and are not significant. The negative spikes in the data at t=25 seconds are the marking of the data sets as calm or emotional by the system controller (one spike for calm, two for emotional) and indicate when the image was shown. The relatively larger peak after the emotional image is shown indicates an increase in impedance after viewing an emotional image. Of interest in this experiment is the relative short-term variation in the seconds just before the image is shown.

Figure 4.3 shows the average human calm and emotional trials zeroed at 3 seconds before the image is shown. This figure is very similar to the ones shown by Dr. Radin. Figure 4.4 shows histograms for all calm and all emotional trials where each data point is the average change referenced to the event minus 3 seconds, of each individual run, over the interval of 3 seconds before the event to 0.2 seconds before the event, as per equation 4.1. The unbiased estimator of the population standard deviation is used to predict error bars around the sample mean. The z-test yields an 87% significance level that means for calm and emotional trials were different. This suggests support for the hypothesis but is not highly significant. A similar analysis for the worm data showed a z-test significance of 85% for the last second of data before the event.

Significance Trending and System Validation

An analysis was made of the rate of convergence of the significance of the z-test for the human and worm data. This allowed estimation of the required number of trials to achieve a statistically significant result. The result are shown in figures 4.5 and 4.6. Based on these plots it may be estimated that a significant results might be achieved for humans with a number of trials in the low thousands. A system validation test was also done. This test replaced the human with an equivalent resistor and capacitor. A one Hz sinusoidal wave was used as a source of signal variation. In all other respects the test and processing was identical to what was performed with human subjects. Figure 4.5 shows the significance trend obtained and serves to validate the testing procedure, equipment, and processing to be free of bias.

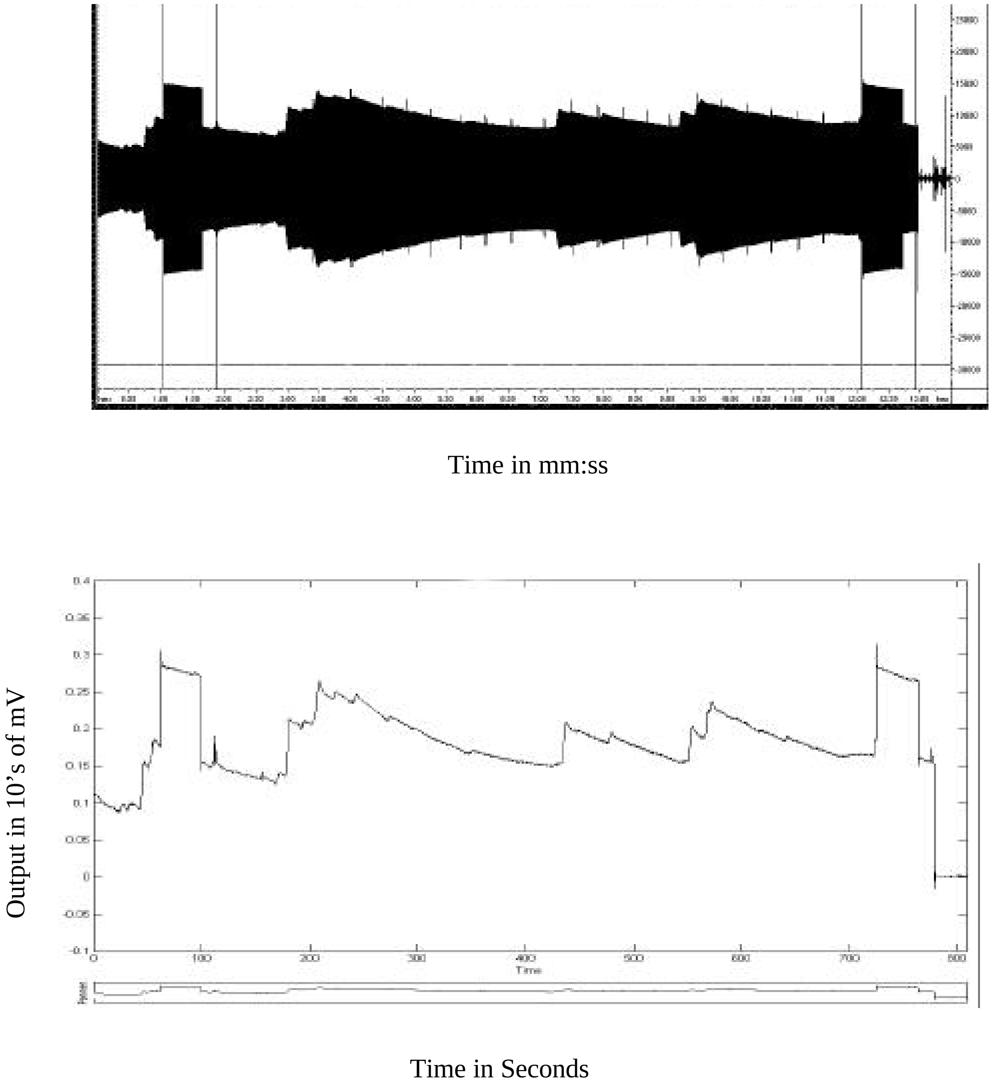


Figure 4.1. Illustration of the entire data set for subject 10, raw and processed.

