Lesson 9: Galvanic Skin Response & The Polygraph

1. INTRODUCTION

Electricity flows through an electrical circuit because of a difference in electrical pressure between the beginning and the end of a circuit. Electrical pressure or electromotive force (E) is measured in volts (V). The flow of electricity, called current (1), is measured in amperes (A) or amps for short. As electricity flows through the circuit, resistance to flow occurs. Electrical resistance (R) is measured in ohms (Ω).

In a simple circuit of direct electrical current, the relationship between the electromotive force causing the electrical current, the resistance to flow of electricity and the resultant magnitude of the current is described by Ohm's Law.

Ohm's Law: I (Amps) = E (Volts) / R (Ohms)

If two of the three variables are known, the unknown third variable can be calculated.

> *For example, if voltage and resistance values for a simple circuit are known, the above formula can be used to calculate the value for current; if the values for current and resistance are known, then the formula for computing voltage is E = IR.*

Ohm's Law implies that if a constant current is applied across a resistance, changes in the resistance will produce a voltage change directly proportional to the resistance change.

> *For example, if a constant current of 1.0 ampere is applied across a resistance of 2.0 ohms, the measured voltage would be 2.0 volts (I = E/R, 1.0 ampere = 2.0 volts/2.0 ohms). If the resistance dropped to 0.5 ohm, the voltage would also fall to 0.5 volt (I = E/R, 1.0 amperes = 0.5 volt/0.5 ohm).*

In this lesson, you will apply principles of Ohm's Law and record changes in the electrical resistance of the skin.

The human skin displays several forms of bioelectric phenomena, especially in areas of the extremities such as the fingers, palms of the hands, and soles of the feet.

> ►**Galvanic skin resistance (GSR)** - When a feeble electric current is steadily applied between two electrodes placed about an inch apart, the recorded electrical resistance between them, referred to as the galvanic skin resistance (GSR), varies in accordance with the emotional state of the subject.
>
> ►**Galvanic skin potential (GSP)** - Similarly, if the electrodes are connected to a suitable voltage amplifier, but without any externally applied current, the voltage measured between them, referred to as the galvanic skin potential (GSP), varies with the emotional state of the subject.

The combined changes in the GSR and GSP related to the emotion of the subject constitute the galvanic skin response.

The physiological basis of the galvanic skin response is a change in autonomic tone, largely *sympathetic,* occurring in the skin and subcutaneous tissue in response to a change in the affective state of the subject. Changes in peripheral autonomic tone alter sweating and cutaneous blood flow, which in turn change GSR and GSP.

> *For example, if a painful stimulus such as a pinprick is applied to the skin in an area distant to the electrode, the stimulus will reflexively elicit a general phasic sympathetic discharge to sweat glands, increasing; secretion. The increase in sweat, although generally small, lowers the electrical resistance of the skin because sweat contains water and electrolytes, both of which increase electrical conductivity of the skin.*

As in the case of somatic sensory stimuli (e.g., pain, pressure, touch), changes in emotion elicit changes in peripheral autonomic tone and hence the galvanic skin response. A common example is the vasodilation of cutaneous blood vessels of the face (blushing) and increased sweating that often occurs in the emotional state of embarrassment.

The detection and recording of the galvanic skin response is often combined with the detection and recording of other autonomic-dependent psychophysiological variables such as heart rate, respiratory rate, and blood pressure. The device that detects and records these variables is called a **polygraph.** Although many people think polygraph is synonymous with lie detector, the literal meaning is "many measures" (poly - many, graph - write). This lesson is a polygraph in the true sense of the word since it uses three types of measures: (a) GSR, (b) respiration, and (c) heart rate.

One of the underlying principles involved in using the polygraph as a lie detector is that autonomic nervous system control of heart rate, respiratory rate, blood pressure and flow, and sweating cannot consciously be altered. Another principle is that changes in emotion associated with intentional falsification of answers to carefully selected and worded questions involuntarily and subconsciously alters autonomic output in such a way as to cause recognizable changes in recorded physiological variables.

In the experiments that follow, you will record respiration, GSR, and heart rate under various experimental procedures so as to gain a better understanding of polygraphy, its applications, and its limitations.

