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Effects of Low-Level Caffeine Consumption
on Long-term Memory Recall
of Southern College Students
L. Shawn Williams
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Running head: CAFFEINE CONSUMPTION ON RECALL ABILITY

Abstract

This study investigates the effects of low caffeine doses on long-term memory as indicated by performance on a multiple choice examination. It was hypothesized that 66 mg. of caffeine, in the form of a cola beverage, would negatively affect examination performance. Experimental subjects, 24 volunteer undergraduate students, were randomly divided into two groups and asked to drink 12-ounces of cola before beginning to study. After 24 hours, subjects completed a 30 question test on the material. A significant correlation between subject's most recent caffeine consumption prior to the experiment and test results, and a non-significant inverse relationship between study time and test performance in the caffeine group were found. While the data generated by this study are inconclusive, several trends are identified for investigation by future research.

Effects of Low-Level Caffeine Consumption
on Long-term Memory Recall
of Southern College Students

Caffeine has long been a part of our culture, consumed daily in tea, coffee, soda pop, and pills. But what are its effects? On a physiological level, caffeine consumption has been linked to several problems, such as increased risk of delivering low birth weight babies for mothers who consume caffeine during pregnancy (Cann & Goldhaber, 1989). Caffeine has also been found to increase the severity of premenstrual syndrome symptoms in young women (Rossignol, 1985).

Connections between caffeine and cognitive functions, however, are more vague and often contradictory. A 1987 study on caffeine and Electroconvulsive Therapy (ECT) reported no significant cognitive differences in patients who consumed caffeine before treatment. The slight differences observed were attributed to increased seizure length in caffeine treated patients (Shapira et al., 1987). Conversely, a 1981 study of college students reported increased depression and anxiety, lower G. P. A.'s , lower single

course grades, and a higher percentage of incomplete grades for students who were high caffeine consumers (Gilliland & Andress, 1981). Mitchell, Ross, and Hurst (1974) found no significant effects of caffeine on verbal recall on a "paced sequential memory task".

One question not addressed in the research concerns effects of low level caffeine consumption on long-term memory or recall of learned material. Among the most frequent consumers of caffeine are students who consume caffeine in conjunction with preparation for examinations. It has been inferred from this that "caffeine may have some beneficial effect" (Loke, 1988, p. 9), but no data are presented to support this inference. Research does indicate that caffeine adversely affects performance on the AVLTL (Auditory-Verbal Learning Test) (Terry & Phifer, 1986); however, this test measures short-term recall ability of classroom material. The amount of caffeine administered in the AVLTL study was 100 mg. in the form one dissolved No-Doz tablet (Terry & Phifer, 1986), the lowest in any study. The greatest amount was over 1000 mg. (Shapira, et al., 1987). But chemical research indicates that one 12-oz. can of the average cola may

contain as little as 31 mg. of caffeine (Hill, McSharry, & Trzupek, 1988).

This study seeks to discover if indeed, as Loke (1988) infers from student behavior, caffeine has a beneficial effect on examination performance by addressing the unanswered question of the effects of low level caffeine consumption--specifically, 12 ounces of a caffeinated cola beverage (66 mg. caffeine¹)--on long-term memory recall. This researcher hypothesizes that this low level caffeine consumption will, in fact, have a negative effect on memory recall ability.

Methods

Subjects

The sample consisted of 24 volunteer subjects (10 male, 14 female) drawn from a population of 106 undergraduate students enrolled in developmental psychology classes at Southern College. All subjects received extra credit points for their participation. The subjects were told that the experiment studied the effects of caffeine on cognitive functioning, and were requested not to consume any caffeinated beverages on the days of the experiment² other than what they may

receive during the experimental sessions. (see Appendix A).

Materials

Questionnaire for session one (see Appendix B).

Questionnaire for session two (see Appendix B).

Study notes (see Appendix C) drawn from items in
Cultural Literacy.

30 question multiple choice test based on study notes
(see Appendix D)

2 Liter bottles of caffeine-free Coca-Cola Classic

3 Liter bottles of Double Cola (caffeinated)

12 oz. styrofoam cups

Procedures

Due to schedule conflicts, the seventh game of the World Series, and the change from daylight to standard time, the experiment was conducted in two sessions, the first on October 27 and 28, and the second on November 3 and 4, at 8:00 p.m. A total of 10 subjects completed the first experimental sessions, and 14 completed the second. Identical procedures were followed at both sessions.

On the first evening of each session, subjects were assigned in the order they entered the test room

to one of two groups, A or B (Group A: N=13, Group B, N=11)³ and given 12 ounces of a cola beverage, simply identified as "A" or "B," with group A receiving a caffeinated beverage, and group B a decaffeinated beverage. Each subject then filled out a questionnaire for session one. After completing the questionnaire, each was given a copy of the study notes and told they would be tested over the material at the next evening's session. Subjects were asked to study the material until they felt they had mastered it sufficiently, at which time they could leave the test room after notifying the experimenter, who recorded the time spent in study, and returning all study notes. At 8:00 p.m. the next evening, the subjects returned to the test room and completed the multiple-choice examination. Subjects also filled out the second questionnaire, which was collected by the experimenter along with the test materials.

Results

The basic unit of analysis was the test score, calculated as the number of correct responses by each subject to the thirty test questions. The t-test analysis for independent samples indicates no

significant difference in the test scores of each group ($t = 0.5168$, $\alpha = 0.05$, $p > 0.20$). Group means and standard deviations are shown in Table 1.

Insert Table 1

Several correlation coefficients were calculated for both groups. These results are shown in Table 2.

Insert Table 2 at the end of this page

The Pearson test identified no significant correlation between body weight, amount of sleep, or frequency of caffeine consumption and test scores. The most significant finding was the relationship between elapsed time and test scores. There was a moderately positive correlation between elapsed time, the amount of time before the beginning of the experiment subjects had last consumed any caffeine, and the test scores. The correlation coefficient for Group A, the caffeine group, was 0.4675; for Group B, 0.4270; and the overall correlation was 0.4525 ($p < 0.05$). Regardless of the group to which subjects were assigned, the greater the

elapsed of time, the better the test scores. The following graphs illustrate this relationship.

Insert Graphs 1, 2, and 3.