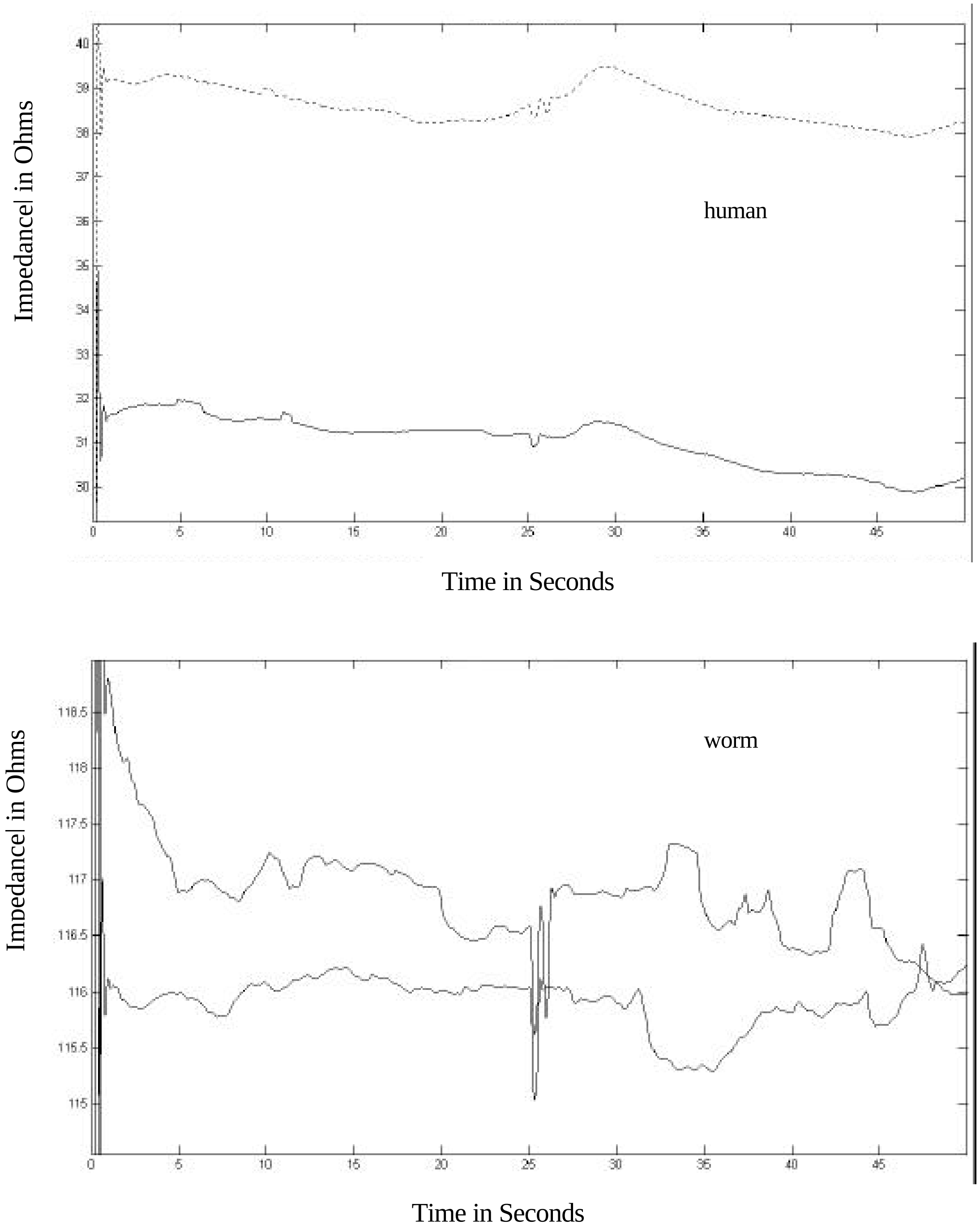


Figure 4.2. Plot of signal averages for all human and worm data sets.

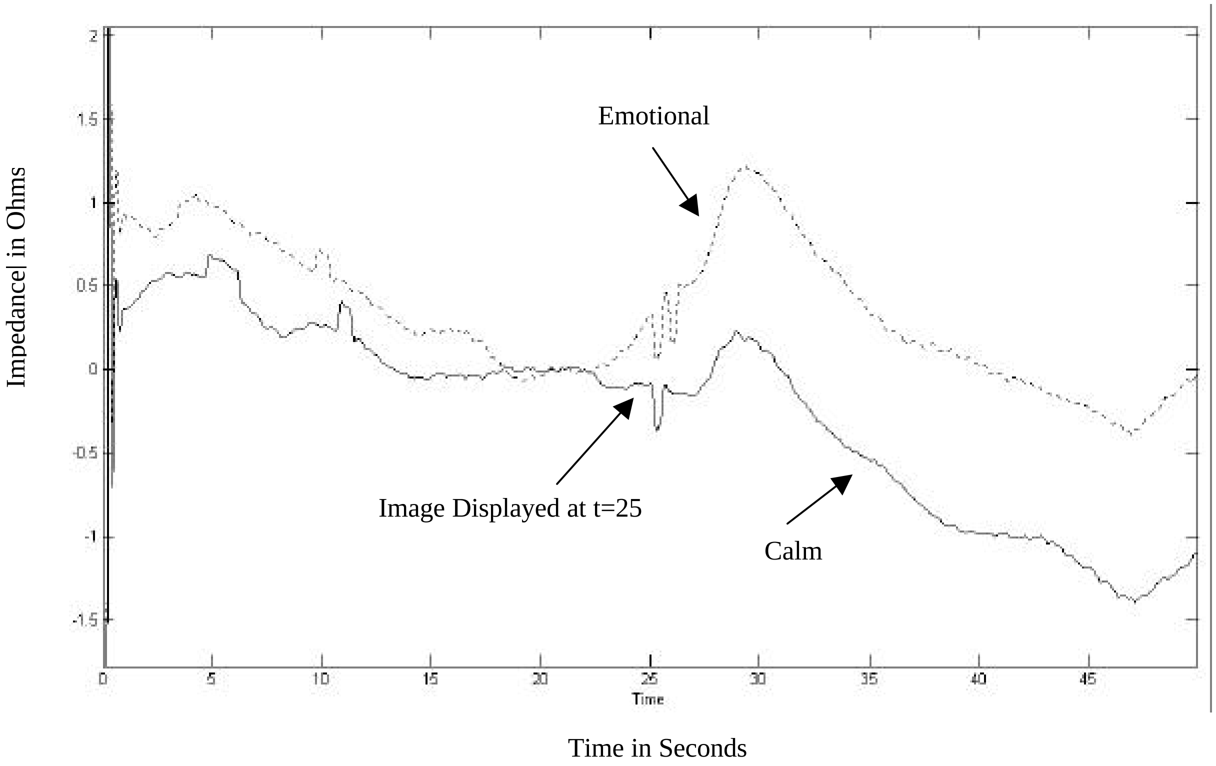


Figure 4.3. Emotional and calm data zeroed at event minus 3 seconds.

$$\text{Average} = \frac{1}{n}\left[\sum_{n} \left(f(0+n) - f(0)\right)\right]$$

Equation 4.1. Average change starting 3 seconds before event to 0.2 seconds before event. f(0) corresponds to the signal at event – 3 seconds, 1/n is the time for 1 sample

