

Experiment 32: The Electroencephalogram (EEG)

Background

The living brain produces a continuous output of small electrical signals, often referred to as *brain waves*. The recording of these signals, called an electroencephalogram (EEG), is the summation of all the postsynaptic potentials (EPSPs and IPSPs) of the neurons in the cerebral cortex. The amplitudes of these signals are so small that they are measured in microvolts which are millionths of a volt or thousands of a millivolt. Though they are small, the signals can be accurately detected and recorded. The electrodes that pick up these signals are attached to the surface of the scalp. The signals are then amplified many thousands of times. The amplified signals are then recorded with an electroencephalograph, which is a device for recording *brain waves*. The *iWorx* data recording unit will function as both an amplifier and an electroencephalograph for the experiments in this chapter.

EEG Parameters

The electroencephalograph is a continuous recording of waves of varying frequency and amplitude. The number of wave cycles or peaks that occurs in a EEG pattern in a set period of time is its frequency. One EEG wave cycle occurring in a second of time is known as a Hertz (Hz). The amplitude of the EEG pattern is the strength of the pattern in terms of microvolts of electrical energy. There are four basic EEG frequency patterns as follows: Beta (14-30 Hz), Alpha (8-13 Hz), Theta (4-7 Hz), and Delta (1-3 Hz). In general, the amplitude of the EEG increases as the frequency decreases.

Cortical Arousal

Each of the four EEG frequencies is associated with a different level of arousal of the cerebral cortex. Cortical arousal refers to the firing patterns of the neurons of the cerebral cortex. As the frequency of the EEG pattern gets lower, the level of cortical arousal diminishes. As the level of arousal diminishes, the EEG pattern gets higher in amplitude. Thus, frequency and amplitude are inversely related in the EEG. An EEG with a large amplitude and a low frequency indicates a more synchronized brain wave pattern (groups of cells are acting in concert), whereas an EEG with a low amplitude and a high frequency generally corresponds with a desynchronized brain wave pattern (groups of cells are involved in separate activities). The level of cortical arousal is correlated with various psychological and behavioral states.

Behavioral and Psychological States

Some of the behaviors or psychological states often associated with the four prominent EEG frequencies are shown in Table 8-1 on page 168.

Table 8-1: EEG Patterns and Behavioral States

EEG Pattern	Behavioral/Psychological State
Beta	Awake, alert, focused attention and problem solving; dream/REM sleep; high level of environmental stimulation (e.g. eyes open).
Alpha	Awake, non-focused, relaxed, drowsy, or non-vigilant; low level of environmental stimulation (e.g. eyes closed).
Theta	Visual imagery, hypnagogic/hypnapopic imagery; light sleep.
Delta	Deep, restful sleep; vague dream states.

Alpha and Beta EEG

Most EEG records are a complex mixture of EEG patterns. It takes a computer to analyze the frequencies represented. The four EEG wave types shown on Figure 8-163 on page 168 are the result of this type of computer analysis. A filter for the specific range of frequencies in each type of EEG wave was applied to the raw EEG wave. As a result of the filtering, each EEG wave type within the raw EEG signal can be displayed on a separate channel.

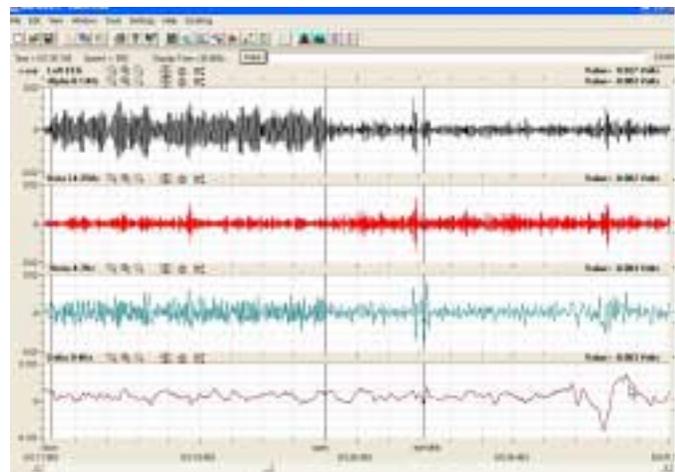


Figure 8-163: Alpha, Beta, Theta, and Delta EEG patterns extracted from an EEG signal recorded from the left hemisphere with eyes closed, then open. Activity shifts from Alpha to Beta EEG waves when the eyes open.

The data displayed on Figure 8-163 on page 168 demonstrates that Alpha EEG waves were prominent when the subject's eyes were closed and she was not concentrating on anything in particular. When the subject opened her eyes, the amplitude of her Alpha EEG waves decreased dramatically and the amplitude of her Beta EEG waves increased slightly. If the subject had been performing a mental task while her eyes were open, the amplitude of her Beta EEG waves would be higher.