The relationship between the amount of time spent studying for the test and test scores was also analyzed using the Pierson correlation. It was expected that there would be a positive correlation; that is, subjects who studied longer would have higher test scores. This expectation was not supported. Analysis of the control group, Group B, discovered practically no correlation ($r = 0.0010$); however, in Group A, it was found that increased study time was slightly related to decreased test scores. The correlation coefficient for Group A was -0.2604 , indicating some correlation; however, this was not statistically significant. This relationship is represented graphically in Graphs 4 and 5, below.

Insert Graphs 4 and 5.

Correlation coefficients for gender and test scores were calculated using the point-biserial test. The test scores for each gender are displayed in Graphs 6 and 7 below. A slight, though statistically insignificant, correlation of 0.3095 was found for Group A, with males scoring slightly higher than females. The correlation for Group B ($r = 0.1580$) was also statistically insignificant.

Insert Graphs 6 and 7.

Discussion

Based on the t analysis of data from this study, there was not enough evidence to support the research hypothesis that caffeine consumption negatively affected test performance. However, correlational analyses indicate some interesting trends.

Independent of group assignment, subjects who had not consumed caffeine for longer periods of time prior to the experiment performed better than those who had more recently consumed caffeine. Conversely, those who had recently consumed caffeine performed worse. It was interesting that male subjects in the caffeine group

performed slightly, though not significantly, better than the female subjects. This effect was not as apparent in the control group, nor apparently due to body weight differences between the sexes. It would be of interest to discover if this effect holds for larger groups, and, if so, to determine its causes.

Contrary to expectation, the longer subjects in the caffeine group studied, the more poorly they tended to perform. This finding is of even greater interest considering that caffeine reaches its highest levels in the body 20 to 30 minutes after ingestion (Kummer, 1990). A serendipitous finding discovered from further comparison of the test results is that subjects in the caffeine group who studied less than 25 minutes answered an average of 16.57 questions correctly; subjects studying 25 minutes or more correctly answered an average of 12.17 questions. It was this researcher's assumption that though the subjects were permitted to study for the amount of time each chose individually, all would have spent 45 minutes or more studying the material. Unfortunately, this assumption was not supported. It seems likely, however, from the results that had subjects been required to wait 15 to

20 minutes after ingesting the cola before beginning to study, or been required to study for 45 minutes or more, a significant difference in test scores would have resulted.

While these correlations, with the exception of elapsed time and test scores, are not statistically significant, and therefore do not offer supporting evidence for the hypothesis that caffeine negatively affects test performance, they do raise several doubts as to the validity of Loke's (1988) inference that caffeine consumption is beneficial to, or even has no effect on, examination preparation. While the data collected in this study are inconclusive, the results indicate a need for more study of the possible effects of caffeine on long-term memory. Time has been identified as a critical variable to be controlled in such research, as has the need for larger samples. Future research will be needed to answer questions regarding gender differences in caffeine's effects on cognitive performance, as well as the relationship between time variables and caffeine's effects.

Appendix A

Dear Student:

Thank you for volunteering to participate in this experiment studying the relationship between caffeine and cognitive functioning. The first session of the experiment will begin at 8:00 p.m. on Sunday, October 27, in Room 213 of Summerour Hall; the second session will be held the next evening at the same location and time. **NOTE: It is important that you do not consume any caffeine-containing substance at any time during the day before the experiment begins (October 27), and that you consume no caffeine from that time until the experiment is completed.**

You will be asked to drink at least one cola beverage during the experiment. This beverage may or may not contain caffeine. Any information obtained in this study which could be used to identify you is strictly confidential, and can be released only with your permission.

Your decision to participate is appreciated, and you will receive extra credit for Developmental Psychology for participation. However, if at any time, even after signing this form, you no longer wish to

participate, simply contact me. You will be dropped from the experiment without prejudice, with no negative effects on your future relations with myself, this department, or your Developmental Psychology Class.

I would be happy to answer any questions that you might have. Please feel free to call me or my advisor, Dr. Ruth Williams-Morris, with your inquiries. You may reach me at 2159; Dr. Williams-Morris may be reached at 2758.

Again, thank you for your participation.

L. Shawn Williams

My signature below indicates that I have read and understood the information above, and that I have voluntarily chosen to participate in this experiment. I understand that I may withdraw at any time for any reason, even after signing this form, simply by informing the experimenter of my desire to discontinue participation in this project.

Signature

Date

PLEASE DETACH AND RETURN TO BOX 159 THATCHER. MUST BE RETURNED BY FRIDAY, OCTOBER 25, IF YOU WISH TO PARTICIPATE.

Appendix B

Session One Questionnaire

_____ Group Letter and Number

Please answer the following questions by writing the number of the appropriate response(s) on the line next to each question. The answers you give will be totally confidential, used only for statistical purposes.

_____ 1. Class standing:

FR=1, SO=2, JR=3, SR=4, PG=5, SP=6

2. Which of the following products do you consume?

Please circle all that apply.

1=Coke/Pepsi or other cola drinks (regular or diet).

2=Mello Yello/Mountain Dew/Sundrop (regular or diet).

3=Dr. Pepper (regular or diet).

4=Coffee

5=Tea

6=Excedrin pain relief tablets

7=Goody's/BC headache powders

8=Chocolate

9=None of the Above

___ 3. How often do you consume any of the above products?

1=More than once per day

2=daily

3=2-3 times per week

4=Once per week

5=Once or twice per month

6=Less than once per month or not at all

___ 4. How long has it been since the last time you used any of the items listed in question 3?

1=less than 12 hours

2=12 to 24 hours

3=2-3 days

4=3-7 days

5=more than 7 days

___ 5. What is your approximate weight?

___ 6. What is your gender?

1=Male

2=Female

7. What is your major?

Session Two Questionnaire

____ Group Letter and Number

Please answer the following questions by writing the number of the appropriate response(s) on the line next to each question. The answers you give will be totally confidential, used only for statistical purposes.

1. What beverages, other than water or milk, have you consumed since last night's experimental session (Please be specific; e.g. One cup of juice, Two cans of Diet Coke, etc.)?

 - ____ 2. How long has it been since you last ate anything?
1=less than 2 hours
2=2-5 hours
3=5-10 hours
4=10-24 hours
5=more than 24 hours
If you answered 1, 2, or 3, what did you eat?
- _____

3. How much sleep did you get last night?

1=less than 4 hours

2=4-5 hours

3=6-7 hours

4=8 hours

5=9 or more hours

Appendix C

Study Notes

In his book Cultural Literacy, E. D. Hirsch, Jr. lists several things that culturally literate Americans should know. The items in these pages are drawn from that list.