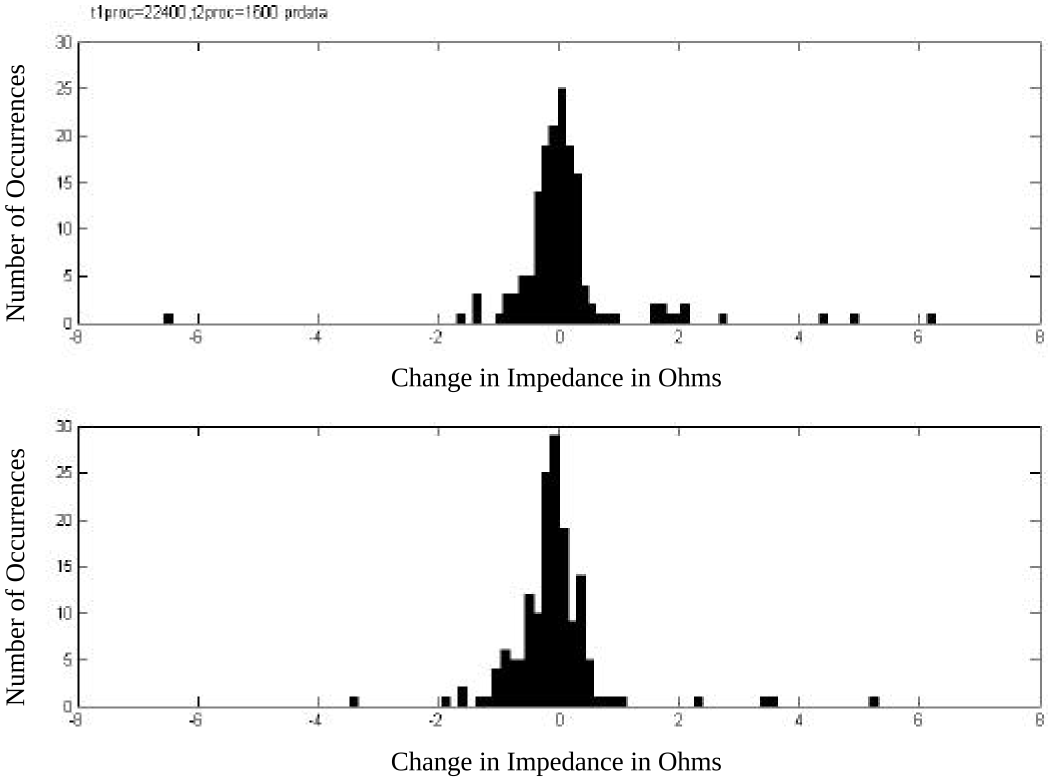
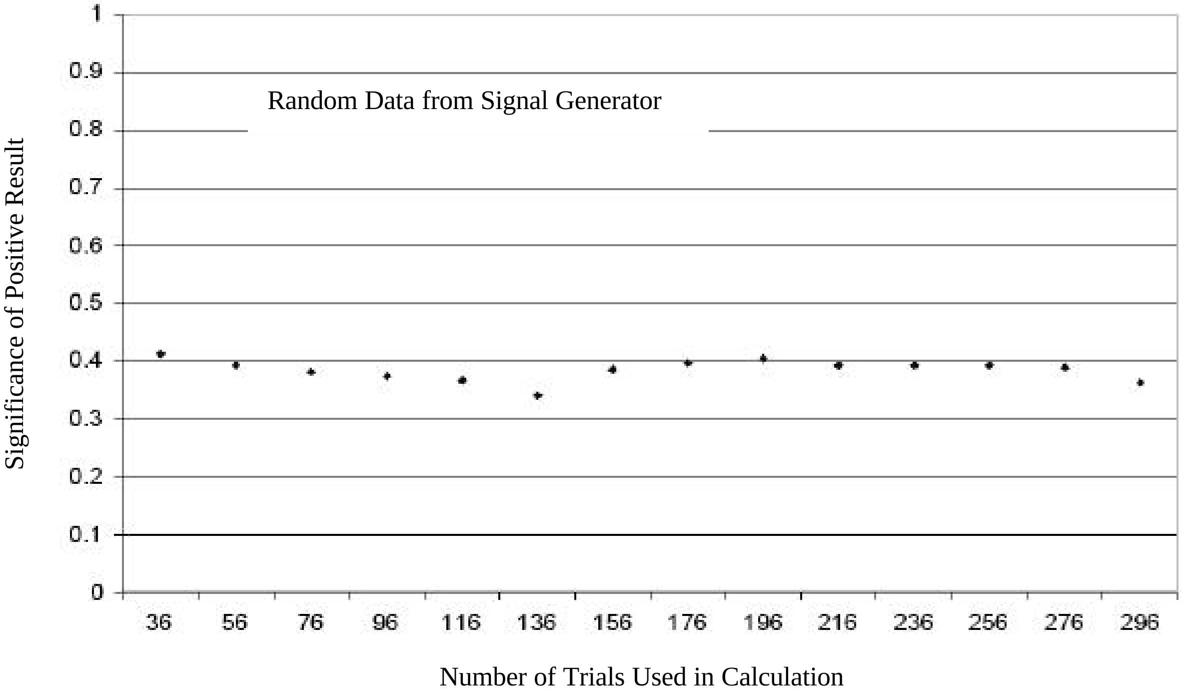


Figure 4.4. Histogram showing distributions of human calm and emotional data runs. Data were averaged over the time period 3 seconds to 0.2 seconds before the image was shown. All outliers are included on the plots.



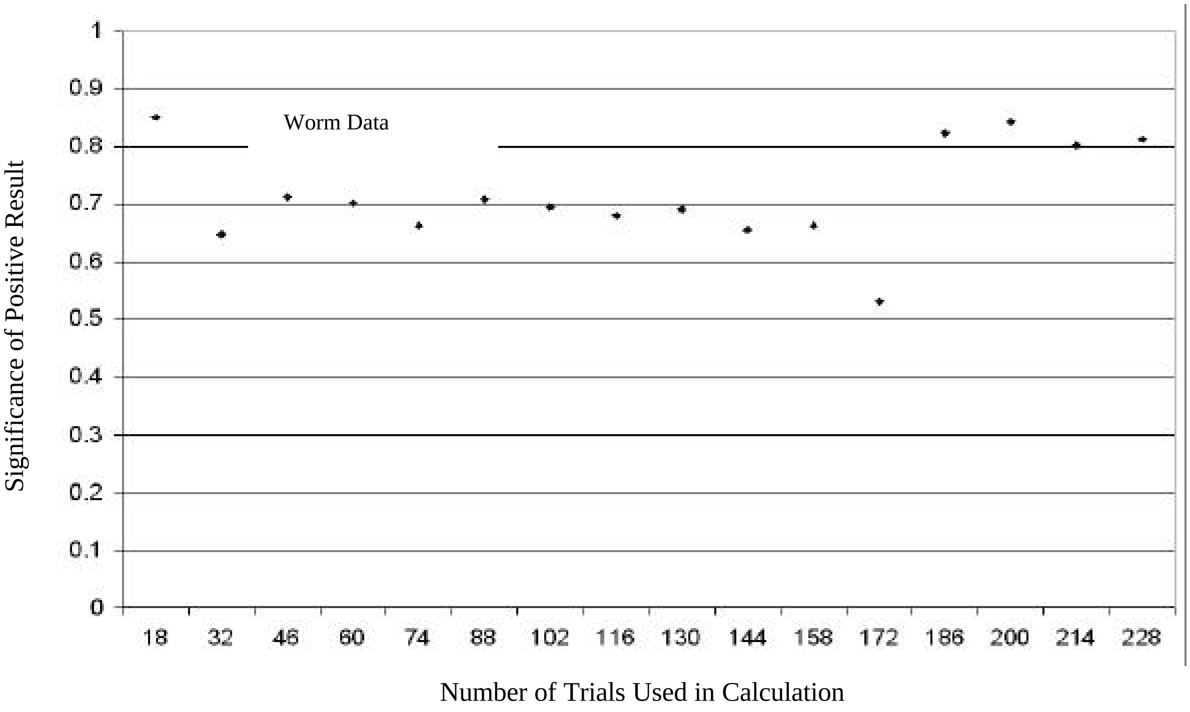


Figure 4.5. Significance of hypothesis test that impedance(emotional) > impedance(calm) versus number of trials used for random and worm data.