A condition known as *Alpha Block* can occur even when the subject's eyes are closed. If a subject's attention can be drawn quickly to the events taking place in his or her environment or if the subject is performing a mental task or focus, the Alpha wave pattern will disappear and the Beta pattern will appear. *Alpha Block* indicates the existence of a higher level of cortical arousal in the subject even though the subject's eyes might be closed.

In this laboratory experiment, subjects will perform tasks that will allow observers to discriminate between the two EEG wave types, Alpha and Beta, which are present in EEG records of subjects that are awake. It is possible to observe Theta waves from an awake subject, if he or she is performing a successful exercise in visual imagery. However, Delta waves should not be found in your subject's recording unless he or she falls asleep during the experiment.

Personality

Individual differences in personality have sometimes been studied with EEG techniques. In 1967, Hans Eysenck theorized that personality can be characterized along a continuum of introversion-extraversion. According to Eysenck (Eysenck, 1967) introverts and extraverts differ in their thresholds for cortical arousal, with introverts having a lower threshold for arousal compared to extraverts. This theoretical framework generates the idea that introverts are chronically "overaroused" and thus seek a state of lower arousal while extraverts are chronically "underaroused" and thus seek a state of higher arousal. Behaviors which differ among the personality types are seen as generated by a characteristic physiological threshold for arousal. Researchers have tested this hypothesis and some, but not all, have found support for it in the EEG data. References are listed at the end of this experiment if you want to read more about the data and issues involved in personality and EEG.

Hemisphere Specialization

There is considerable evidence from studies in neuropsychology that the two cerebral hemispheres of the brain are specialized for different cognitive processes. In general, the left cerebral hemisphere is considered to be specialized for language processes and the right cerebral hemisphere for visuospatial processes. One measure of the activation of a cerebral hemisphere is EEG. If it is hypothesized that one hemisphere is more aroused or activated at a task than the other, the difference would show up as a difference in the EEG frequencies of the two hemispheres. Some researchers have demonstrated that the EEG is lower in frequency and higher in amplitude over the right hemisphere when a subject is processing verbal tasks, presumed to be a left hemisphere function. Likewise, the EEG is lower in frequency and higher in amplitude over the left hemisphere during a visuospatial task, presumed to be a right hemisphere function.

In this experiment, you will:

- learn to collect EEG signals from the left and right cerebral hemispheres.
- learn to recognize common EEG artifacts caused by movements such as eye blinks, facial muscle contractions, and head movement;
- learn to recognize and analyze Alpha and Beta EEG patterns associated with closed and open eye conditions;
- observe the Alpha block which occurs when eyes are closed and the mind is focused on problem solving;
- test an experimental hypothesis about relative levels of Alpha and Beta EEG waves in each hemisphere in two psychological states; and
- test an experimental hypothesis about personality and EEG.

Equipment Required

PC Computer
iWorx unit, and USB or serial cable
AAMI cable and EEG leads
EEG Electrodes
Elastic headband
Alcohol swabs

Equipment Setup

- 1 Connect the iWorx unit to the computer (described in Chapter 1).
- 2 Select one person from your group to be the subject in this experiment.
- 3 Use alcohol swabs to clean the skin where the electrodes will be placed.

4 Use silver/silver chloride EEG electrodes held in place by a headband or disposable adhesive electrodes. If disposable electrodes are used, the electrodes need to have as little hair as possible under their centers. Five electrodes will be placed on the head:

- one is high on the forehead, to the left or right of the centerline.
- one about two inches above each ear, on the left and right temporal lobes.
- one on each parietal-occipital area, two inches to the left and to the right of the midline.

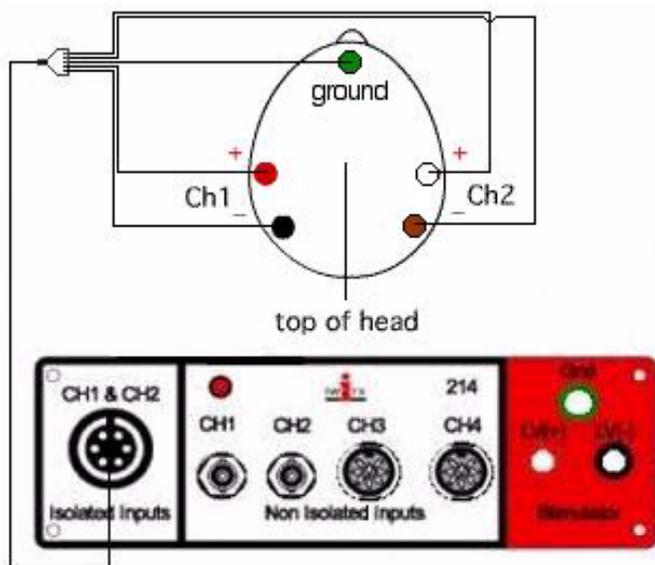


Figure 8-164: The equipment used to measure the ECG from a subject.