Literature**Great Works by American Authors:**

J. D. Sallinger, The Catcher in the Rye

Louisa May Alcott, Eight Cousins, Little Men

Mark Twain, A Connecticut Yankee in King Arthur's Court, Tom Sawyer

James Fenimore Cooper, The Last of the Mohicans

Thornton Wilder, Our Town

Great Works by British Authors

Lewis Carroll, Alice in Wonderland, Through the Looking Glass

Charles Dickens, A Tale of Two Cities, David Copperfield, A Christmas Carol

William Shakespeare, Twelfth Night, As You Like It, Hamlet, Othello

Great Works by Authors of the Middle Ages and Ancient World

Aristophanes: Greek satirical/comic playwright.

Plays include Lysistrata, The Birds

Homer, Illiad: The story Achilles, the greatest Greek warrior of the Trojan war.

Odyssey: The story of the Odysseus' voyage home after the Trojan war.

Sophocles, Oedipus Rex: The story of King Oedipus, who was fated to kill his father and marry his mother. The Oedipus complex of Freudian theory is named for this king.

Virgil, Aeneid: An epic tale of the Trojan ancestors of the founders of Rome. Relates the fall of Troy and the story of the Trojan Horse.

Dante, Divine Comedy

History

In 1066, William of Normandy, later known as William the Conquer, invaded England and defeated the English army at the Battle of Hastings. As a result of this battle, the knight on horseback came to be regarded as the ultimate soldier, and remained so throughout the Middle Ages.

The American Revolution brought about a change in the composition of armies. Since the end of the middle ages, the majority of soldiers had been drawn from the dregs of society--the mentally ill, unemployed, criminals, vagrants, etc.--and had to be forced to fight by its aristocratic officers. During the Revolution, it was seen that an army composed of citizens fighting for a cause they believed in was much more effective. Some of the most famous battles of this war were the Battles of Lexington and Concord, the Battle of Bunker Hill, which, incidentally, was misnamed as it was actually fought on Breed's Hill; and the Battle of Yorktown, the site of Lord Cornwallis' surrender and the end of the war.

At the Battle of Trafalger, the British navy, under the command of Wellington, destroyed the French navy, thereby preventing Napoleon from invading England. It was Wellington who later defeated Napoleon again at the Battle of Waterloo.

One of the next major conflicts, after the defeat of Napoleon, was the Crimean War between Russia and the English, Turks, and French. The most famous battle of this war was the Battle of Balaklava in 1854. It was

during this battle that the infamous Charge of the Light Brigade, immortalized in the poem of that title by Alfred Lord Tennyson, occurred.

During the latter part of the 19th century, Mary Baker Eddy founded the Christian Science faith. After a severe injury, while reading the gospel of John, she believed she had gained insight into the healing methods of Christ, and immediately felt herself healed. She began to heal the sick and teach others to heal, finally establishing the organized church of the Christian Science religion, the Church of Christ, Scientist.

Chou En-lai was a Communist administrator who ran the central government of the People's Republic of China as Premier under Mao Tse-tung from 1949 to 1976. Many Chinese people who had fled from Mao's regime settled in Taiwan; in 1949 Taiwan's capital, Taipei, became the capital of the free Republic of China.

The French, fearing German invasion during the 1930's, constructed a massive system of fortification along the eastern border from Switzerland to Belgium, a distance of over 200 miles. However, this defensive fortification, known as the Maginot Line, was

unsuccessful. The Germans simply went around the end of the line through Belgium.

It was at nearly the same location that the famous Battle of the Bulge was fought in 1944-45. This battle, also known as the Battle of the Ardennes, was the last major German attempt to turn back the Allies' European invasion. The Germans drove a wedge (bulge) into the center of the Allied lines, but were halted by the U.S. 1st and 3rd Armies, the latter of which was under the command of General George Patton.

Dien Bien Phu (1954) was the climactic battle of France's struggle to maintain control of Indochina. After their defeat here, French rule was ended in Vietnam, Laos, and Kampuchea, and Vietnam was divided into Communist North Vietnam and anti-Communist South Vietnam. It was only three years later that the conflict which escalated into the Vietnam War began.

One of the most grim actions of this war was the My Lai incident of May 16, 1968. U.S. troops under the command of Lt. William Calley entered the hamlet of My Lai and massacred over 300 unarmed Vietnamese civilians, most of whom were elderly men, women and

children. Lt. Calley was eventually court-martialed and convicted of war crimes for this incident.

Terms

Anthropomorphism: Interpreting non-human things in terms of human characteristics. e.g. "The hand of God."

Aphorism: concise statement of a principle, truth or sentiment, usually in one sentence or less.

Bowlerize: Named for Thomas Bowdler, editor of an 1825 edition of Shakespeare's works, the term refers to removing objectionable or offensive matter from something.

Caveat emptor: A principle in trading that the buyer should make sure he gets what he's paying for, i.e., "Let the buyer beware."

Cosmology: Philosophy dealing with the processes of nature and the universe.

Deus ex machina: Literally, "god from a machine." A person or thing that suddenly or unexpectedly appears, providing a contrived, miraculous, or artificial solution to an apparently unsolvable problem.

Eugenics: Science or process of improving the genetic quality of a race by controlling [human] mating and reproduction.

Fin de siècle: French phrase referring to the end of an age, literally "End of [the] century."

Hoi polloi: Ordinary people, the general populace.
Also sometimes used as a slang term for people of wealth or high social status.

Utilitarianism: Principle that social, moral, and political action should be what provides the greatest good or happiness to the greatest number of people.

Appendix D

Please write the letter of the correct answer on the line next to each question.