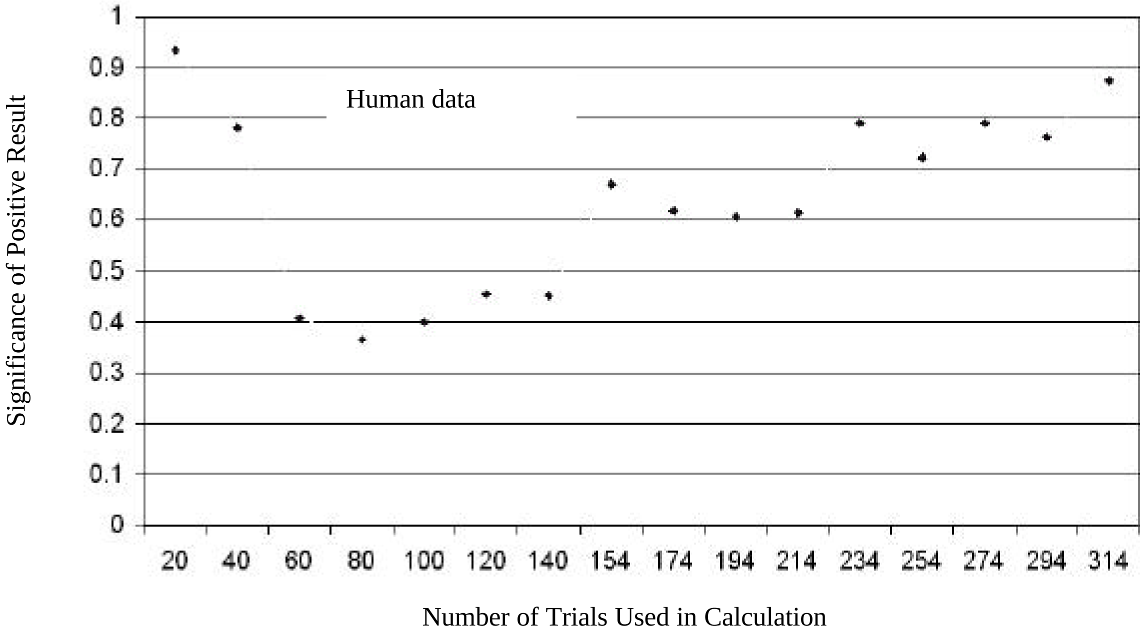


Figure 4.6. Significance of hypothesis test that impedance(emotional) > impedance(calm)versus number of trials used for human data. Values < 0.5 indicate the reverse condition.

CHAPTER 5

CONCLUSION AND FUTURE WORK

The results of this experiment support the hypothesis that skin impedance changes predict randomized future emotional responses in people. The results are not highly statistically significant. There is a one in eight probability that the result is due to chance. Things that suggest significance include average impedance plots very similar to those obtained by the original experimenters and the trend toward higher significance as more data sets were added to the analysis. A rough estimate of the number of data points required for high significance is in the low thousands. Similar results were found using earthworms with the time window extending one second before the stimulating event compared to three seconds before the event in human subjects.

To obtain 5,000 data sets, 250 human subjects are required and total lab testing time would be 65 hours. This experiment assumes that the random number generator is truly random, with no possibility of a predicting signal. Care was taken in the electrical design to insure this randomness. A Geiger counter based random number generator would eliminate even the slightest possibility of some unknown electrical feedback path and should be used for any larger scale future experiment.

APPENDIX A

BASIC PROGRAM FOR SYSTEM CONTROLLER TO RUN HUMAN TRIALS

```
1 S1=0:C1=0:REM INITIALIZE .. FIRST FIND MEAN OF RV GENERATOR
2 Y1=0:N1=0:RANDOMIZE
3 OUT 195,129:OUT 193,0:REM SET UP PORTS TO ZERO OUTPUT
4 R1=0:REM FIRST FIND RANDOM NUMBER DECISION POINT VARIABLE
5 FOR J = 1 TO 400:REM CHANGE TO 400 FOR RUNS
6 FOR I = 1 TO 33
7 T=10*10
8 NEXT I
9 OUT65,3:OUT64,0
10 Q1=INP(65):Q2=INP(64)
11 Q3=(Q1*4+Q2/64)*.004
12 R1=R1+Q3
13 NEXT J
14 R1=R1/400:REM PRINT R1

16 FOR K = 1 TO 20:REM 20 TRIALS FOR EACH PERSON
18 R=0:REM R1 IS THE PREDICTED MEAN OF THE RV, R IS THE
DECISION VALUE

25 B=2
26 OUT 193,B:REM TURN ON BUTTON LAMP
30 REM
40 REM TEST FOR BUTTON PRESS
50 A=INP(194)
60 IF A = 7 THEN GOTO 90:REM PRINT"BUTTON PRESS"
70 GOTO 50
80 REM
90 REM
100 REM TURN OFF LAMP AND START TIME DELAY
110 B=B-2
120 OUT 193,B
130 C=8:REM WAIT INTERAL BEFORE SHOWING PIC - SHOULD BE ABT
400 FOR 2 MINUTES

150 FOR J = 1 TO C:REM TIME DELAY LOOP UNTIL SHOW PIC
155 REM PRINT J,C
160 FOR I = 1 TO 33:REM 0.3 SECOND INTERVAL, REPEATED C TIMES
170 T=10*10
180 NEXT I
190 NEXT J
200 REM
300 REM GENERATE R

320 OUT65,3:OUT64,0:REM SET UP A/D INPUT
330 Q1=INP(65):Q2=INP(64):REM READ RV GENERATOR ONE TIME
```

```
340 Q3=(Q1*4+Q2/64)*.004:REM CONVERT BINARY TO DECIMAL
350 R=Q3-R1/26

371 REM PRINT "R":REM PRINT R
380 IF R>R1 THEN GOTO 500:REM SHOW CALM PICTURE
385 S1=S1+1:REM SHOW SCARY PICTURE
390 B=B+128+64:REM 'J' SCARY KEY ON AND MARK ON
392 OUT 193,B
395 FOR L=1 TO 2
400 T=10*10
405 NEXT L
410 B=B-128:OUT 193,B:REM TURN OFF J KEY
415 FOR I = 1 TO 33:REM 0.3 SEC DELAY
420 T=10*10
425 NEXT I
430 B=B-64
435 OUT 193,B:REM MARK OFF KEY OFF
440 FOR I = 1 TO 33:REM 0.3 SEC DELAY
445 T=10*10
450 NEXT I
455 B = B+64
460 OUT 193,B:REM MARK ON
465 FOR I = 1 TO 33
470 T=10*10
475 NEXT I
480 B = B-64
485 OUT 193,B:Y1=Y1+1:REM MARK OFF
490 GOTO 600:REM GO TO NEXT TRIAL

500 C1=C1+1:REM SHOW CALM PICTURE
510 B = B+64+1:REM DATA MARK AND SHOW CALM PIC
520 OUT 193,B:REM PRINT "K":REM MARK ON 'K' KEY ON
521 FOR L=1 TO 2
522 T=10*10
523 NEXT L
524 B=B-1:OUT 193,B:REM TURN OFF J KEY

525 B=B-1:OUT 193,B:REM K KEY OFF
525 FOR I = 1 TO 33:REM 0.3 SECOND DELAY
530 T=10*10
535 NEXT I
560 B = B-64
570 OUT 193,B:N1=N1+1:REM MARK OFF
600 REM
700 REM TIME DELAY BEFORE LIGHTING LAMP FOR NEXT RUN
```

```
710 FOR J = 1 TO 60:REM 60 FOR 18 SEC DELAY IN RUN
720 FOR I = 1 TO 33
730 T=10*10
740 NEXT I
750 NEXT J
800 NEXT K

850 REM FLASHING KEY ROUTINE TO INDICATE RUN OVER

860 B =2
870 OUT 193,B:REM LAMP ON
880 FOR I = 1 TO 33
890 T=10*10
900 NEXT I
910 B = 0
911 OUT 193,B:REM LAMP OFF
912 FOR I = 1 TO 33
914 T=10*10
916 NEXT I
930 GOTO 850

950 END
```