- 5 Remove the plastic disks from the disposable electrodes and apply them to the scrubbed areas (Figure 8-164 on page 170).
- 6 Place the elastic headband around the subject's head. The band should be snug enough that it does not slip up or down easily, but it should not be so tight as to be uncomfortable. The headband should be placed as high over the ear as possible.
- 7 Attach the AAMI connector on the end of the gray patient cable to the isolated Channel 1 & 2 inputs of the iWorx unit (Figure 8-164 on page 170).
- 8 Attach the five color-coded electrode cables to the ground and Channels 1 and 2 inputs on the lead pedestal. Snap the other ends onto the electrodes, so that:
- the red "+1" lead is over the left temporal lobe.
 - the black "-1" lead is on the left parietal-occipital area.
 - the white "+2" lead is over the right temporal lobe.
 - The brown "-2" lead is over the right parietal-occipital area.
 - the green "C" lead (the ground) is on the forehead.
- 9 The green "C" lead wire should not hang down in the

person's eyes. Drape it loosely over the top of the subject's head. This lead can be secured under a headband.

10 Drape the leads for the other electrodes over the subject's shoulder to the lead pedestal which hangs freely down the subject's back and over the chair. There should be no tension on the electrodes.

11 The subject should sit quietly with their hands in their lap.

Start the Software

- 1 Click the **Windows Start** menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the **LabScribe** icon on the Desktop.
- 2 When the program opens, select **Load Group** from the **Settings** menu.
- 3 When the dialog box appears, select **IPLMV3.iws**. Click **Load**.
- 4 Click on the **Settings** menu again and select the **EEG-CorticalArousal** settings file.
- 5 After a short time, **LabScribe** will appear on the computer screen as configured by the **EEG-CorticalArousal** settings.
- 6 **Right-click** in the recording area of Channels 1 and 2 and confirm that the **Input Mode** of each channel is set to **0.3-35 Hz**. This setting will filter out frequencies below 0.3 Hz and above 35 Hz, frequencies not generated by the brain.

Exercise 1: Common EEG Artifacts

Aim: To learn how to record EEGs and to become familiar with identifying EEG artifacts, especially those related to motion in the subject.

Procedure

- 1 Ask the subject to sit quietly and not move unless told to do so, and to keep his or her eyes open during this phase of the experiment.
- 2 Click **Start**, and then click the **AutoScale** buttons for all six channels displayed.
- 3 Over the first 30 seconds of the recording, ask the subject to blink his or her eyes. Before you ask the subject to blink, type the letter "B" (for *blink*) in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording each time the subject is requested to blink.
- 4 Over the next 30 seconds of the recording, ask the subject to contract his or her forehead or facial muscles. Before you ask the subject to smile (or frown), type the letter "S" (for *smile*) in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording each time the subject is requested to smile (or frown).
- 5 Finally, over the last 30 seconds of the recording, ask the subject to rotate (or tilt) her or his head from side to side. Before you ask the subject to rotate their head, type the letter "R" (for *rotate*) in the comment line to the right of the

Mark button. Press the **Enter** key on the keyboard to mark the recording each time the subject is requested to move his or her head.

- Click **Stop** to halt recording.
- Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

Analysis

- Scroll through the recording using the scroll bar at the bottom of the **Main** window. Stop at marks (vertical lines in the EEG record) where you have entered comments.
- Notice that movement of any kind will cause artifacts in the EEG record. An example of an eye blink artifact can be seen in the middle of the recording in Figure 8-165 on page 171. Learn to recognize these types of motion artifacts and eliminate them from any EEG analysis because they are not indications of brain activity. Variations in waking brain activity will never appear as large amplitude potentials; when these appear in the record they are always artifacts.

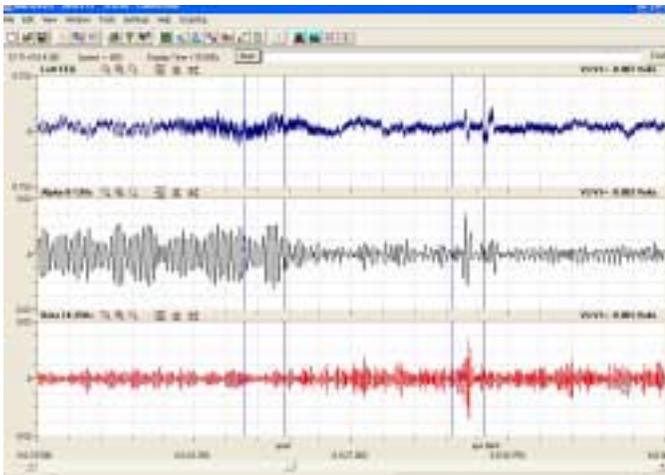


Figure 8-165: An eye blink artifact appears on the raw EEG (top), Alpha wave (middle), and Beta wave (bottom) channels about two-thirds across the screen.