> ***It is important to*** *keep in mind that although the recording procedures and measures used are similar to those that might be used in a real polygraph recording, this is not a "lie detector test." All you will do here is record the subject's physiological responses to certain questions. Some types of physiological responses are typically associated with "lying," although even under the best conditions about one-third of innocent people "fail" lie detector tests. The best you can hope for here is to get a better understanding of how these types of procedures work.*

II. EXPERIMENTAL OBJECTIVES

1) To become familiar with procedures for recording the galvanic skin response.

2) To observe and record changes in respiratory rate, heart rate, and skin resistance associated with somatic and special sensory stimuli.

3) To observe and record changes in respiratory rate, heart rate, and skin resistance associated with cognitive behavior and emotion.

4) To analyze a 3-channel polygram recorded under various experimental conditions to gain a better understanding of polygraphy and its potential for use and misuse.

III. MATERIALS

> BIOPAC disposable vinyl electrodes (EL503) - 3 electrodes per Subject

> BIOPAC Electrode lead set (SS2L)

> BIOPAC GSR setup

- Disposable Setup: EDA/GSR Lead (SS57L) and EDA Gelled Electrodes (EL507 x 2)

- Reusable setup: GSR transducer (SS3L) and Electrode gel (GELI)

> BIOPAC Respiration transducer (SS5LB or older SS5LA or SS5L)

> BIOPAC PAPER 1
Or nine sheets of different colored paper. Recommended: 8-1/2" x 11" sheets in white, black, green, red, blue, yellow, orange, brown, purple

> Computer system

> Biopac Student Lab 3.7 for PC running Windows

> BIOPAC acquisition unit (MP35/30 with USB)

> BIOPAC wall transformer (AC I 00A

IV. EXPERIMENTAL METHODS

A. SET UP

DETAILED EXPLANATION OF SET UP STEPS

The desktop should appear on the monitor. If not, ask the laboratory instructor for assistance.

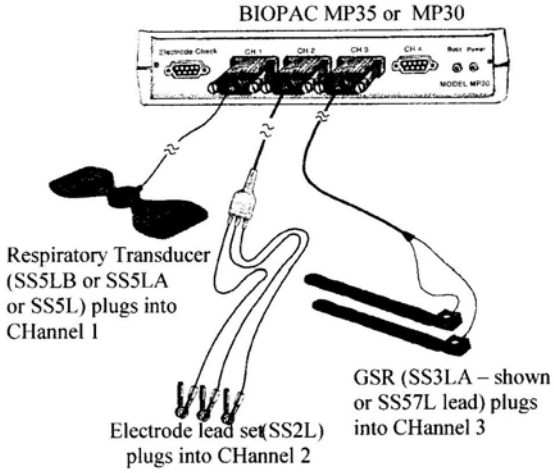

Fig. 9.1 Equipment Connections

Attach the respiratory transducer around the chest below the armpits and above the nipples (Fig. 9.2). The correct tension is critical. The respiratory transducer must be slightly tight at the point of maximal expiration. The respiration transducer can be applied over thin clothing, such as a T-shirt.

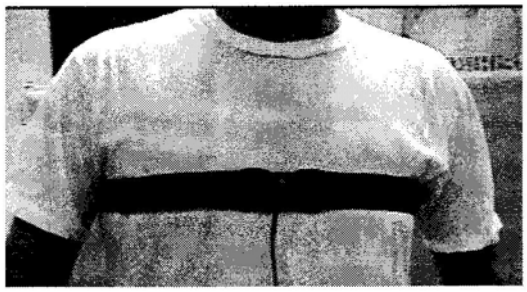

Fig. 9.2 SS5LB Placement

If using the SS5LB or SS5L, simply attach the Velcro ends together at the correct tension.

HINT

For a good signal to be picked up, it helps if the subjects have a little sweat on their hands (not a lot, but enough so that their hands are not completely smooth or cold). If subjects wash their hands just prior to the recording or if they have been sifting in a cold room, then they must do something to activate the sweat glands before beginning calibration or recording. If subjects begin with colder hands, the scale will be diminished and the signal will be easily saturated once they "warm up" during the lesson.

Attach two EL507 electrodes to the subject's fingertips and connect the SS57L lead, as shown in Fig. 9.3.