APPENDIX B

BASIC PROGRAM FOR SYSTEM CONTROLLER FOR RUN WORM TRIALS

```
1 REM INITIALIZE .. FIRST FIND MEAN OF RV GENERATOR
2 RANDOMIZE
3 OUT 193,0
4 R1=0:REM FIRST FIND RANDOM NUMBER DECISION POINT VARIABLE
5 FOR J = 1 TO 400
6 FOR I = 1 TO 33
7 T=10*10
8 NEXT I
9 OUT65,3:OUT64,0
10 Q1=INP(65):Q2=INP(64)
11 Q3=(Q1*4+Q2/64)*.004
12 R1=R1+Q3
13 NEXT J
14 R1=R1/400:PRINT R1

15 R=0:RANDOMIZE:REM R1 IS THE PREDICTED MEAN OF THE R R
20 OUT 195,129:REM SETUP PORTS
25 B=2
26 OUT 193,B:REM TURN ON BUTTON LAMP
30 REM
40 REM TEST FOR BUTTON PRESS
50 A=INP(194)
60 IF A = 7 THEN GOTO 90:REM PRINT"BUTTON PRESS"
70 GOTO 50
80 REM
90 FOR K = 1 TO 15:REM 15 TRIALS FOR EACH WORM
100 REM TURN OFF LAMP AND WAIT
110 R=0:B=B-2
120 OUT 193,B
130 C=RND(400):REM RANDOM INTERAL - SHOULD BE ABT 400 FOR 2
MINUTES
140 C = C+400:C=INT(C):REM ADD MINIMUM INTERAL - SHOULD BE ABT
600 FOR 3 MINUTES
150 FOR J = 1 TO C:REM TIME DELAY LOOP UNTIL BUZZ/NO BUZZ
155 REM PRINT J,C
160 FOR I = 1 TO 33:REM 0.3 SECOND INTERVAL, REPEATED C TIMES
170 T=10*10
180 NEXT I
190 NEXT J
200 REM
300 REM GENERATE R

320 OUT65,3:OUT64,0
330 Q1=INP(65):Q2=INP(64)
340 Q3=(Q1*4+Q2/64)*.004
```

```
350 R=Q3+.025

371 REM PRINT "R":REM PRINT R
380 IF R>R1 THEN GOTO 500:REM NO BUZZ WORM
385 REM BUZZ WORM
390 B=B+128+64:REM BUZZ AND MARK ON
391 OUT 193,B
392 FOR I = 1 TO 33:REM 0.3 SEC DELAY
393 T=10*10
394 NEXT I
395 B=B-64
396 OUT 193,B:REM MARK OFF
397 FOR I = 1 TO 33:REM 0.3 SEC DELAY
398 T=10*10
399 NEXT I
416 B = B+64
417 OUT 193,B:REM MARK ON
418 FOR I = 1 TO 33
419 T=10*10
420 NEXT I
421 B = B-64
430 OUT 193,B:REM MARK OFF
431 FOR I = 1 TO 1000:REM ON-TIME
432 T=10*10
433 NEXT I
434 B = B-128+2
435 OUT 193,B:RANDOMIZE:REM OFF BUZZ ON LIGHT ON
440 GOTO 600:REM GO TO NEXT TRIAL
500 REM NO BUZZ WORM
510 B = B+64
520 OUT 193,B:REM MARK ON
521 FOR I = 1 TO 33:REM 0.3 SECOND DELAY
522 T=10*10
523 NEXT I
560 B = B-64+2
570 OUT 193,B:RANDOMIZE:REM MARK OFF LIGHT ON
600 NEXT K
610 GOTO 50:REM GO TURN BACK ON LIGHT TO INDICATE END OF RUN
```

