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The Interactive Effects of Caffeine and Phase of Menstrual Cycle on the Recall of Prose Passages

Jacqueline Marie McPherson

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THE INTERACTIVE EFFECTS OF CAFFEINE
AND PHASE OF MENSTRUAL CYCLE
ON THE RECALL OF PROSE PASSAGES

by

Jacqueline Marie MacPherson
Bachelor of Arts, University of North Dakota 1990
Master of Arts, University of North Dakota 1992

A Dissertation

Submitted to the Graduate Faculty

of the

University of North Dakota

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for the degree of

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This dissertation, submitted by Jacqueline MacPherson in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read and is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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Dean of the Graduate School

July 17, 1995

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Title The Interactive Effects of Caffeine and Phase of Menstruation
Cycle on the Recall of Prose Passages

Department Psychology

Degree Doctor of Philosophy

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ABSTRACT

Previous research has yielded inconsistent results regarding the effects of caffeine on memory. Such inconsistency is likely to a large extent a function of the complex interaction effects of caffeine and other variables such as estrogen. The purpose of the present study was to discern possible variation in the effects of caffeine on the recall of prose for females tested during days 1-5 or 9-13 of their menstrual cycle. One hundred and seven subjects received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine. Following an absorption period, subjects read six passages from a computer terminal and immediately afterwards, wrote their recall of each passage.

The primary result of the present study is that overall, caffeine facilitated recall performance. Although a marginal interaction involving phase of menstrual cycle was demonstrated, contrary to what was expected, no significant effects were revealed. Results of the present study are discussed in the context of previous research, and possible explanations regarding the lack of significant effects of phase of menstrual cycle are offered.

CHAPTER I INTRODUCTION

Caffeine has been consumed and enjoyed by people throughout the world for centuries. Use of caffeine dates back to as early as the Paleolithic period. Caffeine is a unique pharmacological agent in that it is a potent central nervous system (CNS) stimulant which is considered part of the normal diet. According to Gould, Murphy, Katims, and Snyder (1984), caffeine is probably the most widely used psychoactive compound in the United States. One factor contributing to caffeine's widespread popularity is that it occurs naturally in more than sixty plant species throughout the world.

Pharmacologically, caffeine is an alkaloid structurally identified as a 1,3,7, trimethylxanthine (Graham, 1978). Two other well-known related methylxanthines are theophylline (1,3 - dimethylxanthine) and theobromine (3,7 - dimethylxanthine). Caffeine, theophylline and theobromine are all methylated derivatives of xanthine, which is a dioxypurine. Although caffeine, theophylline, and theobromine share several pharmacologic actions, these agents differ markedly in the intensity of their actions on various structures. Caffeine and theobromine are powerful CNS stimulants, whereas theophylline has its greatest impact on the cardiovascular and musculoskeletal systems and is particularly effective in relaxing the bronchoids (Stephenson, 1977) The degree to which these agents are present in various substances also differs, in that all methylxanthine beverages and food contain caffeine whereas theobromine is significantly present only in cocoa and theophylline is present in substances only in extremely small amounts (Spiller, 1984).

Common sources of caffeine include plants used to make coffee (*Coffea arabica*), chocolate (*Theobroma cocoa*), kola (*Cola nitida*), and tea (*Thea sinensis*) - coffee and tea being the most frequent sources (Graham, 1978). Based on world production of coffee and tea, Gilbert (1981) estimated that the average daily consumption of caffeine from a global perspective, is 50 milligrams (mg) per day per person. Rall (1980) and Pilette (1983) estimated U.S. daily consumption of caffeine from all sources to be about 200 mg per capita or 15 pounds per person per year. Dews (1982) suggested that 80% of the adult population uses caffeine in some form. Since its original chemical isolation in 1820, caffeine has been used therapeutically for infant apnea, acne and other skin ailments, migraine headaches, and as a bronchial and cardiac stimulant. Caffeine is present in a variety of over-the-counter (OTC) products such as analgesics, diuretics, weight control aids, allergy relief preparations, and alertness compounds (Dews, 1984). Caffeine is also present in some prescription drugs used for analgesic purposes such as APC's (compounds containing aspirin, phenacetin, and caffeine) and Darvon. The pharmacologically active dose usually utilized in prescription and non-prescription drugs is 200 mg (Graham, 1978). Caffeine is also used as a flavor component in cola-type soft drinks. Additionally, according to the Food and Drug Administration (FDA), caffeine is used as a flavoring agent in baked goods, dairy desserts, puddings and fillings, and candy (FDA, 1980).