SECTION I: MULTIPLE CHOICE

- ___ 1. Which of the following battles was misnamed?
a. Battle of Lexington c. Battle of Bunker Hill
b. Battle of Concord d. Battle of Cowpens
- ___ 2. Which battle destroyed Napoleon's navy?
a. Battle of Trafalger c. Battle of Cannae
b. Battle of Britain d. Battle of Hastings
- ___ 3. The Oedipus complex in Freud's theories is named for the Greek legend of King Oedipus, recorded in the play Oedipus Rex by
a. Sophocles c. Aeschylus
b. Euripides d. Aristophanes
- ___ 4. Which of the following terms refers to censoring objectionable materials?
a. parvenu c. anthropomorphism
b. Stalinism d. Bowdlerize
- ___ 5. The philosophy dealing with the processes of nature and the universe is
a. cosmetology c. cosmology
b. naturalism d. existentialism

- ___ 6. "Let the buyer beware" defines or is an example of
- a. caveat emptor.
 - b. an aphorism
 - c. both (a) and (b)
 - d. none of the above
- ___ 7. The story of the Trojan Horse is found in
- a. The Iliad
 - b. The Aeneid
 - c. The Odyssey
 - d. Othello
- ___ 8. Mary Baker Eddy was the founder of the
- a. Church of God
 - b. Church of Jesus Christ of Latter-day Saints
 - c. Disciples of Christ
 - d. Church of Christ, Scientist
- ___ 9. The Charge of the Light Brigade took place during which of the following?
- a. World War I
 - b. Crimean War
 - c. Battle of Sevastopol
 - d. None of the above
- ___ 10. Chou En-Lai was
- a. emperor of the People's Republic of China after Mao Tse-tung.
 - b. a major battle of the Vietnam War.
 - c. Premier of the People's Republic of China under Mao Tse-tung.
 - d. None of the above.

- ___ 11. As a result of the Battle of Hastings,
- a. volunteer citizen armies were established.
 - b. knights were regarded as the ultimate soldiers.
 - c. military discipline became more strict.
 - d. Napoleon became emperor of France.
- ___ 12. The phrase "Achilles' Heel" comes from the legend of Achilles, the main character which of the following?
- a. The Odyssey
 - b. The Aeneid
 - c. Agammemon
 - d. The Iliad
- ___ 13. Which of the following was the sight of a major conflict during the Vietnam War?
- a. Dien Bien Phu
 - b. Taipei
 - c. Hoi Polloi
 - d. None of the above
- ___ 14. The defensive fortification built along the eastern border of France was known as
- a. Fin de siècle
 - b. Maginot Line
 - c. Suisse-Belge Line
 - d. None of the above
- ___ 15. After the conflict at Dien Bien Phu,
- a. France lost control of Indochina.
 - b. U. S. troops withdrew from Vietnam.
 - c. Vietnam was divided.
 - d. Both (a) and (c)

Appendix E

Table 1

Summary of Means and Standard Deviations

	Group A		Group B		Overall	
	\bar{x}	s	\bar{x}	s	\bar{x}	s
Test Score	13.77	4.87	14.73	4.08	14.21	4.45
Males	15.60	3.58	15.40	3.44	15.50	3.31
Females	12.63	5.42	14.17	4.79	13.29	5.03
Study Time						
(Minutes)	26.00	8.68	22.36	2.16	24.33	6.69

Table 2

Variables Correlated with Test Scores

Variable	Group A	Group B	Overall correlation
Study Time	-0.2604	0.0010	-0.2228
Gender*	0.3095	0.1580	0.2505
Body Weight	-0.1841	-0.0041	-0.1290
Previous night's sleep	-0.1223	-0.1586	-0.0899
Elapsed Time	0.4675	0.4270	**0.4525
Frequency of caffeine use	-0.0445	0.1849	0.0683

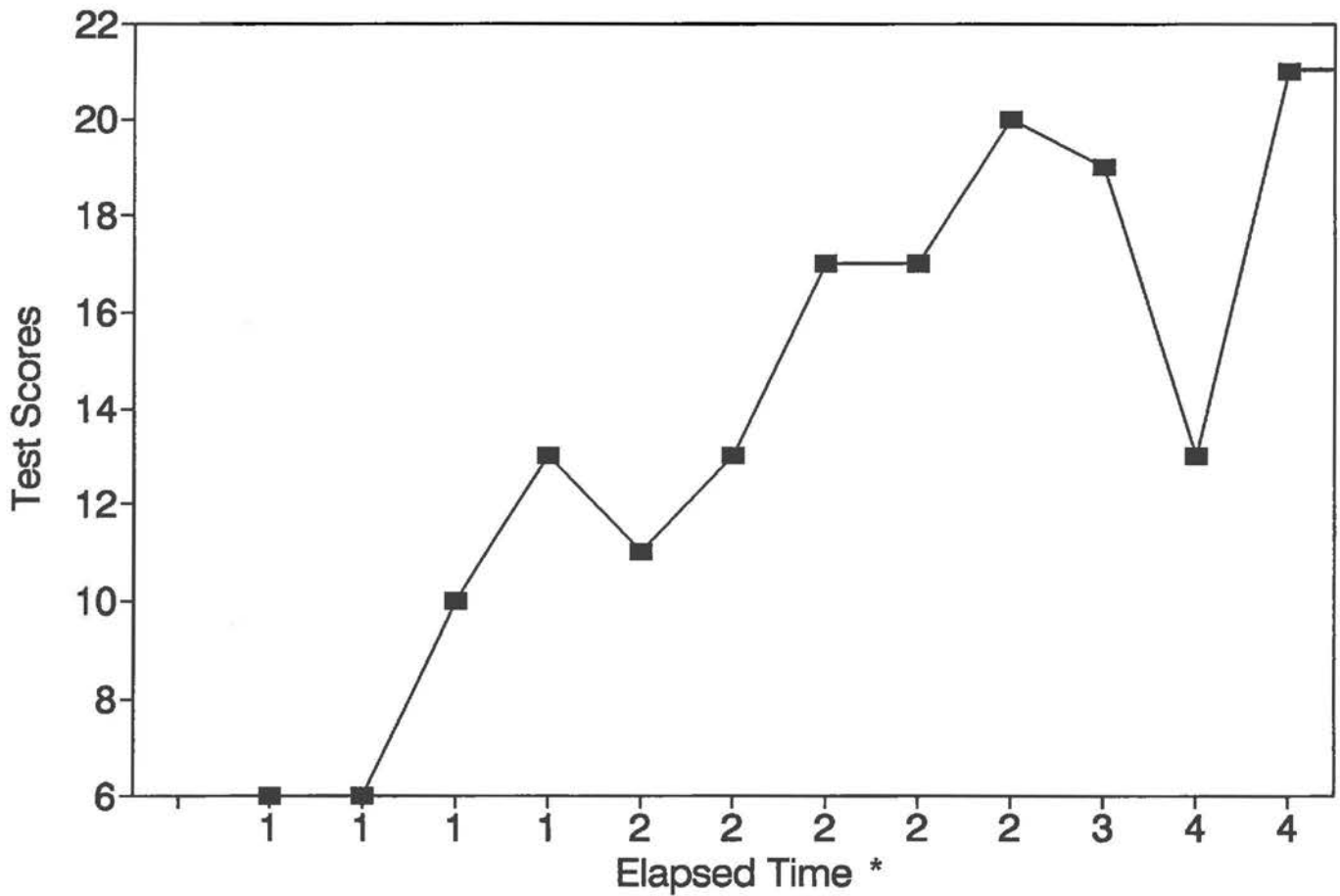
*Point-biserial correlation.