Exercise 2: Alpha and Beta EEG Patterns

Aim: To identify Alpha and Beta EEG patterns from a subject with open and closed eyes.

Procedure

- Inform the subject that he or she needs to avoid any movement other than opening or closing his or her eyes. The subject will be asked repeatedly to open and close his or her eyes during this exercise.
- During this exercise, you will also need to enter two comments to indicate:
 - the section of the recording when the eyes are open (O);
 - the section of the recording when the eyes are closed (C).

- Click **Start**, and then click the **AutoScale** buttons for all six channels. You should observe an EEG similar to the topmost trace in Figure 8-163 on page 168.
- The subject should have his or her eyes open at the beginning of the recording. Type the letter "O" (for *Eyes Open*) in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording. Record for 20 seconds.
- While the subject has his or her eyes open, type the letter "C" (for *Eyed Closed*) in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording as you instruct the subject to close his or her eyes. Record the subject's EEG pattern with his or her eyes closed for an additional 20 seconds.
- Continue to record the subject's EEG pattern for a total of 2 minutes as the subject alternates having his or her eyes open or closed for alternating 20 second periods. Annotate the recording with comments each time the subject opens or closes his or her eyes.
- Click **Stop** to halt recording.
- Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

Analysis

- Scroll through the two minute recording made as the subject alternated periods when his or her eyes were open or closed. Notice the differences in the EEG patterns for the two eye conditions. They should resemble those seen previously in Figure 8-163 on page 168.
- Click the **2-Cursor** icon (Figure 8-166 on page 171) so that two blue vertical lines appear over the recording window. Place the cursors on either side of an artifact-free, "Eyes Open" section of data.

Note: Avoid sections of the EEG recording that contain obvious artifacts.

- Click the **Analysis** icon (Figure 8-166 on page 171) to open the **Analysis** window.

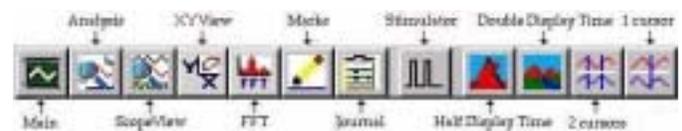


Figure 8-166: The **LabScribe** toolbar.

- Display the left and right hemisphere EEG waves (**Left Alpha** (CH3), **Left Beta** (CH4), **Right Alpha** (CH5), and **Right Beta** (CH6)) in the **Analysis** window
- Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max-Min**, and **Avg_Freq** from the **Table Functions** list.

- Select **Left Alpha** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be the maximum peak to peak difference in amplitude (**Max-Min**) and average frequency (**Avg_Freq**) of the waves displayed on the **Left Alpha** channel.

- Select **Left Beta** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be for the same parameters, **Max-Min** and **Avg_Freq**, from the **Left Beta** channel.

6 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.

7 Repeat Steps 5 and 6 on the **Right Alpha** and **Right Beta** channels.

8 Return to the **Main** window. Scroll through the recording and locate the section of data when the subject had his or her eyes closed.

9 Repeat Steps 2 through 7 on an artifact-free, “Eyes Closed” section of data. Find the average frequencies and maximum peak to peak differences for each wave type from the subject’s left and right hemispheres. Enter this data into the **Journal** as done previously.

10 Return to the **Main** window. Repeat Steps 2 through 7 on the data recorded in the other “Eyes Open” and “Eyes Closed” sections of the recording. Enter this data into the **Journal** as done previously.

11 Find the grand averages of the frequencies and maximum peak to peak differences for the Alpha and Beta waves, from both hemispheres, for all the “Eyes Open” sections of the recording. Enter these values on Table 8-2 on page 172. Find the grand averages for these parameters for both wave types, from both hemispheres, for all the “Eyes Closed” sections of the recording. Enter these values on the same table.

Table 8-2: EEG Frequencies & Amplitudes - Different Environmental Stimulation

Subject_____	CH	Eyes	
Grand Averages		Open	Closed
Left Alpha Frequency (Hz)	3		
Max L Alpha Peak to Peak Difference (mV)	3		
Left Beta Frequency (Hz)	4		
Max L Beta Peak to Peak Difference (mV)	4		
Right Alpha Frequency (Hz)	5		
Max R Alpha Peak to Peak Difference (mV)	5		
Right Beta Frequency (Hz)	6		
Max R Beta Peak to Peak Difference (mV)	6		

Questions

- 1 Do both hemispheres have a higher level of Alpha wave activity (higher maximum peak to peak amplitude and a frequency within an 8-13 Hz range) during the “Eyes Closed” condition than during the “Eyes Open” condition?
- 2 Do both hemispheres have a higher level of Beta wave activity (higher maximum peak to peak amplitude and a frequency within a 14-30 Hz range) during the “Eyes Open” condition than during the “Eyes Closed” condition?
- 3 Is the Alpha wave level of activity higher in one hemisphere than in the other during the “Eyes Closed” condition?
- 4 Is the Beta wave level of activity higher in one hemisphere than in the other during the “Eyes Open” condition?
- 5 Do these results demonstrate that the subject had an increased state of arousal when his or her eyes were open or closed? Give the reasoning.
- 6 Do these results demonstrate one hemisphere had a higher state of arousal than the other? Give the reasoning.