When ingested, caffeine is rapidly and completely absorbed from the gastrointestinal tract and enters all organs and tissues within a few minutes after consumption (Graham, 1978). Peak plasma levels are reached within 30 - 120 minutes following oral ingestion (Bonati et al., 1980) and caffeine's half-life in the plasma varies from 2.5 to 4.5 hours (Gilbert, 1976). Caffeine is eliminated from the body principally through liver biotransformation to several metabolites, namely dimethylxanthines examples of which include theophylline, paraxanthine, and thesbromines which can be further demethylated to the respective monomethylxanthines

(Dews, 1984). The majority of ingested caffeine is metabolized with only three to six percent appearing in the urine unchanged. Excretion is primarily renal and the major urinary excretion product is 1 - methyluric acid, formed by demethylation of caffeine (Graham, 1978). The rate at which the body metabolizes caffeine may be modulated by the influence of other substances such as nicotine and estrogen. Pilette (1983) reported that nicotine consumption is associated with an increased rate of caffeine metabolism, which produces a shorter half-life of caffeine. In contrast, higher levels of estrogen tend to decrease the metabolism of caffeine. For example, a prolonged metabolic half-life of caffeine has been demonstrated in females taking estrogen containing oral contraceptives (Bruce, 1986).

The fact that caffeine is a drug with potentially powerful physiological effects escapes many of its consumers. Indicative of the potency of caffeine are the numerous physiological effects induced by its consumption. Caffeine acts as: a diuretic, a smooth muscle relaxant, a cardiac muscle stimulant, a CNS stimulant, a gastric acid stimulant, and a stimulant for plasma free fatty acids and glucose (Graham, 1978). Pharmacologically, it appears that the methyl group on position 1 is associated with the psychoactive properties of caffeine (Bruce, 1986). The mechanism by which caffeine exerts its CNS effects is not completely clear, however, evidence suggests that adenosine may be involved in the production of such effects (Snyder & Katims, 1981). The cellular actions of caffeine include increased accumulation of cyclic nucleotides - cyclic AMP in particular (which promotes the mobilization of calcium from intracellular stores resulting in higher plasma calcium levels), and the blockade of adenosine receptors (Rall, 1980). It is thought that the inhibition of phosphodiesterase, an enzyme which aids in the breakdown of cyclic AMP, may contribute to the caffeine-induced behavioral effects of activation and wakefulness (Murray, 1988). Inhibition of adenosine receptors may also antagonize the effects of adenosine, which acts as a naturally-occurring behavioral, electrophysiological, and biochemical depressant (Hirsch,

1984), Such inhibition could reduce the natural depression of neural activity, resulting in a stimulant effect.

Physiological effects of caffeine can vary depending upon dose and individual sensitivity. In low doses, caffeine's stimulating activity of the CNS, as well as other body organs, results in more rapid, clearer flow of thought and greater sustained intellectual effort. Low doses of caffeine also induce a keener appreciation of sensory stimuli and reduce reaction time (Bolton & Null, 1981). Adverse effects of caffeine may result from an oral dose of one gram and a dose of approximately ten grams or more taken orally can be fatal (Gleason et al., 1972). Toxic effects are due to CNS and circulatory system stimulation. Acute adverse effects induced by high doses of caffeine (or low doses in hypersensitive persons) include: Tachycardia, low grade fever, mild delirium, extrasystoles, tinnitus, and hyperesthesia (Bolton & Null, 1981).

Caffeinism may occur when daily ingestion of caffeine reaches more than 500 to 600 mg of caffeine, an amount equivalent to approximately four to seven cups of coffee a day (James & Stirling, 1983; Shisslak et al., 1985). Caffeinism refers to a set of behavioral and physiological symptoms associated with excessive consumption of caffeine-containing substances (Foxy & Rubinoff, 1979; Greden, 1974; Victor, Lubetsky, & Greden, 1981). Symptoms associated with caffeinism include: nervous irritability, tremulousness, quivering muscles, insomnia, palpitations, diuresis, and gastrointestinal disturbances (Boulenger & Uhde, 1982; Greden, 1974). Ingestion of caffeine has been linked in the medical literature to such disorders as cardiovascular disease, hiatus hernia, fibrocystic breast disease, birth defects, cardiac arrhythmia, and cancer of the larynx, lung, intestine, prostate, and pancreas (James & Sterling, 1983; Pilette, 1983). However, since the above research is correlational. definitive evidence to support these suspected relationships is lacking. The possible relationship between caffeine and pathogenesis of peptic ulcers has been debated for many years. Several single dose experiments have shown the stimulation of gastric secretions by caffeine. A variety of feeding

studies, however, have failed to establish a definitive cause and effect relationship between caffeine ingestion and induction or exacerbation of peptic ulcers (Graham, 1978).

The question of whether tolerance to the effects of caffeine may develop, remains open to debate. Colten, Gosslin and Smith (1968) demonstrated that individuals do acquire tolerance to certain actions of caffeine.

Graham (1978), however, reported that definitive tests have shown that repeated consumption of caffeine does not diminish the stimulant effects it produces. Thus, It appears that individuals may develop tolerance to certain actions of caffeine, but tolerance to the stimulant effects produced does not occur. Definitive tests have demonstrated that caffeine is habit forming or addictive (Bolton & Null, 1981), and characteristic withdrawal symptoms such as headaches, anxiety and lethargy may occur when consumption of this substance is discontinued (Graham, 1978; Greden, Victor, Fontaine & Lubetsky, 1980).