**Significant, $p < 0.05$.

Appendix F

Graph 1

Elapsed Time and Test Scores Group A

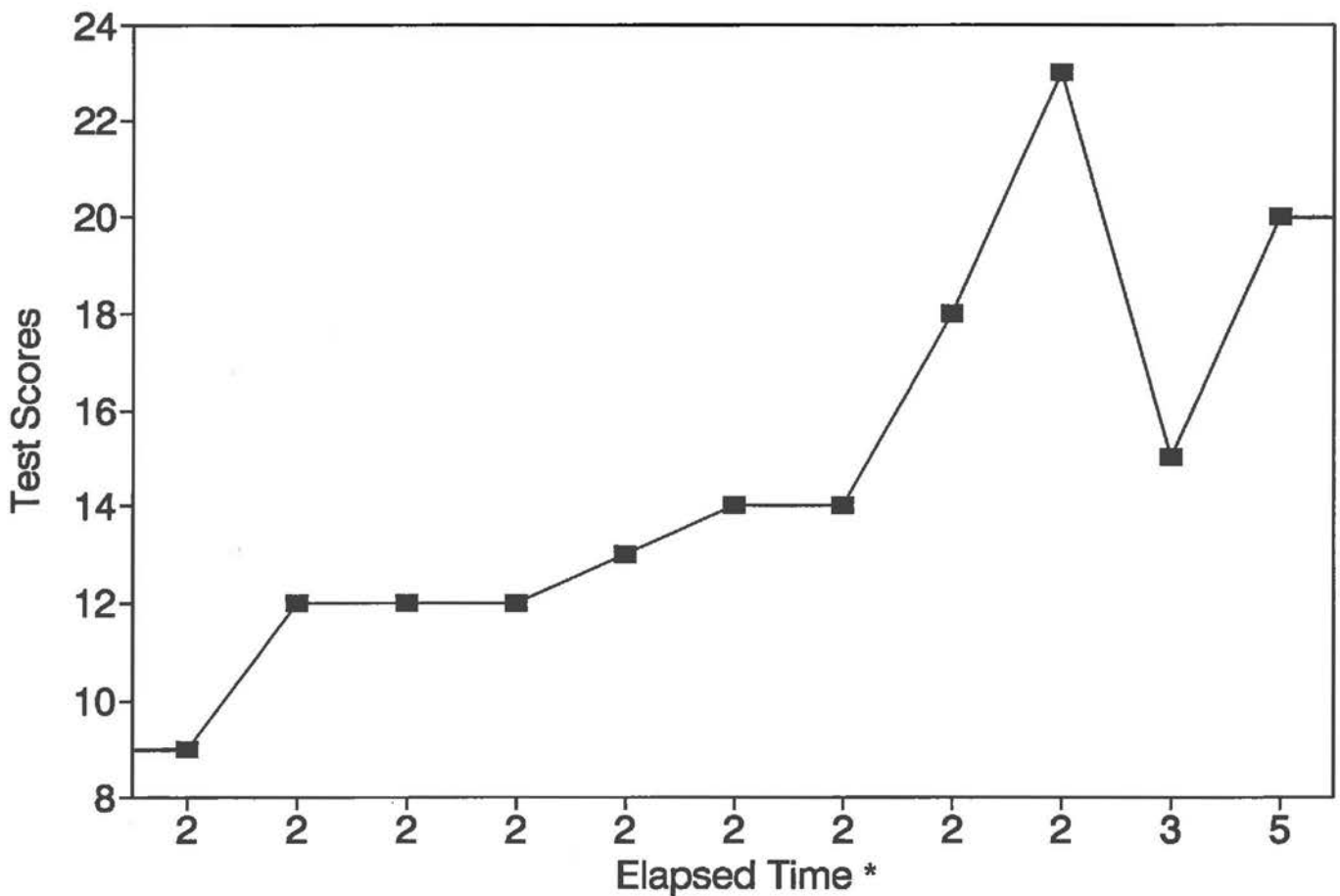


*Indicates time elapsed between subjects' most recent consumption of caffeine and the beginning of the experiment.

- 1 = less than 12 hours
- 2 = 12-24 hours
- 3 = 2-3 days
- 4 = 3-7 days
- 5 = more than 7 days

