Human Biology & Health

Can Your Body Temperature Tell the Time of Day? Find Out with Human Circadian Cycles.

(from http://sciencebuddies.com/science-fair-projects/project_ideas/HumBio_p020.shtml?fave=no&isb=c2lkOjEsaWE6SHVtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

In this human biology science fair project, you will measure how body temperature and reaction time vary throughout the course of a day.

Introduction

In order to stay healthy and to function efficiently, living things must coordinate their internal processes with the external world. The most obvious feature of our environment that most creatures have to respond to is the daily cycle of light and dark. Biological processes that follow this 24-hour cycle, such as our sleep-wake cycle, are said to follow a **circadian rhythm.** One of the best-known circadian rhythms in humans is the daily change in **body temperature.** We tend to be at our coolest in the early morning and at our warmest in the late afternoon and early evening. Other circadian rhythms include hormone levels, alertness, muscle strength, and heart rate. The controlling regulator for these cyclic processes within the body is thought to be the **hypothalamus,** which is in the brain.

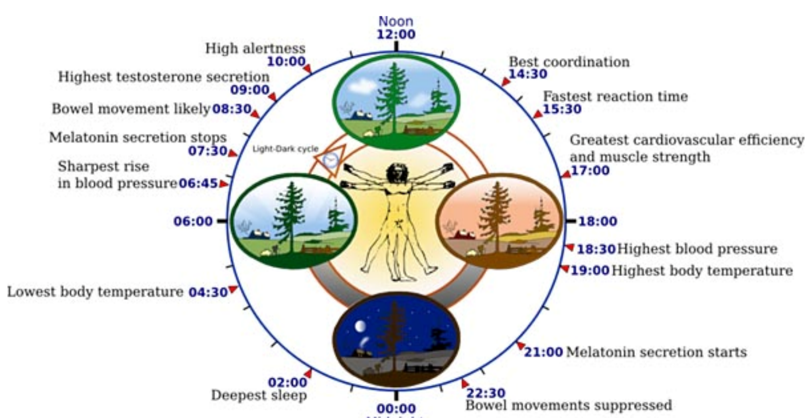

Figure 1. Overview of circadian cycles in humans. This diagram depicts some of the circadian patterns that occur in humans. Note that the clock is on a 24-hour cycle, so that 3:30 p.m., for example, is noted as 15:30. The hormone melatonin, which is a key regulator of the internal circadian clock, peaks in concentration at 21:00 (9:00 p.m.). (Wikipedia, 2008.)

Any change in the circadian cycle (such as jet lag and other conditions associated with travel) requires a certain period for readjustment. Jet lag can cause excessive sleepiness and a lack of daytime alertness in people who travel across time zones. Another factor that can affect circadian rhythm is work schedule. For instance, people who work at night are more prone to on-the-job injuries because their circadian rhythm is off-balance with the light and dark times of day.

According to William Garret (see Bibliography), "Reaction time peaks in the early evening at the same time as the maximum body temperature. This is partially because the **nerve conduction velocity** increases 2.4 meters per second (m/s) for every 1°C increase in body temperature."

Do you think Garret is correct that your reaction time is fastest in the early evening? When do you think it lowest? And how much difference is there? Find out in this human biology science fair project by measuring body temperature and **reaction time** at various times during the day. Reaction time will be measured using online tests that are based on how fast you respond with your mouse to visual cues on the computer screen. You will then chart your results to graphically show how your temperature and reaction times vary during the course of the day.

Terms, Concepts and Questions to Start Background Research

- Circadian rhythm
- Core body temperature
- Hypothalamus
- Nerve conduction velocity
- Reaction time

Questions

- What physiological processes have circadian rhythms in humans?
- Can you think of professions where a slight change in reaction time at different times of the day could be critical?
- Research how the time of day affects performance in sports.

Bibliography

- Garret, William E. *Exercise and Sport Science.* New York: Lippincott Williams & Wilkins, 1999, p. 354.