As researchers have become cognizant of the numerous physiological effects of caffeine, in particular its effects on the CNS, interest in its effect on human cognitive performance has increased. One approach to investigating whether ingestion of caffeine influences human cognition is to examine the effects of this substance on memory performance. The examination of the effects of caffeine on memory has its roots in an experiment conducted by Revelle, Amaral, and Turiff (1976). The dependent measure utilized in this experiment was performance on a 60-item verbal test (similar to the Graduate Record Examination), which consisted of analogies, antonyms and sentence completion. One hundred and one undergraduate students were administered three comparable forms of this test under three stressful conditions on three consecutive evenings. In one session, subjects were allowed as much time as they needed to complete the items (relaxed condition). A second condition required subjects to complete a comparable test in 10 minutes (time press condition). In a third conditions subjects were administered 900 milligrams of caffeine, and after an absorption period, were given 10

minutes to complete another comparable 60-item test (time press and caffeine condition). The Eysenck Personality Inventory (1964) a self-report instrument designed to measure the introversion/extraversion dimension of personality, was used to classify subjects as introverts or extraverts. According to Eysenck, extraverts are persons who have low levels of cortical excitation (arousal) and as a result of this, they tend to seek out external sources of stimulation. Introverts, on the other hand, are individuals who have high levels of cortical excitation and tend to avoid additional or external sources of stimulation (Eysenck, 1967). Results of the study conducted by Revelle et al., (1976) indicated that introverts in the relaxed condition performed better than introverts under time press with caffeine, whereas extraverts under time press with caffeine performed better than relaxed extraverts. These results, however, are difficult to interpret in that the administration of caffeine was not dependent upon subjects' body weight which resulted in subjects of unequal weight receiving equivalent doses of caffeine. Additionally, caffeine was administered in conjunction with the time press condition as opposed to being independently administered. Consequently, it is difficult to discern which variable (caffeine or time press) influenced the performance of subjects in this study.

A more precise method of manipulating the effects of caffeine on memory was employed in a subsequent replication of Revelle et al. (1976) by Gilliland (1980). In an attempt to reduce possible differences resulting from disproportionate doses of caffeine, administration of caffeine was dependent upon subjects' body weight. Three treatment levels were employed in this study, in that subjects received either a placebo, 2 milligrams of caffeine per kilogram of body weight, or 4 milligrams of caffeine per kilogram of body weight. Subjects (N=144) were allotted 10 minutes to complete the initial Graduate Record Examination - Verbal (GRE-V), after which they received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine. Subjects waited for 30 minutes for the caffeine to be absorbed into their systems and then completed a comparable form of the GRE-V

under a 10-minute time press condition. Results indicated that introverts' performance dramatically increased between the 0 mg/kg and 2 mg/kg conditions. Extraverts, however, improved only slightly at the 2 mg/kg condition and showed marked improvements at the 4 mg/kg condition. Introverts increased in both speed and accuracy at the low dose of caffeine, but decreased in both speed and accuracy at the high dose of caffeine. Extraverts showed continual increases in speed and accuracy across the increasing doses of caffeine. No significant effect of gender or any interaction of treatment with gender were observed.

Revelle, Humphreys, Simmon and Gilliland (1980) conducted a series of experiments which investigated the effects of personality, time of day and caffeine on performance. Assuming the existence of a curvilinear relationship (an inverted U) between levels of performance and the administration of caffeine (Yerkes & Dodson, 1908), the investigators hypothesized that increases in stress should hinder the performance of introverts (who naturally experience a high level of cortical excitation), but facilitate the performance of extraverts (who naturally experience a low level of cortical excitation). Subjects (N=157) participated in two one hour sessions held at 9 a.m. and 7 p.m. At each testing time low Impulsive subjects (introverts) and high impulsive subjects (extraverts) were administered either a placebo or 200 milligrams of caffeine. Under this cross-over design it was found that the time of day in which subjects were tested critically influenced performance. For low impulsive subjects (introverts), caffeine hindered performance in the morning but facilitated performance in the evening. The reverse occurred for high impulsive subjects, or extraverts, in that caffeine facilitated their performance during the early part of the day but impaired their performance in the evening.

A major result of Revelle et al. (1980) was that the interactive effects of caffeine and trait arousal appeared more clearly and consistently when the impulsivity subscale was employed to measure trait arousal rather than the entire Introversion/Extraversion scale of the

Eysenck Personality Inventory (1964). As a result of this discovery, the preponderance of subsequent investigations in this area have used the impulsivity subscale of the Eysenck Personality Inventory to assess variability in trait arousal.