APPENDIX C

SEGMENTS OF VISUAL BASIC CODE FOR SLIDE VIEWING PROGRAM

```
Public jCounts As Integer
Public fCounts As Integer
Public jEN As Integer
Public fEN As Integer

Private Sub Form_Load()

Randomize
fCounts = Int((19 - 1 + 1) * Rnd + 1)

Randomize
jCounts = Int((19 - 1 + 1) * Rnd + 1)

End Sub

Private Sub Command1_KeyPress(KeyAscii As Integer)

If KeyAscii = 114 Then
Randomize
fCounts = Int((19 - 1 + 1) * Rnd + 1)
Randomize
jCounts = Int((19 - 1 + 1) * Rnd + 1)
End If

If KeyAscii = 106 Then
jCounts = jCounts + 1
jEN = 1
Timer1.Enabled = True
End If

'calm counts

If KeyAscii = 102 Then
fCounts = fCounts + 1
fEN = 1
Timer1.Enabled = True
End If

If jEN = 1 Then
If jCounts = 1 Then
Picture2.Picture = Picture22.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 2 Then
```

```
Picture2.Picture = Picture23.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 3 Then
Picture2.Picture = Picture24.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 4 Then
Picture2.Picture = Picture25.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 5 Then
Picture2.Picture = Picture26.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 6 Then
Picture2.Picture = Picture27.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 7 Then
Picture2.Picture = Picture28.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 8 Then
Picture2.Picture = Picture29.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 9 Then
Picture2.Picture = Picture30.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 10 Then
Picture2.Picture = Picture31.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 11 Then
Picture2.Picture = Picture32.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 12 Then
Picture2.Picture = Picture33.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 13 Then
```

```
Picture2.Picture = Picture34.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 14 Then
Picture2.Picture = Picture35.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 15 Then
Picture2.Picture = Picture36.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 16 Then
Picture2.Picture = Picture37.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 17 Then
Picture2.Picture = Picture38.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 18 Then
Picture2.Picture = Picture39.Picture  'Button Must Have Focus
Picture2.Visible = True


ElseIf jCounts = 19 Then
Picture2.Picture = Picture40.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf jCounts = 20 Then
Picture2.Picture = Picture41.Picture  'Button Must Have Focus
Picture2.Visible = True
jCounts = 0

End If

End If

If fEN = 1 Then
If fCounts = 1 Then
Picture2.Picture = Picture1.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 2 Then
Picture2.Picture = Picture3.Picture  'Button Must Have Focus
```

```
Picture2.Visible = True

ElseIf fCounts = 3 Then
Picture2.Picture = Picture4.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 4 Then
Picture2.Picture = Picture5.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 5 Then
Picture2.Picture = Picture6.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 6 Then
Picture2.Picture = Picture7.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 7 Then
Picture2.Picture = Picture8.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 8 Then
Picture2.Picture = Picture9.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 9 Then
Picture2.Picture = Picture10.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 10 Then
Picture2.Picture = Picture11.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 11 Then
Picture2.Picture = Picture12.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 12 Then
Picture2.Picture = Picture13.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 13 Then
Picture2.Picture = Picture14.Picture  'Button Must Have Focus
Picture2.Visible = True
```

```
ElseIf fCounts = 14 Then
Picture2.Picture = Picture15.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 15 Then
Picture2.Picture = Picture16.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 16 Then
Picture2.Picture = Picture17.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 17 Then
Picture2.Picture = Picture18.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 18 Then
Picture2.Picture = Picture19.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 19 Then
Picture2.Picture = Picture20.Picture  'Button Must Have Focus
Picture2.Visible = True

ElseIf fCounts = 20 Then
Picture2.Picture = Picture21.Picture  'Button Must Have Focus
Picture2.Visible = True
fCounts = 0

End If

End If

fEN = 0
jEN = 0

End Sub
```

APPENDIX D

CONSENT FORM

1. Study Title:
   Impulse Response Of Biological Systems

2. Principal Investigator:
   Chester Wildey

3. Telephone Number And Email Address For Contacting Principal Investigator:
   817.861.3023 email: iamsnoozin@yahoo.com

4. Purpose Of This Study:
   This study is designed to measure your biological response (in this case your skin conductance) to visual stimulus.

5. Benefit Of This Study To Principal Investigator:
   This study is an integral part of the principal investigators Masters Thesis in Electrical Engineering.

6. Explanation Of What You Are Being Asked To Do:
   You will view a series of images on a computer screen. Some of the images will be of calm scenes, some will be of scenes designed to evoke an emotional response (emotional images). The emotional images are intended to be arousing, disturbing or shocking. Images will appear on-screen for approximately 3 seconds.

7. This Is How You Were Identified For Participation:
   Participants were identified at random.

8. The Maximum Number Of Subjects In This Study:
   There will be a maximum of 40 participants in this study.

9. Risks And Benefits Of This Study For You:
   Approximately one half of the images in this study will be of highly emotional and graphic content. If these types of images will unduly disturb you, you may withdraw from this study at any time with no penalty.

10. Participation Is Voluntary:
    You may stop your participation in this test at any time. There is no penalty if you decide to stop your participation.

11. Confidentiality Statement:
    Your name will not be released in the results of this study. Individual results will be identified only by non-personal data, for example, participant #1, participant #2, etc. All identifying documentation (including consent forms and questionnaires) will be kept under lock and key, and the only access will be by the principal investigator. Personal

identifying information will not be shared with any other person during this experiment or at any later time.

12. You May Ask Questions Of The Principal Investigator:

I have had a chance to ask and have had answered all questions concerning this study.

Initial Here To So Indicate: ___________.

13. UTA Statement:

This research study has been reviewed and approved by The University of Texas at Arlington Institutional Review Board for the Protection of Human
Subjects. If you have questions about your rights as a research subject or about a research related injury, you may contact a representative of the committee by calling 817-272-2105.

14. Statement Of Limited Indemnity:

In the event I am injured in the course of this study, I may go to the UTA Health Service Center and be treated in the usual way providing I am a student currently registered at UTA. Otherwise, I may be covered under optional medical insurance that I carry. UTA does not offer any other compensation for injury.

15. Faculty Supervisor Of The Principal Investigator:

This study is under the direction of faculty Dr. Adrian Fung, Department of Electrical Engineering, Telephone Number (817) 272-3422. Please call for any concerns or questions related to the study.

I have read and agree to the above 15 statements.