- Chudler, E, University of Washington. (2008) *Biological Rhythms—Experiment 1: The ups and downs of body temperature.* Retrieved August 1, 2008, from http://faculty.washington.edu/chudler/clock.html

To learn more about the biology of circadian rhythms, visit this website at the University of Utah:

- Siegel, L. (2008). *The Time of Our Lives*, Retrieved July 8, 2008, from http://learn.genetics.utah.edu/features/clockgenes/

This test from the British Broadcasting Corporation (the BBC) tests your reaction time by measuring how fast you are able to shoot escaping sheep with a tranquilizer:

- British Broadcasting Company. (2008). *Sheep Dash!* Retrieved August 1, 2008, from http://www.bbc.co.uk/science/humanbody/sleep/sheep/

This website from the Exploratorium Museum, in San Francisco, California, tests your ability to react to a 90-mile-per-hour fastball:

- Exploratorium. (2008). *Fastball Reaction Time.* Retrieved August 1, 2008, from http://www.exploratorium.edu/baseball/reactiontime.html

Materials and Equipment

- Thermometer to measure body temperature (digital is best)
- A computer with Internet access (so you can use websites that have tests for reaction time)
- Lab notebook
- Graph paper

Experimental Procedure

In these experiments, you will need to make sure you get the best possible data so that the variation in temperature and reaction time can be measured accurately. Your body temperature may vary from 1 to 2 degrees Celsius. Perform each trial three times and average the results.

1. Set up a schedule for the times you will measure your body temperature and reaction time. Obviously you will need to work this into your normal schedule for sleeping and school. Be sure to get data early in the morning, say 5:00 a.m., since this is a critical point in your body's temperature cycle.
2. Taking a reading every three hours is probably sufficient. You might make your measurements at these times: 5 a.m., 8 a.m., 11 a.m., 2 p.m., 5 p.m., and 8 p.m.
3. Design a data table in your lab notebook to record your observations. It should include the following information: date, time of day, reaction time (three trials), body temperature (three readings), average reaction time, and average body

temperature. Keep notes on your methods and observations, such as precisely how you measured your reaction time and body temperature.

4. Try to control any variables that might affect your readings and give you poor results. For example, avoid drinking hot or cold beverages before you take your temperature.
5. Lighting and noise levels should be the same or similar during all reaction tests.
6. Try various thermometers to see which works best. The thermometer should be able to read the temperature at 0.1-degree intervals (or better). It is vital that you take your temperature accurately to be able to document the daily variation. Take your temperature three times each time and calculate the average for each time segment.
7. To measure your reaction time, use a website with an online test. Here are two examples:
    a. This test from the British Broadcasting Corporation (the BBC) tests your reaction time by measuring how fast you are able to shoot escaping sheep with a tranquilizer: Sheep Tranquilizer Game.
    b. This website from the Exploratorium Museum, in San Francisco, California, tests your ability to react to a 90-mile-per-hour fastball: Hit the Baseball Test.
8. Record the individual times and the average time for the reaction time trials. Set up the trials any way you like, but once you have a procedure you like, use it consistently. For example, each time you measure reaction time, do one practice test, then record the next three trials for your data.
9. Repeat steps 2-8 on at least three different days.
10. Graph your average temperature and reaction times.
11. Did you observe a change in body temperature or reaction time during the course of each day? If so, how big was the change?
12. Write a report on your observations. Some things you might include are: How accurately could you measure your temperature? What test of reaction time did you find worked the best? At what time of day was your body temperature highest? At what time of day was your body temperature lowest? Did you see a correlation between body temperature and reaction time?

Variations

- Test your friends and family, too (you could send your data table and instructions to them if they don't live nearby). Do you see any differences in circadian rhythms, based on age or gender?
- Make more frequent observations, say every hour. Do you observe a small decrease in body temperature in the middle of the afternoon? Some people claim

this dip in body temperature can explain cultural behaviors, such as afternoon siestas in Latin countries and the drinking of tea in the United Kingdom.

- Research other types of physiological processes that are governed by circadian rhythms and devise ways to test them. Combine this data with the body temperature and reaction time data.
- If you are not able to observe a circadian cycle in a physiological process, can you estimate how large the change would have to be for you to observe it (*Hint:* Look at the standard deviation of your data)? Include the standard deviation data as error bars in your graph.

Measuring Your Taste Threshold

(from http://sciencebuddies.com/science-fair-projects/project_ideas/HumBio_p013.shtml?fave=no&isb=c2lkOjEsaWE6SHVtQmlvLHA6MixyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this project is to determine your threshold of taste for sweetness, sourness and saltiness. You will determine what is the lowest concentration of a solution that still has perceptible taste for salt, sugar and vinegar.