Exercise 3: The Alpha Block

Aim: To identify the presence of the Alpha Block that occurs when the subject’s eyes are closed and his or her mind is focused on problem solving.

Procedure

- 1 Before beginning this exercise, inform the subject of the experimental conditions:
 - The subject should sit quietly with his or her eyes closed throughout the recording period.
 - Following a quiet period when the subject’s resting EEG pattern is established, the subject will be given a mental arithmetic problem to solve.
 - The subject should understand that the correct answer is not as important as just working on the problem until an answer is found.
 - When the subject has completed the problem, he or she should say the answer out loud, and then resume sitting quietly with no particular mental focus.

- The person operating the computer will enter appropriate comments on the recording to indicate the beginning of the quiet period, the time at which the question was asked, the time when the subject speaks the answer, and the time when the recording ended.
- 2 Click **Start**. Click the **AutoScale** buttons for Channels 1 and 2. Type the letter “R” (for *Resting*) in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording. Make a recording of at least 30 seconds of Alpha EEG while the subject is sitting quietly with his or her eyes closed. You will observe an EEG similar to the one in Figure 8-167 on page 173.
 - 3 Type “P1” (for *Problem 1*) in the comment line to the right of the **Mark** button. Ask the subject to solve a mental arithmetic problem such as “multiply 46 by 28” or “divide 157 by 16.” The problem should be delivered to the subject quickly. Press the **Enter** key on the keyboard to mark the recording as soon as the problem is first given to the subject.
 - 4 Type “EP1” (for *End of Problem 1*) in the comment line to the right of the **Mark** button. When the subject finishes the problem and announces the answer out loud, press the **Enter** key on the keyboard to indicate the end of the problem solving period.
 - 5 Repeat this procedure (Steps 2, 3, and 4) one more time, using a different mental arithmetic problem labeled as “P2”.
 - 6 Click **Stop** to halt recording.
 - 7 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

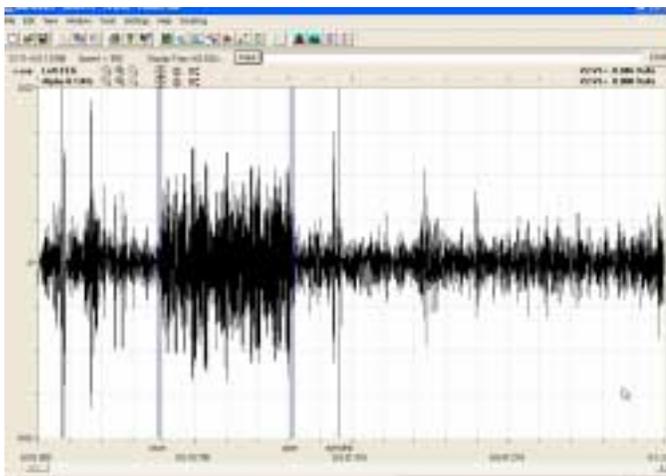


Figure 8-167: An example of Alpha EEG wave pattern when the subject's eyes are closed (greater amplitude signals) or open (lower amplitude signals).

Analysis

- 1 Scroll through the recording and find the section of data that is prior to the first arithmetic problem being given to the subject. The predominant Alpha EEG rhythm should exist in this section.
 - 2 Click the **2-Cursor** icon (Figure 8-166 on page 171) so that two blue vertical lines appear over the recording window. Place the cursors on either side of an artifact-free, “Resting” section of this data.
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- Note:** Avoid sections of the EEG recording that contain obvious artifacts.
-
- 3 Click the **Analysis** icon (Figure 8-166 on page 171) to open the **Analysis** window.
 - 4 Display the Alpha EEG waves of the left and right hemispheres (**Left Alpha** (CH3) and **Right Alpha** (CH5)) in the **Analysis** window
 - 5 Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max-Min**, and **Avg_Freq** from the **Table Functions** list.
 - Select **Left Alpha** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be the maximum peak to peak difference in amplitude (**Max-Min**) and average frequency (**Avg_Freq**) of the waves displayed on the **Left Alpha** channel.
 - Select **Right Alpha** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be for the same parameters, **Max-Min** and **Avg_Freq**, from the **Right Alpha** channel.
 - 6 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.
 - 7 Return to the **Main** window. Scroll through the recording and locate the section of data when the subject was solving the first problem.
 - 8 Repeat Steps 2 through 6 on first problem (P1) section of data. Find the average frequencies and maximum peak to peak differences for the Alpha waves from the left and right hemispheres. The predominant Alpha EEG rhythm should have disappeared as the subject was solving the problem. This phenomenon is known as *Alpha Block*. Enter this data into the **Journal** as done previously.
 - 9 Return to the **Main** window, scroll to the next section of data, and repeat Steps 2 through 6 on the data recorded after the end of first problem (EP1), the data recorded during the second problem (P2), and the data recorded after the end of second problem (EP2). The Alpha EEG rhythm should have resumed after the first problem was solved, disappeared during the solving of the second problem, and reappeared after the second problem was solved.
 - 10 Enter the values for the average frequency and maximum peak to peak difference from the Alpha channels, for both hemispheres, during the five sections of the recording on Figure 8-3 on page 174.