Humphreys and Revelle (1984) attempted to identify specific factors involved in determining when caffeine facilitates performance and when it inhibits performance. They concluded that caffeine's effects on memory were dependent upon degree of impulsivity (high or low), time of day, and type of cognitive task performed. These researchers identified two classes of tasks that are affected by caffeine: tasks involving vigilance and those involving short-term memory (STM). Sustained information or vigilance tasks (e.g., reaction time, simple arithmetic, and letter cancellation) are direct stimulus-response activities that involve very little use of the STM. Tasks using STM require manipulation of the stimuli prior to making responses, e.g., prose processing.

Humphreys and Revelle (1984) asserted that sustained information tasks (SIT) and STM tasks represent opposite ends of a theoretical continuum. Although elements of each of these classes are involved in many tasks performed, experimental tasks may be distinguished in terms of whether they mainly involve SIT or STM forms of information processing. The model purported by Humphreys and Revelle (1984) assumes that information processing capacity is limited and asserts that heightened arousal reduces the resources available for processing information in STM. Accordingly, Humphreys and Revelle suggested that ingestion of caffeine will result in detrimental effects on the performance of STM tasks because under conditions of high arousal, information is available in the STM for less time than usual (due to the reduction of resources available for processing) which adversely affects the processing and subsequent recall of the material presented. Conversely, the authors suggest that a positive association exists between caffeine ingestion and SIT, in that arousal facilitates performance of these stimulus-response forms of tasks.

Another theoretical work pertinent to the study of the effects of caffeine on memory is that of Easterbrook (1959). Easterbrook hypothesized that increases in arousal result in decreases in the range of cues that an organism can use. In a low arousal state subjects may successfully attend to both important and less important information. According to Easterbrook, when arousal is increased, however, the range of cues utilized by subjects will be decreased and, therefore, only important information will be attended to.

In an attempt to investigate how the processing demands of a task modulate the impact of caffeine on cognitive performance, Anderson and Revelle (1982) conducted a study in which sixty subjects, classified as high or low impulsives were administered either a placebo or 4 mg/kg of caffeine dissolved in an orange flavored breakfast drink. Following a 30-minute absorption period, subjects proofread three passages. For the first passage, subjects were instructed to correct any errors they detected, regardless of type. For a second passage, subjects were asked to find interword errors, which were contextual errors such as faulty grammar or incorrect word usage. For a third passage, subjects were asked to identify intraword or noncontextual errors such as misspellings or typographical errors. It was hypothesized that detecting interword errors was a task with a larger STM component than detecting intraword errors, since the former required more manipulation of words and phrases in a sentence in the determination of whether or not the word was a contextual error. Results indicated that caffeine impaired interword error detection for low impulsive (habitually more aroused) subjects, while caffeine improved the interword error detection rate of high impulsive (habitually less aroused) subjects.

In a subsequent experiment, Anderson and Revelle (1983) utilized a visual search task with varying processing demands to discern whether or not the effects of caffeine change as a function of the task demands placed on STM. The task required subjects to pick out target letters from strings of 20 letters. The number of different letters to be picked out of

the string was varied. A target size of two letters represented low STM load and a target size of six represented a high STM load. Eighty-four subjects, classified as high or low impulsive, received either a placebo or 4 mg/kg of caffeine dissolved in an orange flavored breakfast drink. Following a 20-minute absorption period, subjects scanned four pages of letters under a three minute time press condition. Subjects were instructed to cross out letters at the two and six letter target sizes. Results indicated that caffeine slightly improved to a non-significant degree) subjects' detection of the two letter target, which represented the low memory load task, while it decreased subjects detection of the six letter target, which represented the high memory load. The authors concluded that these results provide evidence that the effects of arousal on performance are modulated by the demand characteristics of the task employed. More specifically, they concluded that the results of their experiment are consistent with the theorizing of Easterbrook (1959). As mentioned previously, Easterbrook hypothesized that the range of cue utilization narrows as arousal increases, with task irrelevant information being excluded prior to task relevant information. According to this hypothesis, the curvilinear relationship between arousal and task performance (Yerkes & Dodson, 1908) is modulated by a single monotonic relationship between arousal and the range of cue utilization. Anderson and Revelle's (1983) finding that caffeine facilitated greater efficiency on the two letter search task requiring fewer cues), but decreased efficiency on the six letter search task (task requiring more cues) is consistent with the Easterbrook hypothesis in that the range of cue utilization appeared to be narrowed by increased levels of arousal.