Name(print):_____________________________

Date:___________________________________

Signature:_______________________________

APPENDIX E

MATLAB SCRIPT TO FIND CALM AND EMOTIONAL AVERAGES FOR A SINGLE DATA SET

```
%import the required filters from sptool - 2khz bpf and 2 hz lpf before running this program

%change file name for wavread to correct data set

%Time indexes for calibrations before and after the run:
% Three files - one for calibration, one for no inpulses and one for yes impulses for each data
run
%The output for the impulse files are the data points for each event or yes or no
%The output for the calibration file are the two data points showing the delta R
%responses for before and after the run.

%Data is input into the session by import ascii data func before this script is run: the
locations of impulses - y(1),y(2)...n(1), n(2) .. and
%cal(1) and cal(2)location indexes. Cal1proc is the time to ignore before the calibration
switch, ca12proc is the time to go before
%cal1proc to start the cal averaging. cal3proc is the time to ignore after the cal switch, and
cal4proc is the time after
%cal3proc to average for calibration of the second point.

%PLACES REQUIRING MODS FOR A SPECIFIC FILE ARE MARKED WITH
COMMENTS IN ALL CAPS LIKE THIS

y = load('c:\athesis\run data\pr1yes.txt');
n = load('c:\athesis\run data\pr1no.txt');
cal = load('c:\athesis\run data\pr1cal.txt');

%SET PARAMETERS AS DESIRED
%!!!!!!!! SET THIS VARIABLE IN WORKSPACE
tpre=80000;tpost=80000;t1proc=16500;t2proc=500;
%time window to use in calculation of data point

%tpre=80000;tpost=80000;t1proc=16500;t2proc=500;cal1proc=40;cal2proc=133;cal3proc=8
00;cal4proc=133;

%!!!!!!!! SET THIS VARIABLE IN WORKSPACE
cal1proc=40;cal2proc=133;cal3proc=800;cal4proc=133;

%time windows for processing calibration points

% ENTER NUMBER OF YESSES AND NUMBER OF NOS
numno=10;
numyes=10;
%number of yesses and nos
```

```
%tpre is the number of data points before the event the data is to be taken from
%tpost is the number of data points after the event that are to be processed
%t1proc and t2proc set the interval for integration of the signal, t1proc sets how many data
poinst before event to begin
%integration, t2proc sets how many data points before the event to stop integration.


%Import the yes/no/cal data set indexes:

%change file to correct data set, delete data sets not used.

%DELETE LINES FOR UNUSED FILES

data1n =wavread('c:\athesis\run data\pr1.wav',[n(1)-tpre,n(1)+tpost]);
   databpf1n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data1n);
   databpfabs1n=abs(databpf1n);
   signal1n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs1n);

data2n =wavread('c:\athesis\run data\pr1.wav',[n(2)-tpre,n(2)+tpost]);
   databpf2n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data2n);
   databpfabs2n=abs(databpf2n);
   signal2n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs2n);

data3n =wavread('c:\athesis\run data\pr1.wav',[n(3)-tpre,n(3)+tpost]);
   databpf3n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data3n);
   databpfabs3n=abs(databpf3n);
   signal3n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs3n);

data4n =wavread('c:\athesis\run data\pr1.wav',[n(4)-tpre,n(4)+tpost]);
   databpf4n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data4n);
   databpfabs4n=abs(databpf4n);
   signal4n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs4n);

data5n =wavread('c:\athesis\run data\pr1.wav',[n(5)-tpre,n(5)+tpost]);
   databpf5n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data5n);
   databpfabs5n=abs(databpf5n);
   signal5n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs5n);

data6n =wavread('c:\athesis\run data\pr1.wav',[n(6)-tpre,n(6)+tpost]);
   databpf6n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data6n);
   databpfabs6n=abs(databpf6n);
   signal6n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs6n);
```

```
data7n =wavread('c:\athesis\run data\pr1.wav',[n(7)-tpre,n(7)+tpost]);
    databpf7n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data7n);
    databpfabs7n=abs(databpf7n);
    signal7n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs7n);

data8n =wavread('c:\athesis\run data\pr1.wav',[n(8)-tpre,n(8)+tpost]);
    databpf8n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data8n);
    databpfabs8n=abs(databpf8n);
    signal8n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs8n);

data9n =wavread('c:\athesis\run data\pr1.wav',[n(9)-tpre,n(9)+tpost]);
    databpf9n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data9n);
    databpfabs9n=abs(databpf9n);
    signal9n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs9n);

data10n =wavread('c:\athesis\run data\pr1.wav',[n(10)-tpre,n(10)+tpost]);
    databpf10n=filter(filtBP2k.tf.num,filtBP2k.tf.den,data10n);
    databpfabs10n=abs(databpf10n);
    signal10n=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs10n);

    %now the yes cases:

    %DELETE LINES FOR UNUSED FILES

data1y =wavread('c:\athesis\run data\pr1.wav',[y(1)-tpre,y(1)+tpost]);
    databpf1y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data1y);
    databpfabs1y=abs(databpf1y);
    signal1y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs1y);

data2y =wavread('c:\athesis\run data\pr1.wav',[y(2)-tpre,y(2)+tpost]);
    databpf2y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data2y);
    databpfabs2y=abs(databpf2y);
    signal2y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs2y);

data3y =wavread('c:\athesis\run data\pr1.wav',[y(3)-tpre,y(3)+tpost]);
    databpf3y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data3y);
    databpfabs3y=abs(databpf3y);
    signal3y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs3y);

data4y =wavread('c:\athesis\run data\pr1.wav',[y(4)-tpre,y(4)+tpost]);
    databpf4y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data4y);
    databpfabs4y=abs(databpf4y);
    signal4y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs4y);
```

```
data5y =wavread('c:\athesis\run data\pr1.wav',[y(5)-tpre,y(5)+tpost]);
    databpf5y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data5y);
    databpfabs5y=abs(databpf5y);
    signal5y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs5y);

data6y =wavread('c:\athesis\run data\pr1.wav',[y(6)-tpre,y(6)+tpost]);
    databpf6y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data6y);
    databpfabs6y=abs(databpf6y);
    signal6y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs6y);

data7y =wavread('c:\athesis\run data\pr1.wav',[y(7)-tpre,y(7)+tpost]);
    databpf7y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data7y);