Table 8-3: EEG Frequencies & Amplitudes - Low Environmental Stimulation

Subject_____	CH	Resting	Problem1	Problem Solved	Problem 2	Problem Solved
Average Left Alpha Frequency (Hz)	3					
Max L Alpha Peak to Peak Difference (mV)	3					
Average Right Alpha Frequency (Hz)	5					
Max R Alpha Peak to Peak Difference (mV)	5					

Questions

- 1 Does either hemisphere have a lower level of Alpha wave activity (lower maximum peak to peak difference and a frequency above the 8-13 Hz range) during the problem-solving tasks than during the rest period?
- 2 Does either hemisphere have a higher level of Alpha wave activity (higher maximum peak to peak difference and a frequency within the 8-13 Hz range) during the periods after the problems are solved than during the problem-solving tasks?
- 3 How do the levels of Alpha wave activity in the periods after the problems are completed compare to the Alpha wave activity in the rest period?
- 4 Is the level of Alpha wave activity higher in one hemisphere than in the other during the rest period? During the problem-solving tasks? During the periods after the problems are completed?
- 5 Do your results demonstrate the presence of *Alpha Block* in the subject?

Exercise 4: EEG Pattern in Psychological States

Aim: To test whether a subject’s left hemisphere is more active (alert, aroused) than the right hemisphere, when the subject is engaged in language processes. And, to test whether a subject’s right hemisphere is more active (alert, aroused) than the left hemisphere, when the subject is engaged in spatial processes.

Evidence for a more active or alert brain is a higher EEG frequency and a lower EEG amplitude. Conversely, evidence for a less active or alert brain is a lower EEG frequency and a higher EEG amplitude.

Procedure

- 1 There are three experimental conditions in this exercise. During the exercise, you will also need to enter comments to indicate:
 - **Control Task:** Sitting quietly with eyes closed for one minute.

- **Spatial Task:** Sitting quietly with eyes closed for one minute. During that one minute period, the subject should mentally “walk” through his or her house using imagery to “see” the rooms and their contents. The subject should not use verbal guidance, nor label what is seen, as he or she “walks” from room to room. The subject should imagine each room as he or she “walks” slowly through it.

- **Language Task:** Sitting quietly with eyes closed for one minute. The subject should use mental language to “name” each object known to be in his or her kitchen (or any other chosen room of the house). Name as many objects as possible in the one minute of time. The subject should not visualize the objects, just name them.

- 2 Explain each of the three conditions to the subject. Stress that the spatial task should involve imagery without language, and that the language task should involve naming without visual imagery. All tasks are performed silently with the eyes closed.
- 3 The control task is the first in the sequence. Flip a coin to determine which of the two experimental tasks follows the control task.
- 4 Click **Start**. Click the **AutoScale** buttons for Channels 1 and 2. Type the letters “CT” (for *Control Task*) in the comment line to the right of the **Mark** button. Inform the subject when the control task begins, and press the **Enter** key on the keyboard to mark the recording.
- 5 As you record for 1 minute, type the letters “ECT” (for *End Control Task*) in the comment line to the right of the **Mark** button. Inform the subject when the control task ends, and press the **Enter** key on the keyboard to mark the recording.
- 6 Following the control task, administer the two experimental tasks in random order. Prior to beginning each task, announce the task and remind the subject of the instructions for performing the task. Enter comments on the recording when each task begins and ends. Use letters “LT” and “ST” for language and spatial tasks, respectively. Use “ELT” and “EST” for the ends of each respective task.
- 7 Click **Stop** to halt recording.
- 8 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file(e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

Analysis

- 1 Scroll through the recording and find the section of data when the subject was sitting quietly with his or her eyes closed. The predominant Alpha EEG rhythm should exist in this section.
- 2 Click the **2-Cursor** icon (Figure 8-166 on page 171) so that two blue vertical lines appear over the recording window. Place the cursors on either side of an artifact-free, “Control Task” section of this data.

Note: Avoid sections of the EEG recording that contain obvious artifacts.