In a further attempt to investigate how the processing demands of a task modulate the impact of caffeine on cognitive performance, Bowyer, Humphreys and Revelle (1983) investigated the effects of caffeine on recognition memory. One hundred college students received either 4 mg/kg of caffeine or a placebo. Following a 45-minute absorption period, subjects were exposed to four lists (two 24-item and two 80-item) of four

letter words. Immediately after viewing each list, they were given a forced choice recognition test on the last 20 words of each list. The repeated performance of this recognition test over four lengthy lists contains elements of a vigilance task and requires more sustained attention and less manipulation of information in STM. Results of this study revealed no significant overall effect of impulsivity. Interestingly though, the performance of high impulsives (low trait arousal) who were given a placebo, declined as a function of the number of lists learned, whereas the performance of low impulsives (high trait arousal) showed significantly less decline. It was found that caffeine significantly improved recognition memory, in that subjects who received caffeine experienced less of a decrement in performance over trials relative to subjects in the placebo group. Moreover, both caffeine and impulsivity appeared to have a greater impact on recognition memory for lists appearing late in the experimental session. The authors concluded that the reduction of decrement effects associated with repeated task performance noted in this study, resulted from changes in motivational state brought about by increases in arousal level.

Erikson, Hager, Houseworth, Dungan, Petros, and Beckwith (1985) examined the effects of caffeine on memory for supraspan word lists. One hundred and seven college students (47 male, 60 female), classified as high or low impulsive, received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine dissolved in six ounces of an orange flavored breakfast drink. After a 30-minute absorption period, each subject was instructed to remember four lists of 12 nouns presented at a slow rate (1 word every 3 seconds) and four lists presented at a fast rate (1 word every second). The different presentation rates were utilized in an effort to place increasing demands on the working memory (Brodie & Prytulak, 1975). Subjects were asked to orally recall each word list immediately after hearing it. Results demonstrated that caffeine inhibited females' recall at the slow rate but not at the fast rate and no significant effect of caffeine was observed on the recall performance of males. In addition, no

significant effect of impulsivity was observed. Erikson et al. (1985) hypothesized that the results demonstrated in their study were due to caffeine's impairment of the efficiency with which information was encoded or manipulated in the working memory of subjects tested.

Results of the studies previously discussed (e.g., Anderson and Revelle, 1982; 1983; Bowyer, Humphreys and Revelle, 1983; Erikson et al. 1985) may be interpreted as being supportive of the theoretical notions purported by Humphreys and Revelle (1984), in that ingestion of caffeine resulted in a decrement in performance on tasks that relied heavily the use STM processing, yet facilitated performance on vigilance tasks. It should be noted, however, that the experimental procedures employed in these investigations may not have adequately controlled for the effects of various potential confounding variables that have been identified. For example, in the past decade medical research has demonstrated that the level of estrogen-based hormones present in an individual, modulates the way in which caffeine is processed by the body. Research conducted by Patwardhan, Desmond, Johnson, and Schenker (1980) examined the effect of oral contraceptive steroids on the disposition and elimination of caffeine. Caffeine (250 mg) was orally administered to 13 males, nine females taking no oral contraceptives, and nine females taking oral contraceptives. All subjects were asked to abstain from consuming beverages and medications containing caffeine for at least two days prior to the study. Blood samples were obtained from these subjects at various time periods following caffeine ingestion: 15, 30, 45 minutes and 1, 1 1/2, 2, 3, 4, 5, 6, 7, 8, 24, 32 and 48 hours. Results of this research demonstrated that the rate of caffeine absorption was equal in all groups, with peak plasma levels being reached within 30-60 minutes after ingestion. However, the half-life of caffeine was significantly longer for females using oral contraceptives than for females not using oral contraceptives (10.7 hours vs. 6.2 hours). Patwardhan et al. (1980) concluded that the demonstrated decrease in the rate of elimination or

clearance of caffeine from the body may be related to increased estrogen and/or progesterone levels found in females taking oral contraceptives. More recently, Abernethy and Todd (1985) examined the effects of chronic (> 3 months) administration of low-dose estrogen-containing oral contraceptives on the pharmacokinetics of caffeine. Caffeine (162mg) was administered orally to nine females taking oral contraceptives and nine females taking no oral contraceptives. Blood samples were collected prior to caffeine ingestion and at various time periods following ingestion: 5, 10, 15, 30, 45, and 60 minutes, and 2, 3, 4, 6, 8, 10, and 24 hours. Results demonstrated that oral contraceptive users experienced a half-life of caffeine that was significantly longer than non-oral contraceptive users (7.88 hours vs. 5.37 hours). The results also indicated that the length of time for caffeine to reach peak concentration was significantly longer for subjects on oral contraceptives than for subjects not on oral contraceptives (91 minutes vs. 47 minutes).

It appears, then, that the rate at which caffeine is absorbed and eliminated from the body differs depending upon whether or not oral contraceptives are used. The research investigations previously discussed (Anderson and Revelle, 1982; 1983; Bowyer et al., 1983; and Erikson et al., 1985) did not attempt to control for the possible influence of oral contraceptive use, in that subjects who were using oral contraceptives were allowed to participate. Thus, the detrimental effects of caffeine on the performance of female subjects demonstrated by previous studies (i.e., Erikson et al., 1985) may have been modulated by differences in the pharmacokinetics of caffeine among female subjects (Patwardhan et al., 1980; Abernethy and Todd, 1985).