Introduction

Our neural system for taste is remarkably sensitive. Not only can we sense compounds at extremely low concentrations, we can also discriminate between compounds that are closely related. For some molecules, we can distinguish between different stereoisomers—molecules that are made of exactly the same atoms, but are mirror images of one another (Dodd & Castellucci, 1991). The artificial sweetener aspartame is an example. It tastes sweet, but its stereoisomer does not. Our noses are similarly sensitive: one stereoisomer of carvone smells of spearmint while its mirror image smells of carraway (Dodd & Castelluci, 1991).

In this experiment, you will determine your own taste thresholds for sweet, sour and salty solutions. You will start with a 10% solution, and use the process of *serial dilution* to make a series of solutions, each 10-fold weaker than the preceding one (i.e., 1%, 0.1%, 0.001%, etc.) If done properly, this is an extremely accurate method.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- taste perception,
- taste buds,
- interactions between smell and taste,
- Weber-Fechner law,
- Stevens' power law.

Bibliography

- For an introduction to the physiology of taste, check out these websites:
    - Bowen, R., 2003. "Physiology of Taste," Colorado State University [accessed January 19, 2006] http://arbl.cvmbs.colostate.edu/hbooks/pathphys/digestion/pregastric/taste.html.
    - Jacob, T., 2003. "Taste—A Brief Tutorial by Tim Jacob," School of Biosciences, Cardiff University [accessed January 19, 2006] http://www.cf.ac.uk/biosi/staff/jacob/teaching/sensory/taste.html.
- Here's an interesting news article about an electronic chemosensor: Unattributed news release, 1998. "Researchers Taste Success with Electronic Tongue," College of Engineering, University of Texas at Austin [accessed January 20, 2006] http://www.engr.utexas.edu/news/articles/19981026319/index.cfm.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- salt (sodium chloride),
- granulated sugar (sucrose),
- vinegar,
- water (preferably distilled),
- stirring rod or spoon,
- gram balance,
- 100 mL graduated cylinder,
- 10 mL graduated cylinder,
- cotton swabs,
- paper cups,
- paper towels.

Experimental Procedure

1. Make a data table in your lab notebook like the one below. Use as many columns as you need to determine your taste threshold for each substance. You may want to leave more space or make a separate data table for additional observations that you make during the experiment (e.g., testing different areas of your tongue).

Substance	10%	1%	0.1%	0.01%	etc.
sucrose					
sodium chloride					
vinegar					

2. Measure 90 ml of distilled water and pour it into a paper cup. Add 10 g of granulated sugar. Stir until dissolved. This gives you a 10% (weight/weight, or w/w) sucrose solution.
3. Rinse your mouth with plain tap water and wipe your tongue dry with a clean paper towel.
4. Dip a clean cotton swab into the 10% sugar solution and smear it all around your tongue. If you can taste the sweetness, put a + in your data table for 10% sucrose. Note any other observations that you make.
5. Now measure out 10 ml of the 10% sucrose solution and pour it into a clean paper cup. Add 90 ml of distilled water and stir. (Note: use a clean stirrer, or else thoroughly rinse and dry the previous stirrer, so that you don't carry over concentrated solution into the dilute solution.) This will give you a 1% sugar solution.
6. Again rinse your mouth with plain tap water and wipe your tongue dry with a clean paper towel.
7. Now dip a clean cotton swab into the 1% sugar solution and smear it all around your tongue. If you can taste the sweetness, put a + in your data table for 1% sucrose. Note any other observations that you make.
8. Continue making serial dilutions, rinsing and drying your tongue, and testing each new solution with the cotton swab procedure. Record the results in your lab notebook. The lowest concentration at which you can still taste the sweetness is your approximate taste threshold.
9. Repeat the experiment with salt (sodium chloride) and vinegar (main ingredient: acetic acid). To make a 10% (volume/volume, or v/v) solution of vinegar, use 2 ml of vinegar and 18 ml of water.

Questions

- Were your thresholds the same for all three tastes? Can you think of reasonable explanations for your results?
- Do sugar solutions that are 10-fold more concentrated taste 10× as sweet? Same question for salt and vinegar solutions.

- Some textbooks will tell you that certain areas of the tongue are more sensitive to certain tastes, for example, the the tip of the tongue is more sensitive to sweetness. From your observations while doing this experiment, did you find that certain areas of your tongue are more sensitive to a particular taste (sweet/sour/salty)? If you did, draw a diagram to show the areas with the lowest threshold for each taste.