- 3 Click the **Analysis** icon (Figure 8-166 on page 171) to open the **Analysis** window.
- 4 Display the left and right hemisphere EEG waves (**Left Alpha** (CH3), **Left Beta** (CH4), **Right Alpha** (CH5), and **Right Beta** (CH6)) in the **Analysis** window.
- 5 Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max-Min**, and **Avg_Freq** from the **Table Functions** list.
 - Select **Left Alpha** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be the maximum peak to peak difference in amplitude (**Max-Min**) and average frequency (**Avg_Freq**) of the waves displayed on the **Left Alpha** channel.
 - Select **Left Beta** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be for the same parameters, **Max-Min** and **Avg_Freq**, from the **Left Beta** channel.

- 6 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.
- 7 Repeat Steps 5 and 6 on the **Right Alpha** and **Right Beta** channels.
- 8 Return to the **Main** window. Scroll through the recording and locate the section of data when the subject was solving the first experimental (spatial or language) task.
- 9 Repeat Steps 2 through 7 on an artifact-free section of data for the first experimental (LT or ST) task. Find the average frequencies and maximum peak to peak differences for each wave type from the subject’s left and right hemispheres. Enter this data into the **Journal** as done previously.
- 10 Return to the **Main** window. Scroll through the recording and locate the section of data when the subject was solving the second experimental (spatial or language) task.
- 11 Repeat Steps 2 through 7 on an artifact-free section of data for the second experimental (ST or LT) task. Find the average frequencies and maximum peak to peak differences for each wave type from the subject’s left and right hemispheres. Enter this data into the **Journal** as done previously.
- 12 Enter the average frequency and maximum peak to peak difference for each EEG wave type from each hemisphere for each experimental condition on Table 8-4 on page 175.

Table 8-4: EEG frequencies & Amplitudes - Different Psychological States.

Subject_____	CH	Control Task	Language Task	Spatial Task
Left Alpha Frequency (Hz)	3			
Max L Alpha Peak to Peak Difference (mV)	3			
Left Beta Frequency (Hz)	4			
Max L Beta Peak to Peak Difference (mV)	4			
Right Alpha Frequency (Hz)	5			
Max R Alpha Peak to Peak Difference (mV)	5			
Right Beta Frequency (Hz)	6			
Max R Beta Peak to Peak Difference (mV)	6			

Questions

- 1 Does one hemisphere have more Beta wave activity than the other during the language task? More Alpha wave activity?
- 2 Does one hemisphere have more Beta wave activity than the other during the spatial task? More Alpha wave activity?
- 3 Does the subject have more EEG activity (either Beta or Alpha) during either of the experimental tasks than during the control task?
- 4 Do these results support the hypothesis put forth at the beginning of this exercise?

Exercise 5: EEG and Personality

Aim: To test Eysenck's hypothesis that during baseline conditions, introverts will show greater cortical arousal compared to extraverts.

The hypothesis predicts that subjects scored as introverts should have baseline EEGs with higher frequencies and lower amplitudes than the EEGs from subjects scored as extraverts.

Procedure

- 1 Each person in your group and the class will have the opportunity to serve as a subject for this exercise.
- 2 While recordings are being made, the subject should sit quietly with no particular mental focus. Others in the room should also be quiet.
- 3 Click **Start**, and then click the **AutoScale** buttons for Channels 1 and 2. Type the subject's name and the words "Eyes Open" on the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the recording.
- 4 Record the subject's EEG for one minute while his or her eyes are open. Type the words "Eyes Closed" on the comment line. Record the subject's EEG for one minute while his or her eyes are closed. Anytime the subject opens or closes his or her eyes, mark the recording with a comment.
- 5 Click **Stop** to halt recording.
- 6 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

Analysis

- 1 Scroll through the "Eyes Open" section of the first subject's recording and find the longest segment of data that is free of movement artifacts.

- 2 Click the **2-Cursor** icon (Figure 8-166 on page 171) so that two blue vertical lines appear over the recording window. Place the cursors on either side of this artifact-free, "Eyes Open" segment of data.
- 3 Click the **Analysis** icon (Figure 8-166 on page 171) to open the **Analysis** window.
- 4 Display the left and right hemisphere EEG waves (**Left Alpha** (CH3), **Left Beta** (CH4), **Right Alpha** (CH5), and **Right Beta** (CH6)) in the **Analysis** window.
- 5 Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max-Min**, and **Avg_Freq** from the **Table Functions** list.

- Select **Left Alpha** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be the maximum peak to peak difference in amplitude (**Max-Min**) and average frequency (**Avg_Freq**) of the waves displayed on the **Left Alpha** channel.

- Select **Left Beta** from the **Value from Channel** menu. The values displayed in the table at the top of the **Analysis** window will be for the same parameters, **Max-Min** and **Avg_Freq**, from the **Left Beta** channel.

- 6 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.

- 7 Repeat Steps 5 and 6 on the **Right Alpha** and **Right Beta** channels.