Graph 2

Elapsed Time and Test Scores Group B

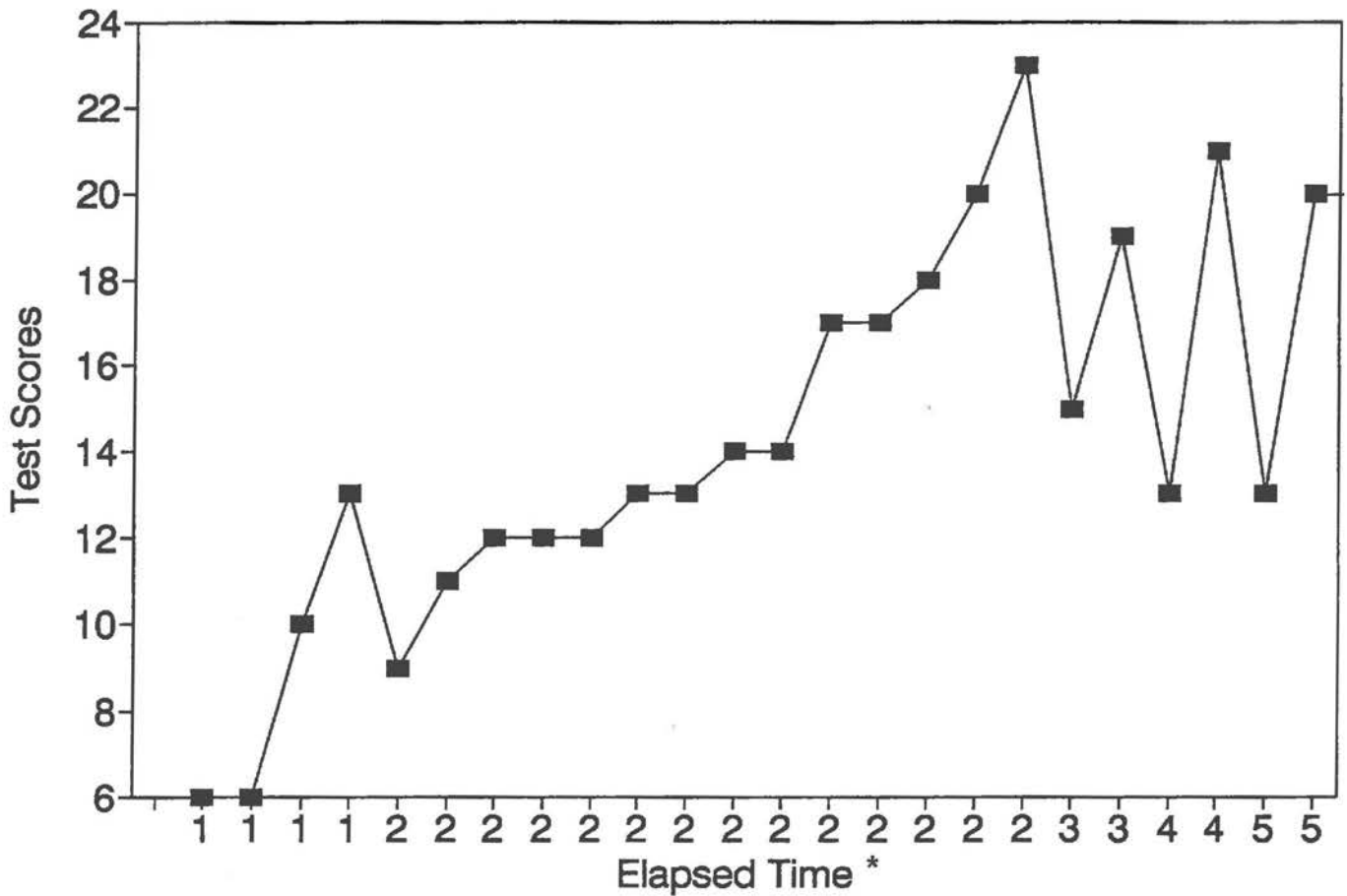


*Indicates time elapsed between subjects' most recent consumption of caffeine and the beginning of the experiment.

- 1 = less than 12 hours
- 2 = 12-24 hours
- 3 = 2-3 days
- 4 = 3-7 days
- 5 = more than 7 days

Graph 3

Elapsed Time and Test Scores Overall Results

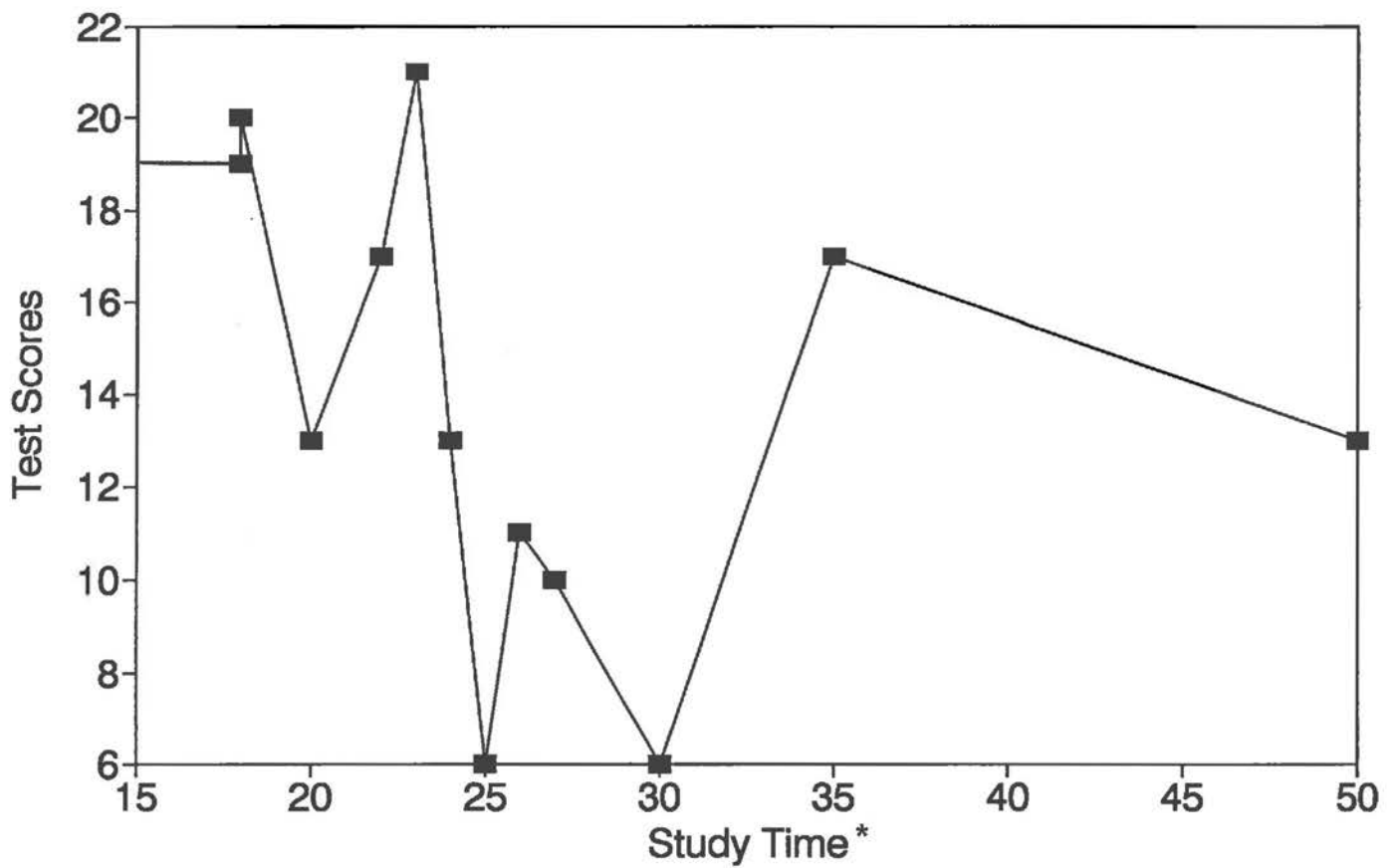


*Indicates time elapsed between subjects' most recent consumption of caffeine and the beginning of the experiment.