The female menstrual cycle represents a complex process marked by cyclical variations in levels of endogenous hormones (e.g., estrogen, progesterone, follicle stimulating hormone, and luteinizing hormone). For the purpose of study, the menstrual cycle has been arbitrarily divided into five phases: the menstrual phase which lasts from days 1-5, the follicular phase lasting from days 6-12; the ovulatory phase lasting from

days 13-15; the luteal phase which lasts from days 16-23; and the premenstrual phase lasting from days 24-28 (Asso, 1983; Shaws 1978). During the paramenstrum, which refers to the premenstrual and menstrual phase combined, estrogen is at the lowest level it will reach across the entire menstrual cycle. Estrogen reaches its highest level toward the end of the follicular phase, declines during the ovulatory phase, and rises once again, but less dramatically during the luteal phase of the menstrual cycle. It is plausible that the detrimental effects of caffeine on female's cognitive performance demonstrated by previous research (i.e., Erikson et al., 1985) may have been influenced by endogenous hormonal fluctuations associated with the menstrual cycle. That is, females were tested without regard to the phase of menstrual cycle they were in, thus, females may have had variable levels of endogenous estrogen concentrations, which possibly resulted in variations in the rate at which caffeine was absorbed and metabolized by female subjects.

In a subsequent replication and extension of the study conducted by Erikson et al. (1985), Arnold, Petros, Beckwith, Coons, and Gorman (1987) sought to clarify and strengthen aspects of the earlier experiment. Eighty-two males and 75 females (N=157), classified as high or low impulsive, served as subjects in this study. Only females who were free of oral contraceptives were solicited for participation and they were tested only during the menstrual phase of their cycle (days 1-5) during which estrogen levels are at their lowest. In an expansion, of Erikson et al. (1985) this study used twelve lists of words presented at one of four rates, one word per .5 seconds, one word per second, one word per three seconds, and one word per five seconds. Subjects received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine. Following a 30-minute absorption period, subjects listened to one practice and 12 experimental lists of 12 words, comparable to those used by Erikson et al. (1985). Each successive four lists of words constituted one level of practice. Immediately after hearing each list, subjects wrote their recall. After

completing the presentation and recall of each individual list, subjects wrote a final free recall of words from all lists.

Results of the study conducted by Arnold et al. (1987) indicated that both 2 mg/kg and 4 mg/kg of caffeine facilitated recall for females at the third level of practice, but had no effect on recall at practice levels one and two. The 2 mg/kg dose of caffeine impaired the recall of males at the second and third levels of practice. A marginal interaction of caffeine, gender, and rate of presentation was reported, such that 2 mg/kg of caffeine impaired recall of males for words at the slower rate of presentation, whereas 4 mg/kg of caffeine improved recall for words at the fast rate of presentation. Overall, these results suggest that caffeine facilitates recall in females and more complexly affects the recall of males. Arnold (1989) investigated the interactive effects of caffeine dose, phase of menstrual cycle, and oral contraceptive use on memory for word lists. This researcher hypothesized that the effect of caffeine would vary as a function of oral contraceptive use since oral contraceptives provide a manipulation of endogenous levels of estrogen. In addition, subjects were tested during the first five days of the menstrual cycle or during days nine through 13 of the menstrual cycle. These testing times were chosen to provide a further manipulation of endogenous levels of estrogen. That is, estrogen is at its lowest level during the first five days of the menstrual cycle, but rises to a peak level between days nine and 13 of the cycle (Asso, 1983). Approximately one half of the two hundred and eight females tested, who were classified as high or low impulsive, were using oral contraceptives. Subjects received 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine. Following a 30-minute absorption period, subjects listened to 13 lists of 12 words, presented at one of four rates, one word per .5 seconds, one word per second, one word per three seconds, and one word per five seconds. Each successive four lists of words constituted one level of practice. Immediately after hearing each list, subjects wrote their recall. Results of the study conducted by Arnold (1989) revealed that overall, caffeine facilitated recall for words in the primacy position of the lists.

Among subjects tested during days 1-5 of their menstrual cycle, caffeine facilitated recall among oral contraceptive users for words in the primacy position at the two slowest rates. Among subjects tested during days 9-13 of their menstrual cycle, caffeine facilitated recall for words in the primary position at the three slowest rates among non-oral contraceptive users. Finally, caffeine facilitated recall for words in the middle position at the fastest rate among oral contraceptive users. The results of this study suggest that the effects of caffeine on word list recall may be complexly modulated according to the phase of menstrual cycle during which testing occurs.