Variations

- Is there a difference in taste threshold for iodized vs. non-iodized salt?
- Do background research to find out how many molecules are in 10 g of salt. Calculate the number of salt molecules that were contained in the lowest-concentration solution which you could taste. If you assume that the cotton swab holds 0.1 ml, how many salt molecules were available on the cotton swab for you to detect? Do the same for sugar, and, if you are really enterprising, for vinegar.
- In this experiment you used 10-fold serial dilutions to establish your threshold of taste. Design an experiment to determine your threshold with higher precision.
- Recruit enough volunteers in different age groups to take this threshold of taste test so that you can test the hypothesis that taste threshold changes predictably with age. Do your results support the hypothesis?

Pinocchio's Arm: A Lie Detector Test

(from http://sciencebuddies.com/science-fair-projects/project_ideas/HumBio_p019.shtml?fave=no&isb=c2lkOjEsaWE6SHVtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

To detect changes in the brain when a person is telling the truth and when a person is lying.

Introduction

Although lying is discouraged in many cultures, lying is a fundamental **social skill** that most humans begin to develop around age three. The development of lying is directly tied to the **Theory of Mind.** When you begin to understand that what you know about the world might be different than what another person knows, then you begin to have the capacity to lie. Lying is tied to **empathy,** which is the ability to "walk in another person's shoes," the ability to see things from another person's perspective.

People with certain brain-development problems, such as **autism spectrum disorders,** have great difficulty lying, and some people with autism never lie. Some **neuroscientists** (scientists who study the nervous system) believe that a problem with special brain nerve cells, called **mirror neurons** may be partly at fault. Mirror neurons are active whenever a person observes or tries to imitate another person's actions. Imitation is an important step toward empathy and viewing the world from another person's perspective. People with autism have difficulty with this skill.

Neuroscientists are also involved in helping the military, law enforcement, and security personnel detect lying in people suspected of having committed a crime. Standard lie-detection techniques include the use of a **polygraph,** a machine that measures the body's response to the **stress** caused by telling a lie. The polygraph continuously monitors heart rate, blood pressure, and sweating and watches for any increases in these that could signal that the person has just lied.

The problem with polygraphs, though, is that there can be **false positives,** which are false increases in heart rate, blood pressure, and/or sweating because of anxiety about the test or other unrelated issues. There can also be **false negatives,** where the person being investigated is telling a lie, but he or she either does not feel guilt about it, or has learned how to stop the body's responses to lies. This has led to an interest in developing alternative methods of detecting lies. The most promising machine is currently the **functional magnetic resonance imaging,** or **fMRI** scanner.

The fMRI differs from a standard **MRI** in that the standard MRI shows the brain's anatomy at high resolution (in great detail), whereas the fMRI shows how the brain is functioning and interacting, in lesser resolution, as the brain performs a specific task. fMRI maps blood flow to different regions of the brain in **real-time.** So, for example, if you were shown a photograph of a family member, the fMRI would tell the neuroscientists which parts of your brain were active when you looked at the image of your family member, such as the vision center, the emotional center, and the facial recognition center. With a standard MRI, your brain will look the same anatomically, regardless of what task you are doing—listening to music, looking a photograph, or telling a lie.

With fMRI, neuroscientists have discovered that your brain works harder when it is telling a lie, than when it is telling a truth! More and different parts of the brain are active during lying, as compared to truth-telling. While just four parts are active during truth-telling, seven parts are active during lying. In this science fair project, you'll take advantage of this difference in **brain states** to form a simple lie detector test. You'll give a person a physical task to do and have him or her tell a truth, and then tell a lie. You'll see if the person is better able to do the task when his or her brain is less active (telling a truth), or more active (telling a lie). So go call all your friends and family, and see if you can detect a harder-working brain!

Terms, Concepts and Questions to Start Background Research

- Social skill
- Theory of Mind
- Empathy
- Autism spectrum disorder
- Neuroscientist
- Mirror neuron
- Polygraph
- Stress
- False positive
- False negative
- Functional magnetic resonance imaging (fMRI)
- MRI
- Real-time
- Brain state
- Resistance

Questions

- What does Theory of Mind mean?
- What does a polygraph do? Are they always accurate? Why or why not?
- What is the difference between fMRI and MRI? Why is low resolution better for detecting lies?
- How do the brains of people who are lying and those who are telling the truth differ when they are observed with fMRI?