- 1 = less than 12 hours
- 2 = 12-24 hours
- 3 = 2-3 days
- 4 = 3-7 days
- 5 = more than 7 days

Graph 4

Study Time and Test Scores Group A

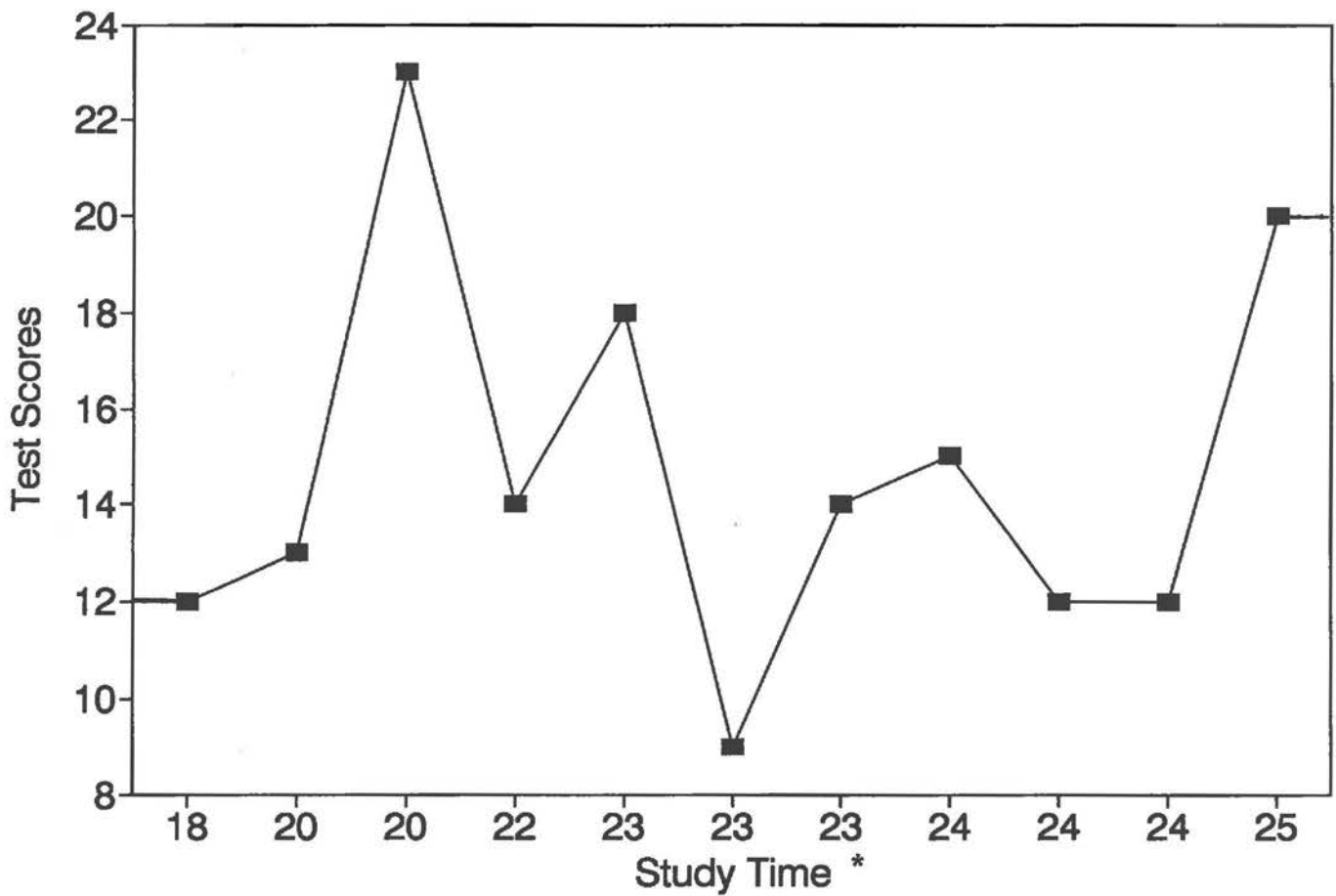


*Study Time is given in minutes.