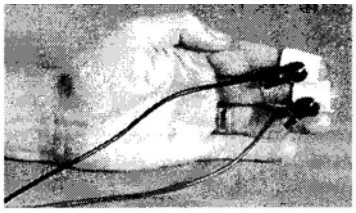

Fig. 9.3 SS57L and EL507 Setup

You must fill the each cavity of the SS3L/SS3LA GSR transducer with electrode gel to obtain accurate recordings.

The SS3L and SS3LA attach to the fingertips in an identical manner (Fig. 9.4) and should be in place for at least five minutes prior to the start of recording.

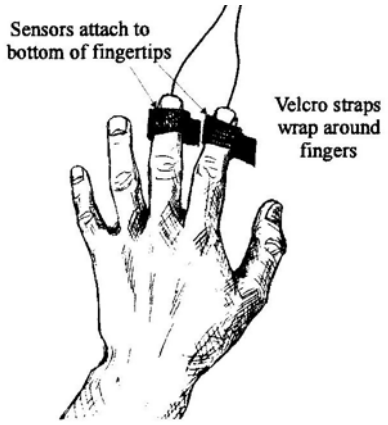

Fig. 9.4 SS3L/SS3LA attachment and connection

The SS3L/SS3LA is typically placed on the index and middle finger of the left hand.

Position the transducer so that the sensor is on the bottom of your fingertip (the part without the fingernail) and wrap the Velcro@ tape around the finger so the transducer fits snugly but not so tight that blood circulation is cut off. It's a fine line between tight and too tight.

Place three electrodes at the positions shown (Fig. 9.5).

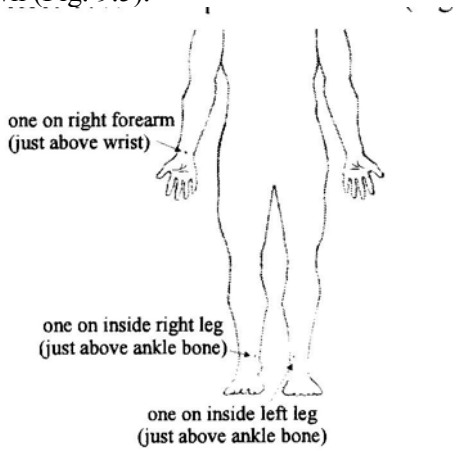

Fig. 9.5

> medial surface of right leg, just above the anklebone.

> medial surface of left leg, just above the ankle bone.

> right anterior forearm just above the wrist (same side of arm as palm of hand).

For optimal electrode adhesion, the electrodes should be placed on the skin at least 5 minutes before the start of the Calibration procedure.

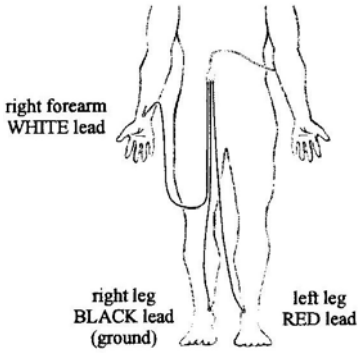

Fig. 9.6

To establish a LEAD II electrode configuration, each of the pinch connectors on the end of the electrode cable must be attached to a specific electrode position. Follow Fig. 9.6 to ensure that you connect each lead (color) to the proper electrode. The pinch connectors will only latch onto the nipple of the electrode from one side of the connector.

Use a unique identifier.

This ends the Set Up procedure.

B. CALIBRATION

The Calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. Pay **close attention to the Calibration procedure.**

DETAILED EXPLANATION OF CALIBRATION STEPS

Fig. 9.7 Calibration Seating

Ideally, the Subject should sit in a chair facing the Director, with arms on the armrest and be in a relaxed state, breathing normally. The **Subject** should not be able to see the screen during recording.

The **Calibrate** button is in the upper left comer of the screen.

The program needs to see a change in the GSR recording during calibration.
The Calibration will run for 10 seconds and then stop automatically, so let it run its course.
At the end of the 10-sec calibration recording, your screen should resemble Fig. 9.8.