Bibliography

This source describes the parts of the brain that are active in truth-telling vs. lying:

- Reuters Contributors. (2004, November 29). Lying Makes Brain Work Harder. Retrieved July 8, 2008, from http://www.wired.com/medtech/health/news/2004/11/65871

This source describes functional magnetic resonance imaging, or fMRI machines:

- Wikipedia Contributors. (2008, July 7). Functional magnetic resonance imaging. Wikipedia: The Free Encyclopedia. Retrieved July 8, 2008, from http://en.wikipedia.org/w/index.php?title=Functional_magnetic_resonance_imaging&oldid=224198848

This source describe how polygraphs work:

- Bonsor, K. (2008). How Lie Detectors Work. How Stuff Works, Inc. Retrieved July 8, 2008, from http://people.howstuffworks.com/lie-detector.htm

Materials and Equipment

- Volunteers (at least 10 and older than age 7)
- Lab notebook
- Paper
- Stool or stair (if needed)

Experimental Procedure

Testing Your Volunteers

1. Have the first volunteer write down or tell you three things that he or she loves to eat or do, and two things that he or she dislikes to eat or do. For example, your friend might tell you that he loves skateboarding, swimming, and ice cream, and dislikes pepper and cleaning his room.
2. Have the volunteer stand facing you, a few feet away. If you are much shorter than your volunteer is, then raise yourself up on a stool or stair so that it is easier for you to conduct the experiment.

3. Have the volunteer extend his or her arm straight out in front, palm facing down. Tell the volunteer that you are going to have him say a few phrases and that you would like him to try to keep his arm up.
4. Extend your arm and place your hand, palm down, over the volunteer's hand and wrist, as shown in Figure 1.

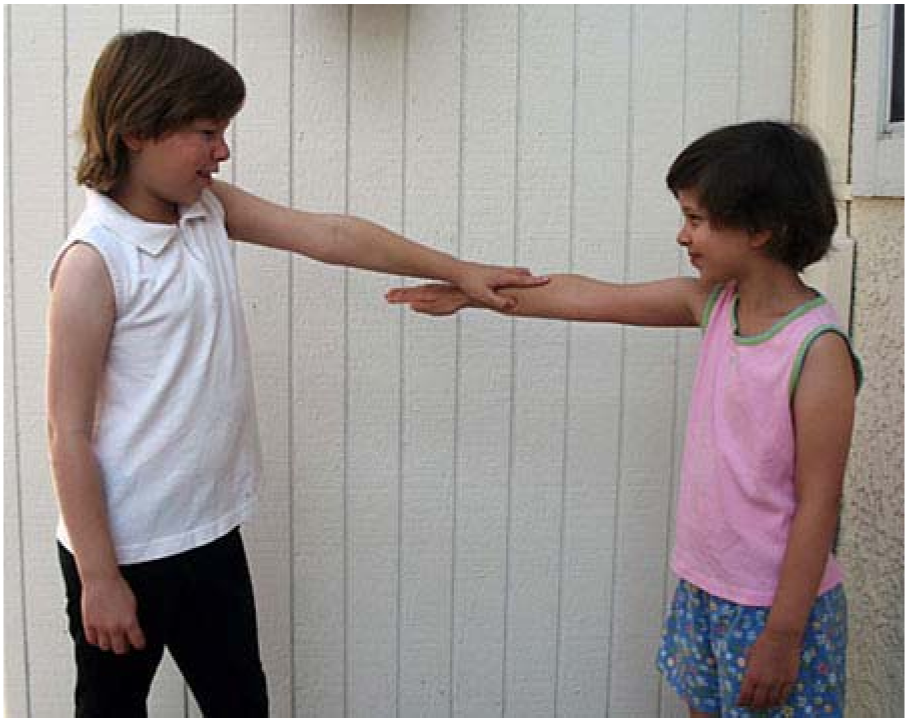

Figure 1. This photograph shows how to conduct a simple lie-detector test.

5. Tell the volunteer to say, I love to ________ (fill in the blank with the first word the volunteer wrote down in the list of things that he or she loves to do). This will be a truth. As the volunteer says the phrase, press down on the volunteer's arm. Apply steady, constant pressure. It is not necessary to force it all the way down if you cannot. You are just trying to get a sense of the **resistance,** or how hard it is to push down.
6. Have the volunteer extend his or her arm again. Tell the volunteer to say, I love to vomit. This phrase will be a lie since nausea is universally an unpleasant experience. As the volunteer says the phrase, press down again on the volunteer's arm. Apply steady, constant pressure. Compare the resistance when the person was telling a truth with the resistance when the person was telling a lie. Write down which resistance felt greater to you, or if there was no difference, in a data table like the one below, in your lab notebook.
7. Repeat steps 5-6 for the volunteer's second like and the volunteer's second dislike.