Graph 5

Study Time and Test Scores

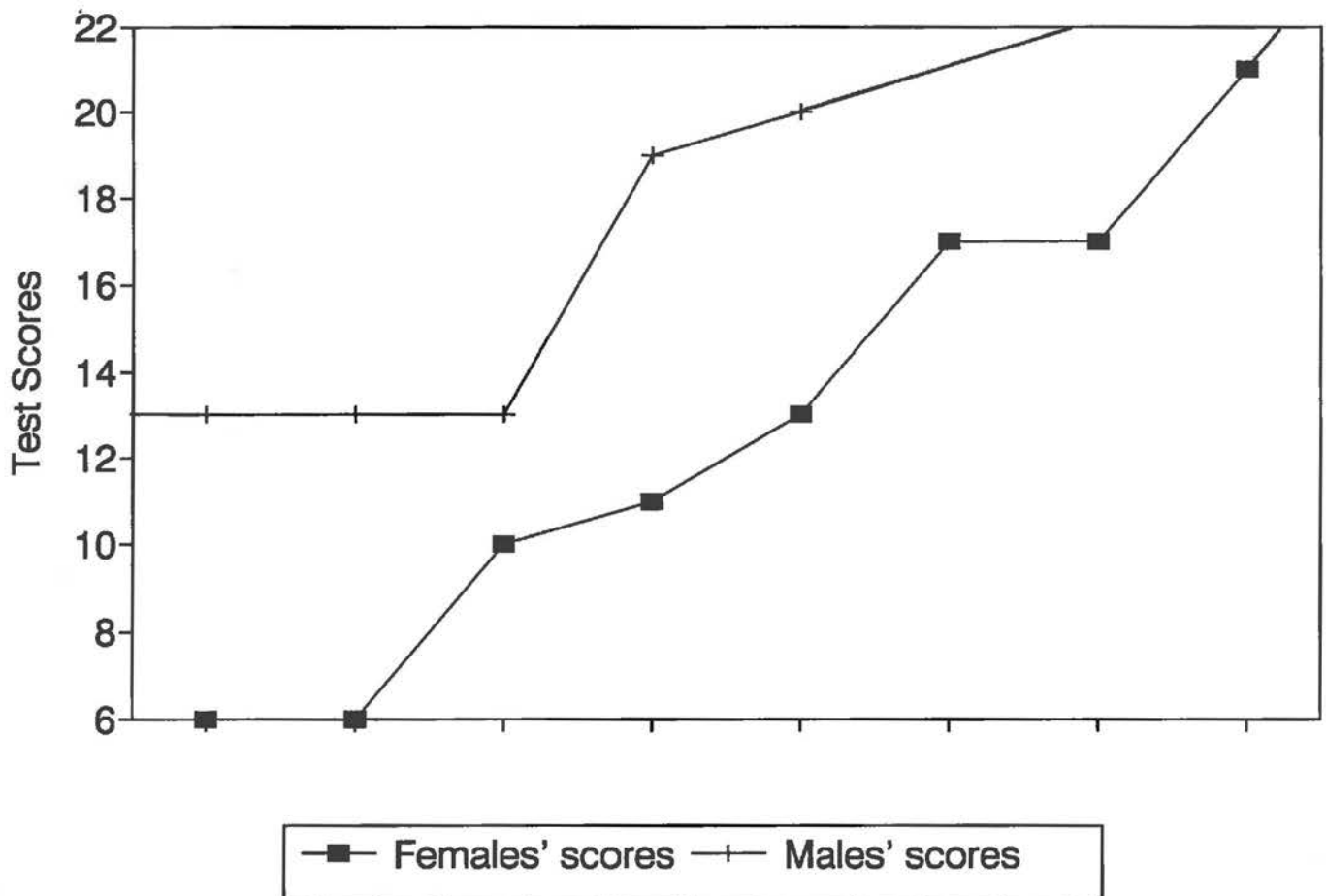
Group B



*Study Time is given in minutes.

Graph 6

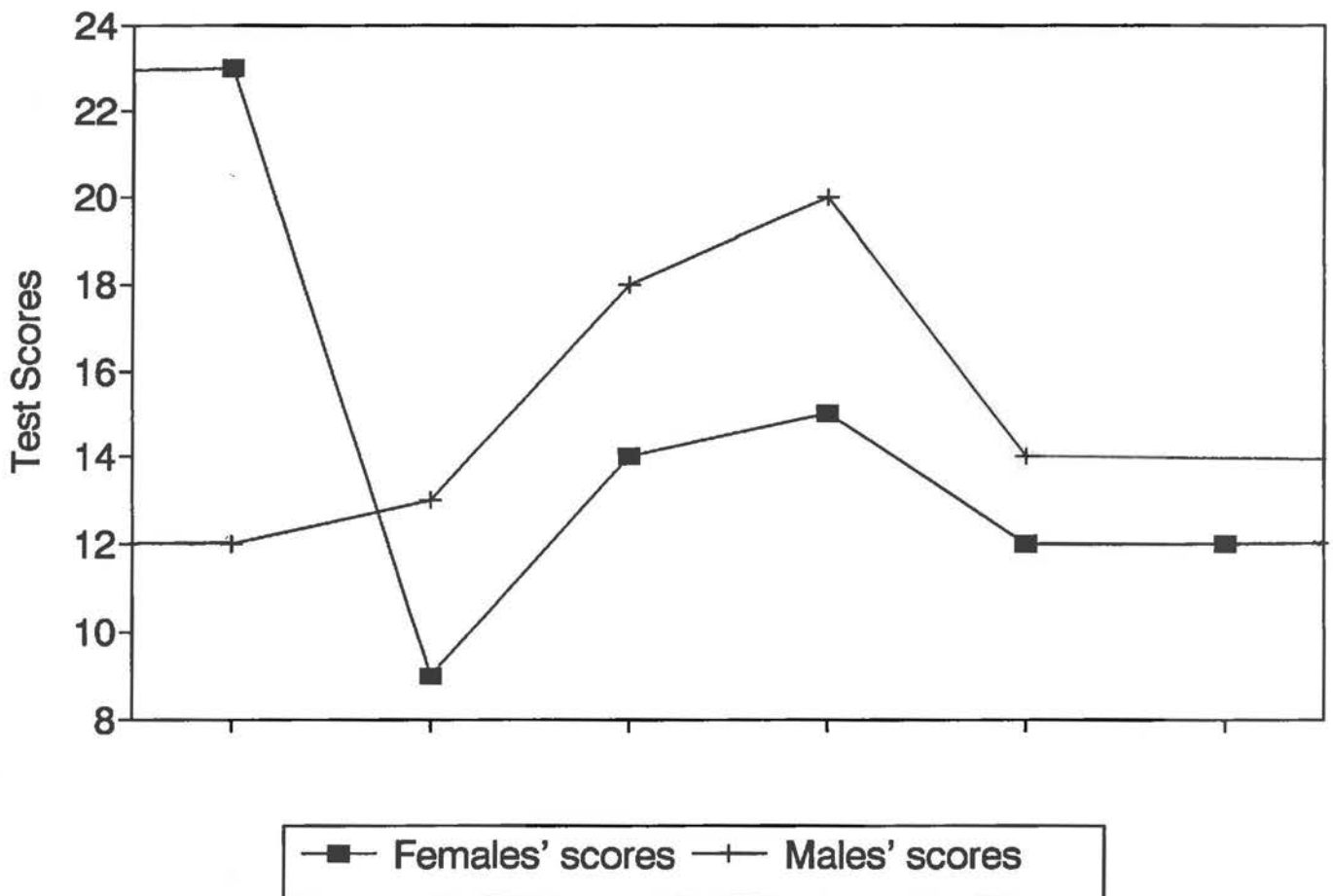
Gender and Test Scores Group A



Graph 7

Gender and Test Scores

Group B



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Footnotes

1. Represents caffeine content of Double Cola. Based on findings by the chemistry department of Double Cola USA, Inc., Double Cola is 185 ppm, or 185 mg/L caffeine. Therefore, a 12-oz. cup would contain 66.07 mg of caffeine.
2. Caffeine is almost completely (94-97%) metabolized by the body, and has a half-life in "plasma and most organs of about three hours" (Graham, 1978).
3. Numbers are unequal due to subjects' failure to complete both sessions.