The studies concerning caffeine and memory reviewed up to this point have utilized memory tasks which involve lists of words, verbal practice exams, and proofreading. Another approach, that theoretically places higher demands upon working memory, is to assess the effect of caffeine on memory for prose material. Kintsch and van Dijk (1978) described the demands placed upon working memory while processing prose material. They purported that text processing is performed in a sequential manner due to limitations in the capacity of working memory. According to this theory, part of working memory is comprised of a short-term memory buffer that is limited in size, therefore, as a person reads, a limited amount of propositions are encoded into short-term memory (STM) in successive cycles. Certain propositions are stored in the buffer and are available for connection with new or incoming material. If connections for new material cannot be found in STM, long-term memory is searched. If old material is not found during this search, an inference process, which adds more propositions to the text base, is initiated and other non-essential propositions are displaced from STM. Kintsch and van Dijk (1978) propose, then, that coherent text bases are constructed by an automatic, cyclical process that works within the constraints of working memory. They further asserted that propositions which are present in more than one processing cycle are recalled more often. Also, propositions that are already connected to many other propositions are

preferentially selected, and thus more important ideas are recalled more often as well.

Several studies have explored the effects of caffeine on the processing of prose material. For example, Hager, Petros, Beckwith, Erikson, and Arnold (1986) examined the effects of caffeine on the recall of short narrative prose passages. One hundred and forty male and female subjects, classified as high or low impulsive, received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine. Following a 30-minute absorption period, the subjects listened to tape recorded prose passages that were presented at three different rates of words per minute (WPM) (120 wpm, 160 wpm, 200 wpm). Immediately after listening to each passage, subjects wrote as much of the story as they could remember. Results demonstrated that subjects who received 2 mg/kg of caffeine recalled a significantly greater number of idea units relative to subjects in either the placebo or 4 mg/kg conditions. No significant differences were noted between subjects who received 0 mg/kg and 4 mg/kg of caffeine. The results demonstrated by Hager et. al., (1986) are contrary to the theoretical predictions of Humphreys and Revelle (1984) in that caffeine facilitated recall of prose, a task which relies heavily on use of STM. One explanation for the failure to produce the expected results is that the narrative passages used did not adequately tax the working memory capacity of subjects tested. More specifically, narrative passages are organized temporally. Such stories have an identifiable theme or story line and the various propositions relate to the development of this theme. This high degree of relatedness between the propositions may make it an easy task to process in working memory. Additionally, previous work has indicated that narrative passages are remembered better than expository passages (Graesser, Hauff-Smith, Cohen, & Pyles, 1980). One explanation for this finding is that expository passages are not organized temporally, as are narrative passages, in that they are more descriptive of the characteristics of an object as opposed to the development of a story line or main theme.

In order to assess whether the results demonstrated by Hager et al. (1986) depended upon the use of narrative passages, Sternhagen (1987) examined the effect of caffeine on the recall of both narrative and expository passages. It was hypothesized that varying the genre of passages used may place greater demands on working memory. Seventy-nine males, classified as high or low impulsive, participated in the study conducted by Sternhagen (1987). Subjects received either 0 mg/kg, 2mg/kg or 4 mg/kg of caffeine and after a 30-minute absorption period they listened to three expository and three narrative prose passages. Immediately after hearing each passage, subjects were instructed to write down, in their own words, their recollection of the passages. Consistent with previous research (i.e., Graesser et al., 1980) the results of this study demonstrated that narrative passages were recalled significantly better than expository passages. Results demonstrated by Sternhagen (1987) failed to reveal any significant effects of caffeine, however, the pattern of results obtained were similar to those found by Hager et al. (1986), in that for high and medium level idea units, there was a tendency for subjects in the 2 mg/kg dose group to recall more idea units than subjects in either the placebo or 4 mg/kg dose groups. Interestingly, as pointed out by Sternhagen (1987), this pattern of results was found only for narrative passages which suggested that caffeine ingestion may differentially effects the processing of narrative versus expository passages.

A study conducted by Brouse (1990) examined the effects of caffeine on the prose recall of non-oral contraceptive using females in days 1-5 of their menstrual cycle. Sixty female subjects, classified as high or low impulsive, received either 0 mg/kg, 2 mg/kg, or 4 mg/kg of caffeine dissolved in six ounces of an orange flavored breakfast drink. Following a 30-minute absorption periods subjects read six short passages (three expository and three narrative) from a computer terminal. Immediately following each story subjects wrote their recollection of the passages, Results of this study demonstrated that subjects receiving 2

mg/kg and 4 mg/kg of caffeine recalled a significantly greater number of idea units than subjects receiving the placebo. No significant difference in the number of idea units recalled was found between subjects receiving the 2 mg/kg and 4 mg/kg doses of caffeine. A significant interaction of treatment by level of importance of idea units was also demonstrated. Subjects receiving 2 mg/kg and 4 mg/kg of caffeine recalled a greater number of idea units of high importance than subjects receiving the placebo. No significant differences were found in the recall of idea units of medium importance, Recall of idea units of low importance improved significantly as a function of treatment (4mg/kg > 2mg/kg > 0mg/kg). This study failed to demonstrate any main effect of impulsivity or any interaction involving impulsivity.