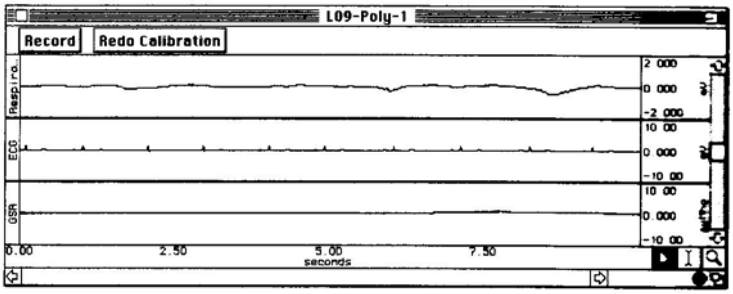

Figure 9.8 Sample Calibration Data

All three recording channels should show some fluctuation. There should be some variation 4-6 seconds into the GSR recording from the deep inhale.

If a channel does not show fluctuation, the transducer may not be connected properly or the **Subject** may not have inhaled deeply enough. Click **Redo Calibration** and repeat the entire calibration sequence until your data resembles the sample data.

C. RECORDING LESSON DATA

DETAILED EXPLANATION OF RECORDING STEPS

You will record three segments of data, 120 seconds each. In order to work efficiently, read this entire section so you will know what to do for each recording segment.

Check the last line of the journal and note the total amount *of* time available for the recording. Stop each recording segment as soon as possible so you don't use an excessive amount *of* time (time is memory).

Hints for obtaining optimal data:

a) The **Subject** must not be able to see the record as it isbeing recorded.

b) The environment must be quiet.

c) Sensory input to the **Subject** must be kept at a minimum since almost any change in the environment may evoke a response.

d) The **Subject** should remain as still as possible during recording, relaxed with arms resting on the armrests.

e) **Subject** should answer question in a quiet tone with minimal movement of the mouth.

f) **Subject** should be at his/her resting heart rate in a relaxed mental and physical state, and should not have performed any recent physical or mental exertion.

Subject should be in a chair in a relaxed state, with arms on the armrest, breathing normally.

Recorder will need to listen for Director's instructions to Subject so s/he knows when to place event markers.

When you click **Record,** an append marker labeled "Count and touch" will automatically be inserted.

The 5-second wait before each request establishes a baseline. This entire segment should be completed within 120 seconds.

In this segment, the Recorder needs to insert an event marker at the precise moment that the subject answers each question. To insert **Markers,** press the F9 key.

Markers and labels can be edited after the data is recorded.

It may be difficult to type in the marker label text while you are recording. The important thing is to get the marker inserted during recording, at the precise moment the event changes. Labels can be keyed or edited after the recording is done.

1. Recorder inserts event markers to indicate event change.
    a. Quietly say his/her name.
    b. Quietly count backward from 10.
    c. Count backward from 30 by subtracting increasing odd numbers. (Subtract 1 from 30, then 3 from 29, then 5 from 26 and so on, by using increasing odd numbers as the subtracted factor.)

d. Director touches Subject on the side of the face.

The recording should halt, giving you time to review the data and prepare for the next recording segment.

If all went well, your data should look similar to Fig. 9.9 and you can proceed to Step 7.

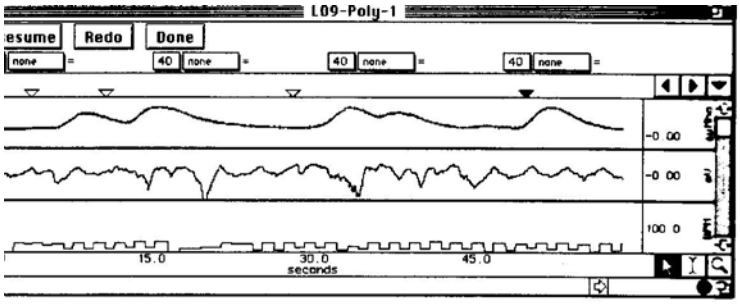

Fig. 9.9

The data would be incorrect if:

a) The Suspend button was pressed prematurely.

b) A transducer slipped off or an electrode peeled up, causing a large baseline drift, spike, or loss of signal.

c) The markers were not inserted or were inserted at the wrong time(s).

In this case, you should redo the recording by clicking Redo and repeating Steps 2-6. Note that once you press Redo, the data you have just recorded will be erased.

This segment should be completed within 120 seconds.