- 8 Return to the **Main** window. Scroll through the recording and locate the section of data when the subject had his or her eyes closed.

- 9 Repeat Steps 2 through 7 on an artifact-free, "Eyes Closed" section of data. Find the average frequencies and maximum peak to peak differences for each wave type from the subject's left and right hemispheres. Enter this data into the **Journal** as done previously.

- 10 Enter the average frequency and maximum peak to peak difference for each EEG wave type from each hemisphere for each experimental condition on Table 8-5 on page 176.

Table 8-5: EEG Frequencies & Amplitudes - Different Environmental Stimulation

Subject_____	CH	Eyes	
		Open	Closed
Personality Score_____			
Left Alpha Frequency (Hz)	3		
Max L Alpha Peak to Peak Difference (mV)	3		
Left Beta Frequency (Hz)	4		
Max L Beta Peak to Peak Difference (mV)	4		
Right Alpha Frequency (Hz)	5		
Max R Alpha Peak to Peak Difference (mV)	5		
Right Beta Frequency (Hz)	6		
Max R Beta Peak to Peak Difference (mV)	6		

Personality Rating Scale

- 1 Read each statement in Table 8-7 on page 178. Pick the number which best indicates the extent to which the statement is characteristic of your personality. Circle the number for each statement.
- 2 Total the numbers that are circled. The highest score possible is 50, and the lowest score possible is 10. Introverts should have low scores; extroverts should have high scores.

Class Data

- 1 The recordings from each subject should be analyzed using the instructions from Exercise 5.

- 2 Each subject should enter her or his identification code, personality score, Alpha and Beta wave frequencies and maximum peak to peak differences, from both hemispheres, for both conditions (eyes open or closed) on their own copy of Table 8-5 on page 176.
- 3 Sort the subjects into two groups based on the personality scores (low vs. high). Use the median score of the class as the division between groups.
- 4 Calculate the group averages for frequencies and maximum peak to peak differences from Alpha and Beta wave types, from each hemisphere, for each experimental condition in both personality groups. Enter these group averages in Table 8-6 on page 177.

Table 8-6: Groups Averages of Alpha and Beta Activity in Subjects Classified by Personality Score

Group Averages	P Score Below Median		P Score Above Median	
	Eyes Open	Eyes Closed	Eyes Open	Eyes Closed
Left Alpha Frequency (Hz)				
Max L Alpha Peak to Peak Difference (mV)				
Left Beta Frequency (Hz)				
Max L Beta Peak to Peak Difference (mV)				
Right Alpha Frequency (Hz)				
Max R Alpha Peak to Peak Difference (mV)				
Right Beta Frequency (Hz)				
Max R Beta Peak to Peak Difference (mV)				

Questions

- 1 Does the group with lower personality scores (introverts) have a higher level of activity (higher mean frequency/lower mean amplitude EEG) than the group with higher personality scores (extraverts) during the “Eyes Open” condition?
- 2 Does the group with lower personality scores have a higher level of activity than the group with higher personality scores during the “Eyes Closed” condition?
- 3 Does the group with lower personality scores have a higher level of activity than the group with higher personality scores from both hemispheres during both eye conditions?
- 4 Does the class data support the hypothesis that introverts have a higher level of baseline arousal than extraverts?

References

- Eysenck, H. (1967). *The Biological Bases of Personality*. Springfield, Ill: Thomas.
- Gale, A. (1983). *Electroencephalographic Correlates of Extraversion and Introversion*. In R. Simz & M. R. Rosenzweig (Eds.), *Psychophysiology 1980*. Amsterdam: Elsevier Biomedical Press.
- Gale, A., & Edwards, J. (1986). *Individual Differences*. In M. Coles, E. Donchin, & S. Porges (Eds.), *Psychophysiology, Systems, Processes, and Applications*. New York: Guilford Press.

Table 8-7: Personality Rating Scale

Statement	Rating				
	1	2	3	4	5
	Very Uncharacteristic				Very Characteristic
1. I prefer parties with lots of people to ones with just a few.	1	2	3	4	5
2. I generally like to study in groups rather than alone.	1	2	3	4	5
3. One of the last things I would do when I have time off is read a book.	1	2	3	4	5
4. When I go on vacation I prefer exciting places with lots of stimulation.	1	2	3	4	5
5. I am often bored when I am home alone and there is seemingly nothing to do.	1	2	3	4	5
6. I prefer to have a lot of people I consider as close friends.	1	2	3	4	5
7. I consider myself an "action" person; I don't spend a lot of time in deep thought.	1	2	3	4	5
8. My friends see me as outgoing and always available for a good time.	1	2	3	4	5
9. I would not like to spend New Year's Eve in a quiet place with just a few friends.	1	2	3	4	5
10. For physical activity I like team sports rather than individual sports.	1	2	3	4	5

Score _____