    databpfabs7y=abs(databpf7y);
    signal7y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs7y);

data8y =wavread('c:\athesis\run data\pr1.wav',[y(8)-tpre,y(8)+tpost]);
    databpf8y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data8y);
    databpfabs8y=abs(databpf8y);
    signal8y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs8y);

data9y =wavread('c:\athesis\run data\pr1.wav',[y(9)-tpre,y(9)+tpost]);
    databpf9y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data9y);
    databpfabs9y=abs(databpf9y);
    signal9y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs9y);

data10y =wavread('c:\athesis\run data\pr1.wav',[y(10)-tpre,y(10)+tpost]);
    databpf10y=filter(filtBP2k.tf.num,filtBP2k.tf.den,data10y);
    databpfabs10y=abs(databpf10y);
    signal10y=filter(filtLP2Hz.tf.num,filtLP2Hz.tf.den,databpfabs10y);


    %find avg data points

    %DELETE LINES FOR UNUSED FILES
    avg1n=0;
    avg2n=0;
    avg3n=0;
    avg4n=0;
    avg5n=0;
    avg6n=0;
    avg7n=0;
    avg8n=0;
    avg9n=0;
```

```
avg10n=0;

 %DELETE LINES FOR UNUSED FILES
avg1y=0;
avg2y=0;
avg3y=0;
avg4y=0;
avg5y=0;
avg6y=0;
avg7y=0;
avg8y=0;
avg9y=0;
avg10y=0;

%DELETE LINES FOR UNUSED FILES
for i = 1:t1proc
    avg1n=avg1n+((signal1n(tpre-t1proc-t2proc)-signal1n(tpre-t2proc-i)));
    avg2n=avg2n+((signal2n(tpre-t1proc-t2proc)-signal2n(tpre-t2proc-i)));
    avg3n=avg3n+((signal3n(tpre-t1proc-t2proc)-signal3n(tpre-t2proc-i)));
    avg4n=avg4n+((signal4n(tpre-t1proc-t2proc)-signal4n(tpre-t2proc-i)));
    avg5n=avg5n+((signal5n(tpre-t1proc-t2proc)-signal5n(tpre-t2proc-i)));
    avg6n=avg6n+((signal6n(tpre-t1proc-t2proc)-signal6n(tpre-t2proc-i)));
    avg7n=avg7n+((signal7n(tpre-t1proc-t2proc)-signal7n(tpre-t2proc-i)));
    avg8n=avg8n+((signal8n(tpre-t1proc-t2proc)-signal8n(tpre-t2proc-i)));
    avg9n=avg9n+((signal9n(tpre-t1proc-t2proc)-signal9n(tpre-t2proc-i)));
    avg10n=avg10n+((signal10n(tpre-t1proc-t2proc)-signal10n(tpre-t2proc-i)));

end

 %DELETE LINES FOR UNUSED FILES
for i = 1:t1proc
    avg1y=avg1y+((signal1y(tpre-t1proc-t2proc)-signal1y(tpre-t2proc-i)));
    avg2y=avg2y+((signal2y(tpre-t1proc-t2proc)-signal2y(tpre-t2proc-i)));
    avg3y=avg3y+((signal3y(tpre-t1proc-t2proc)-signal3y(tpre-t2proc-i)));
    avg4y=avg4y+((signal4y(tpre-t1proc-t2proc)-signal4y(tpre-t2proc-i)));
    avg5y=avg5y+((signal5y(tpre-t1proc-t2proc)-signal5y(tpre-t2proc-i)));
    avg6y=avg6y+((signal6y(tpre-t1proc-t2proc)-signal6y(tpre-t2proc-i)));
    avg7y=avg7y+((signal7y(tpre-t1proc-t2proc)-signal7y(tpre-t2proc-i)));
    avg8y=avg8y+((signal8y(tpre-t1proc-t2proc)-signal8y(tpre-t2proc-i)));
    avg9y=avg9y+((signal9y(tpre-t1proc-t2proc)-signal9y(tpre-t2proc-i)));
    avg10y=avg10y+((signal10y(tpre-t1proc-t2proc)-signal10y(tpre-t2proc-i)));
    %systematic sign error removed when signals combined later

end
```

```
 %DELETE LINES FOR UNUSED FILES
avg1n=(avg1n/t1proc);
avg2n=(avg2n/t1proc);
avg3n=(avg3n/t1proc);
avg4n=(avg4n/t1proc);
avg5n=(avg5n/t1proc);
avg6n=(avg6n/t1proc);
avg7n=(avg7n/t1proc);
avg8n=(avg8n/t1proc);
avg9n=(avg9n/t1proc);
avg10n=(avg10n/t1proc);

 %DELETE LINES FOR UNUSED FILES
avg1y=(avg1y/t1proc);
avg2y=(avg2y/t1proc);
avg3y=(avg3y/t1proc);
avg4y=(avg4y/t1proc);
avg5y=(avg5y/t1proc);
avg6y=(avg6y/t1proc);
avg7y=(avg7y/t1proc);
avg8y=(avg8y/t1proc);
avg9y=(avg9y/t1proc);
avg10y=(avg10y/t1proc);

%now do cal data

cal1a=0;
cal1b=0;
cal2a=0;
cal2b=0;

%if cal(1)=0
  %  cal(1)=100000
  %end

%if cal(2)=0
%    cal(2)=100000
%end

%datacal1 =wavread('c:\athesis\run data\pr1.wav',[cal(1)-tpre,cal(1)+tpost]);
%datacal2 =wavread('c:\athesis\run data\pr1.wav',[cal(2)-tpre,cal(2)+tpost]);

%datacal1f1=filter(filtBP2k.tf.num,filtBP2k.tf.den,datacal1);
```

```
 %datacal1f1abs=abs(datacal1f1);
 %signalcal1=filter(filtLP100Hz.tf.num,filtLP2Hz.tf.den,datacal1f1abs);

 %datacal2f1=filter(filtBP2k.tf.num,filtBP2k.tf.den,datacal2);
 %datacal2f1abs=abs(datacal2f1);
 %signalcal2=filter(filtLP100Hz.tf.num,filtLP2Hz.tf.den,datacal2f1abs);

%for i = 1:cal2proc
%     cal1a=cal1a+signalcal1(tpre-cal1proc-cal2proc+i);
 %    cal1b=cal1b+signalcal1(tpre+cal3proc+i);
 %end

% for i = 1:cal4proc
 %    cal2a=cal2a+signalcal2(tpre-cal1proc-cal2proc+i);
  %   cal2b=cal2b+signalcal2(tpre+cal3proc+i);
  %end

 %calout=zeros(2,1);
 %calout(1)=(cal1a-cal1b)/cal2proc;
 %calout(2)=(cal2a-cal2b)/cal4proc;

% if cal(1)=100000
%     calout(1)=9999
% end
% if cal(2)=100000
 %    calout(2)=9999
 % end

 %output to ascii files

 no=zeros(numno,1);
 yes=zeros(numyes,1);

   %DELETE LINES FOR UNUSED FILES

 no(1)=avg1n;
 no(2)=avg2n;
 no(3)=avg3n;
 no(4)=avg4n;
 no(5)=avg5n;
 no(6)=avg6n;
 no(7)=avg7n;
 no(8)=avg8n;
 no(9)=avg9n;
```

```
no(10)=avg10n;

%DELETE LINES FOR UNUSED FILES

yes(1)=avg1y;
yes(2)=avg2y;
yes(3)=avg3y;
yes(4)=avg4y;
yes(5)=avg5y;
yes(6)=avg6y;
yes(7)=avg7y;
yes(8)=avg8y;
yes(9)=avg9y;
yes(10)=avg10y;

%ENTER FILENAMES FOR OUTPUT DATA
save c:\athesis\rundataout\pr1youtavg.txt yes -ASCII
save c:\athesis\rundataout\pr1noutavg.txt no -ASCII
%save c:\athesis\rundataout\pr1calout.txt calout –ASCII
```

REFERENCES

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   Excerpt of interview with Kary Mullis, May 1999.

   "… demonstrated quite readily to me, that I could see about 3 seconds into the future, like a little thing could say, I can't myself, but my physiology can, my skin conductivity can know that a particular picture that they're going to show me in three seconds is going to scare me. Before anybody can tell what picture it's going to be, it's going to be one of a collection of say 500 pictures, and it is chosen at the very last instant by a device which has got to do with quantum mechanics so nobody could have known it, and the computer doesn't even know which one it was going to select. It's spooky. You sit there and watch this little trace, and about three seconds, on average, before the picture comes on, you have a little response in your skin conductivity which is in the same direction that a large response occurs after you see the picture. Some pictures make you have a rise in conductivity, some make you have a fall. He's done that over and over again with people. That, with me, is on the edge of physics itself, with time. There's something funny about time that we don't understand because you shouldn't be able to do that …"

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BIOGRAPHICAL INFORMATION

The author received his master of science in Electrical Engineering from The University of Texas at Arlington in December 2001 and his bachelor of science in Mathematics from The University of Texas at Arlington in June 1985.