When you click Resume, the recording will continue and an append marker labeled "Concentration on colored squares" will be automatically inserted.

1. Director holds the first colored piece of paper about two feet from Subject's face.

2. Director instructs Subject to look at and concentrate one each square for about 10 seconds, and pauses between requests to reestablish a baseline.

3. Recorder inserts event markers to indicate color change and records the time required for a stimulus to generate a response.

4. Display the colors and insert event markers in the following order:
   a. "White"
   b. "black"
   c. "red"
   d. "blue"
   e. "green"
   f. "yellow"
   g. "orange"
   h. "brown"
   i. "purple"

To insert **Markers,** press the F9 key.

Markers and labels can be edited after the data is recorded.

It may be difficult to type in the marker label text while you are recording. The important thing is to get the marker inserted during recording, at the precise moment the event changes. Labels can be keyed or edited after the recording is done.

The recording should halt, giving you time to review the data and prepare for the next recording segment.

Your data should look similar to Fig. 9. 10.

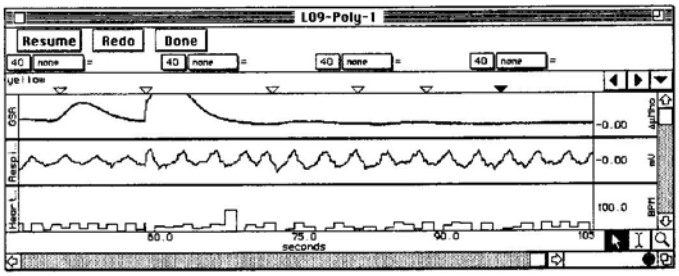

Fig. 9.10 Sample Recording (4 colors used)

Variation in the data will completely depend on the **Subject** and recording conditions. The data would be incorrect for the reasons in Step 6. If incorrect, you should redo the recording by clicking **Redo** and repeating Steps 7- 10. Note that once you **press Redo,** the data you have just recorded will be erased.

This segment should be completed within 120 seconds.

When you click Resume, the recording will continue and an append marker labeled "Series of 'Yes/No' questions" will be automatically inserted.

Each question-answer should take about **10 seconds**.

Subject's replies should be limited to "yes" or "no." **Subject** may answer truthfully or dishonestly.

1. Recorder inserts an event marker when the question is asked and another marker when Subject begins to answer.
   a. “Q” when question asked
   b. “A” when answer starts

2. Questions:
   a. Are you currently a student?

   b. Are your eyes blue?

   c. Do you have any brothers?

   d. Did you earn an “A” on the last physiology exam?

   e. Do you drive a motorcycle?

   f. Are you less than 25 years of age?

g. Have you ever traveled to another planet?

h. Have aliens from another planet visited you?

i. Do you watch “Fear Factor”?

j. Have you answered all of the preceding questions truthfully?

To insert **Markers,** press the F9 key.

Markers and labels can be edited after the data is recorded.

It may be difficult to type in the marker label text while you are recording. The important thing is to get the marker inserted during recording, at the precise moment the event changes. Labels can be keyed or edited after the recording is done.

Director should note **Subject's** responses here by circling "Y" for Yes and "N" for No.

The recording should halt, allowing you to review the data.
If all went well, your data should look similar to Fig. 9.11 and you can proceed to Step 15.

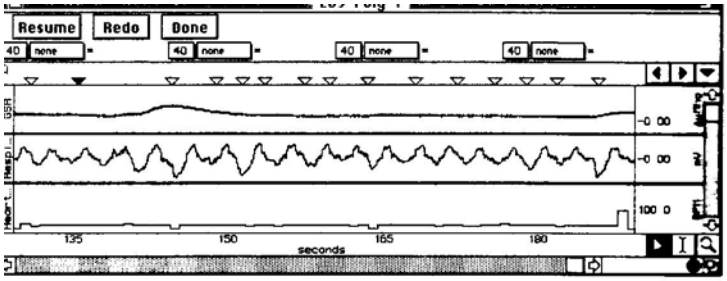

Fig. 9.11

Variation in the data will completely depend on the **Subject** and recording conditions. The data would be incorrect for the reasons in Step 6.

If incorrect, you should redo the recording by clicking Redo and repeating Steps 11 - 14. Note that once you press Redo, the data you have just recorded will be erased.