8. Repeat steps 5-6 for the volunteer's third like and the volunteer's third dislike.

Volunteer 1's Likes and Dislikes Data Table	
Likes	Dislikes
Swimming	Vomiting
Skateboarding	Pepper
Ice Cream	Cleaning Room

Volunteer 1's Truths and Lies Data Table		
First Phrase of Likes (Truths)	Second Phrase of Dislikes (Lies)	Observed Arm Resistance: Greater for first phrase (the truth)? Greater for second phrase (the lie)? Or no difference?
I love to swim.	I love to vomit.	
I love to skateboard.	I love pepper.	
I love ice cream.	I love to clean my room.	

9. Repeat steps 1-8 for at least nine more volunteers.

Combining and Analyzing Your Data Tables

1. Look at the observed arm resistances for each volunteer in the Truths and Lies Data Tables. Write down the one that occurred most frequently in the Combined Data Table. If none occurred most frequently, then write down, "No Difference."

Combined Data Chart	
Volunteer Name or Number	Most Frequently Observed Arm Resistance: Greater for the truth, the lie, or no difference?
1.	

2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

2. Look at your Combined Data Table. Overall, was there greater arm resistance (meaning a better ability to complete the task of keeping the arm up), for the truths, the lies, or did you see no difference? If you saw a difference between truths and lies, what do you think accounts for this difference?

Variations

- Is it possible to defeat the lie detector test? Double the number of volunteers and randomly tell half of them prior to testing what you expect to see in the response of their arm when they lie, and when they tell the truth. Keep track of those volunteers that you told, and those that you did not. Did you see a difference between the two groups? Do you think it is important that the volunteers in a study know what the expected outcomes are? Or does that skew the results? What about the tester? Would it be better for the person doing the testing to be "blind" to the expected outcomes as well?
- Develop a different type of lie detector test using facial and/or body cues.

The Effect of Caffeine on Human Blood Pressure

(Project found at http://www.all-science-fair-projects.com/)

Purpose

The purpose of this experiment is to determine if caffeine affects the blood pressure of 6th grade subjects (or boys, or both, or 7th grade subjects, or boys, or both, etc.)

Experiment Design

The constants in this study were:

- ☑ The amount of caffeinated soft drinks the subjects drink,
- ☑ The amount of time between trials.
- ☑ What the subjects do while waiting to have their blood pressure taken,
- ☑ The person taking the blood pressure,
- ☑ Using the same blood pressure cuff and gauge for each subject.

The manipulated variable is the amount of caffeine the subjects drink. The first time blood pressure is taken, they should have no pop in their system. The second time, blood pressure is taken after the subject had one can of caffeinated soft drink. The third time, blood pressure is taken after the subject had two can of caffeinated soft drink.

The responding variable is the blood pressure, both systolic and diastolic.

Materials

- ☒ Stethoscope
- ☒ Blood pressure cuff and gauge
- ☒ Two cans of caffeinated soda pop

Special Note: ALL subjects in this project must have a permission slip from parents to participate.

Procedure

1. Make sure all the materials are available and that every subject has the permission slip in, and is present. Each should have eaten some breakfast. None of them can have consumed any tea, pop, coffee, or other caffeinated substances.

2. When you begin, take the subject's blood pressure and record it on a table.

3. After the blood pressure is taken, have each, subject, drink a full can, 355 ml. (12 fluid ounces,) of caffeinated soft drink within 5 minutes of having their blood pressure taken.

4. Wait 45-55 min from when each subject finishes the caffeinated soft drink, and then take the blood pressure again, using the same order. Record the results in the table.

5. Immediately have each subject drink another 355ml. can of caffeinated soft drink.

6. Wait another 45-55 min. until testing the blood pressure, in the same order. Record the results in the table.

7. Calculate each subject's blood pressure change. The change is the *difference between the blood pressure with no caffeine and with some can of Caffeinated soft drink, and the difference between no caffeine and two cans of Caffeinated soft drink.*

Sample Table Heading

Subject Number	*Beginning Blood Pressure*	*Blood Pressure After One Can*	*Blood Pressure After Two Cans*