Flip to Table 9.3 in your Data Report and record the **Subject's** truthful answers to each question.

A pop-up window with options will appear. Make your choice, and continue as directed. If choosing the "Record from another Subject" option:

a) Attach the sensors per Setup Steps 5, 6, and 7 and continue the entire lesson from Setup Step 10.
b) Each person will need to use a unique file name.

V. DATA ANALYSIS

DETAILED EXPLANATION OF DATA ANALYSIS STEPS

Enter **Review Saved Data** from the Lessons menu.

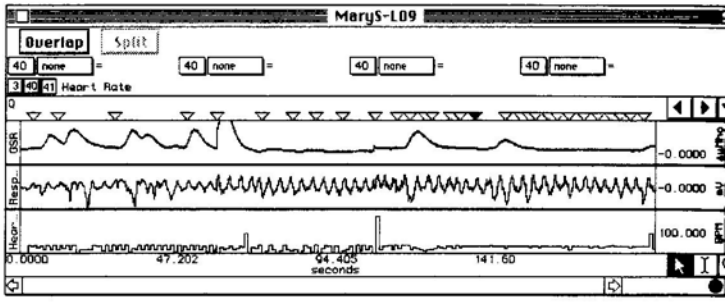

Fig 9.12

The following tools help you adjust the data window:

Autoscale horizontal
Vertical (Amplitude) Scroll Bar
Zoom Previous
Horizontal (Time) Scroll Bar
Autoscale waveforms
Zoom Tool

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and value. The first two sections are pulldown menus that are activated when you click on them. The following is a brief description of these specific measurements.

value: displays the amplitude value for the channel at the selected point. If a single point is selected, the value is for that point, if an area is selected, the value is the endpoint of the selected area.

BPM: In this lesson, the BPM measurement stands for Breaths Per Minute and calculates the difference in time between the end and beginning of the selected area (same as AT), then divides this value into 60 seconds/minute.

none: turns off the measurement channel.

The "selected area" is the area selected by the I-Beam tool (including the endpoints).

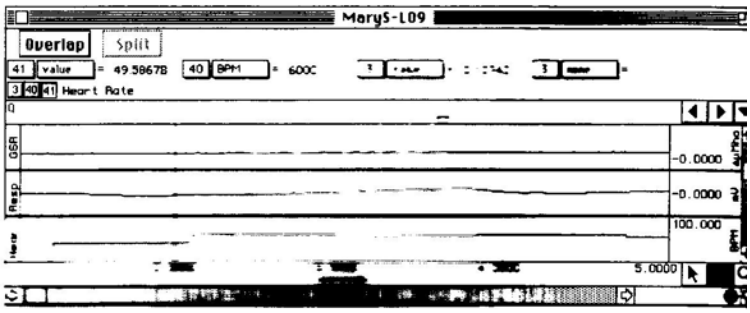

Fig 9.13

The respiration transducer records chest expansion (inhalation) as positive values, and chest deflation (exhalation) as negative values. Therefore, the start of inhalation is recorded as the beginning of the ascending positive waveform.

Note: This measurement may be difficult to perform, depending on your data, because small dips in chest expansion can occur within the normal cycle. You must be able to distinguish the small dips from the big dips.

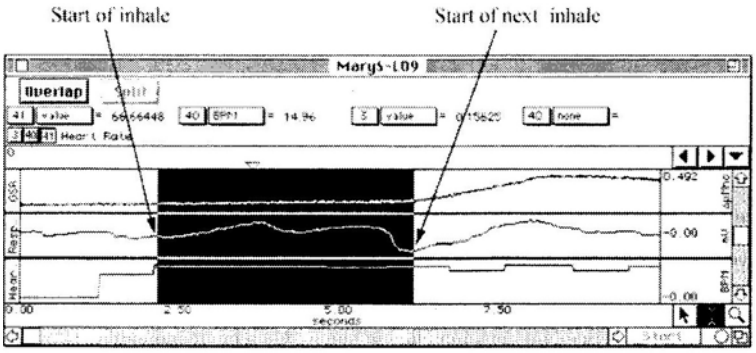

Fig 9.14

This 10-second interval should show the Subject's response to the first instruction of the segment.

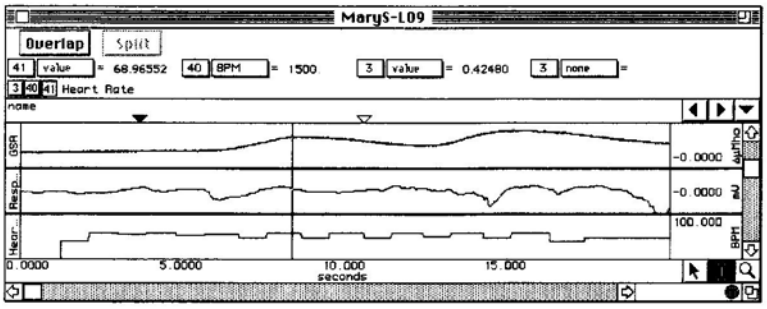

Fig 9.15

The respiration transducer records chest expansion (inhalation) as positive values, and chest deflation (exhalation) as negative values. Therefore, the start of inhalation is recorded as the beginning of the ascending positive waveform.

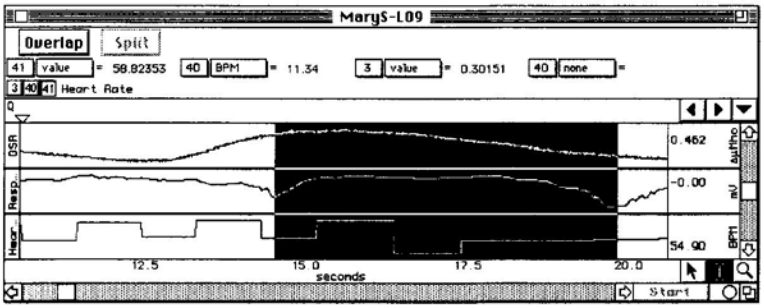

Fig 9.16

Each condition in the data record should be separated by an event marker ( ).

This is the segment beginning with the append marker labeled "Concentration on colored squares."

This is the data beginning with the append marker labeled "Series of 'yes/no' questions."

Measurements should be taken in the interval that begins when the Subject started to answer.

You may save the data to a drive, save notes that are in the journal, or print the data file.

END OF LESSON 9
Complete the Lesson 9 Data Report that follows.

Lesson 9

GALVANIC SKIN RESPONSE & THE POLYGRAPH

DATA REPORT

Student's Name:_____

Lab Section:_____

Date:_____

Subject Profile

Name_____Height _____

Age_____Weight _____

Gender: Male / Female

1. Data and Calculations

A. Complete Table 9.1 with Segment 1data.

Mark I for increase, D for decrease, and NC for no change relative to baseline.

Table 9.1 Segment 1 Data

Procedure	Heart Rate [CH41 Value]	Respiratory Rate [CH 40 BPM]	GSR [CH 3 Value]
Resting (baseline)			
Quietly say name			
Count from 10			
Count from 30			
Face touched			

B. Complete Table 9.2 with Segment 2 data.

Mark I for increase, D for decrease, and NC for no change relative to baseline.

Table 9.2 Segment 2 Data

Square Color	Heart Rate [CH41 Value]	Respiratory Rate [CH 40 BPM]	GSR [CH 3 Value]
white			
black			
red			
blue			
green			
yellow			
orange			
brown			
purple			

C. Complete Table 9.3 with Segment 3 data.

Mark I for increase, D for decrease, and NC for no change relative to baseline.

Table 9.3 Segment 3 Data

Question	Answer	Truth	Heart Rate [CH41 Value]	Respiratory Rate [CH 40 BPM]	GSR [CH 3 Value]
Blue eyes?	Y N	Y N			
Brothers?	Y N	Y N			
Earn "A"?	Y N	Y N			
Motorcycle?	Y N	Y N			
Less than 25?	Y N	Y N			
Another planet?	Y N	Y N			
Aliens visit?	Y N	Y N			
"Fear Factor"?	Y N	Y N			
Truthful?	Y N	Y N			

II. **Questions**

D. Of what practical value is the GSR information obtained from the color experiment?

E. What major physiological changes account for the galvanic skin response?

F. Give three reasons why polygraph testing of a person's sincerity and honesty may yield inconclusive results.