The studies conducted by Hager et al. (1986), Sternhagen (1987), and Brouse (1990) provide fruitful information regarding the effect of caffeine on prose memory, however, limitations in each of these studies may be pointed out. The study conducted by Sternhagen (1987) only assessed the effect of caffeine on the prose memory of male subjects. The study conducted by Hager et al., (1985) did not control for variables such as phase of menstrual cycle or use of oral contraceptives. Variables that, as pointed out previously, influence how caffeine is absorbed and metabolized. Thus, the results demonstrated by Hager et al., (1985) may not clearly depict the effect of caffeine on the recall of prose in females. The investigation conducted by Brouse (1990) did control for use of oral contraceptives and phase of menstrual cycle and, therefore, more clearly depicted the effect of caffeine on the recall of prose in females. Brouse (1990), however, only tested females during days 1-5 of their menstrual cycle and, therefore, this study is limited in the sense that it precludes inferences regarding variations in the effect of caffeine on memory performance observed when females are tested at different phases of the menstrual cycle (Arnold, 1989).

In consideration of the aforementioned limitations, the purpose of the present study was to replicate and extend investigations previously

conducted by Sternhagen (1987), Arnold (1989), and Brouse (1990). More specifically, the intent of this study was to discern possible variations in the effect of caffeine on recall of expository and narrative prose passages in non-oral contraceptive using females who are in days 1-5 or 9-13 of their menstrual cycle. Based upon the results of Hager et al. (1986) and Brouse (1990), it was hypothesized that caffeine would facilitate recall of both expository and narrative prose passages. It was further hypothesized that the facilitation effects observed would be modulated by the phase of menstrual cycle during which subjects were tested.

CHAPTER II

METHODS

Subjects

One hundred and seven female undergraduate students from the University of North Dakota served as subjects and received course credit for their participation in this study. Potential subjects were screened in their undergraduate classes in order to determine their suitability for participation. During this screening, individuals completed a medical complications checklist and calendar indicating the approximate date on which they expected their menstrual period to begin. Subjects were contacted by telephone and screened by self-report for any medical complications which might have been exacerbated by the administration of caffeine. These medical complications included: migraine headaches; hypertension; epilepsy; kidney disease or defect; fainting spells; diabetes; cardiovascular problems; ulcers; and allergies to caffeine, sugar, or orange juice. Individuals reporting a history of any of these ailments were not invited to participate in this study. Subjects were also screened by self-report for phase of menstrual cycle and use of oral contraceptives or other medication on a regular basis. Females reporting they were pregnant or attempting to become pregnant were excluded from participation in this study.

Subjects meeting the preceding criteria were scheduled for participation during days 1-5 or 9-13 of their menstrual cycle and were asked to comply with the following pre-experimental instructions. Subjects were instructed to abstain from taking any medication (prescription or over-the-counter) for 24 hours prior to their participation. This requirement was utilized in an attempt to limit the possibility of the presence of substances in the subject's system which

might interact with caffeine. Subjects were instructed to refrain from consuming caffeine after 10:00 p.m. the night before their experimental appointment. Finally, subjects were instructed to get a minimum of five hours of sleep the night before the experiment to ensure that fatigue was not a determining factor in their performance.

Materials

Three narrative (See Appendix A) and three expository (See Appendix B) stories (201-208 words) were used as stimulus material in the present study. All of the passages were of 7th - 8th grade reading difficulty and had readability scores of 6.52-6.25. Readability scores were derived by calculating the number of unfamiliar words in the passages and the average sentence length (Dale & Chale, 1948). An independent group of 33 undergraduate psychology students divided each story into idea units. Students were asked to read each story thoroughly and divide the text into idea units by placing a vertical line where they thought a simple idea had just been expressed. Determination of the idea units of each story required agreement of at least 17 raters as to the division points of the story.

The same 33 students were then asked to rate the stories in terms of how familiar they were with the material, the amount of difficulty encountered in comprehending the stories, and the degree of narrativity each story possessed. The familiarity ratings were scored 1-5, with a 1 meaning they were not at all familiar with the information and a 5 indicating that they were familiar with the material presented. The average familiarity rating was 2.07 for the expository passages and a 1.67 for the narrative passages. Difficulty ratings were also scored on a scale of 1-5, with 1 indicating that the material was easily comprehended, while a rating of 5 meant that the students found the material difficult to comprehend. The average difficulty rating was 1.20 for narrative passages and 1.53 for expository passages. Narrativity ratings ranged from 1 to 5 meaning the passage conveyed static information about objects and their properties, to 5 which meant the passage conveyed information

about events unfolding in time. The average narrativity ratings were 4.43 for the narrative passages and 1.57 for the expository passages. The importance of each idea unit to the theme of the passage was rated by additional undergraduate students in groups ranging from 42-56 in size (Brown & Smiley, 1977). These raters were asked to read each story carefully and then eliminate one third of the idea units which they judged to be the least important to the theme of the passage, This procedure was then repeated again, resulting in only one third of the idea units remaining. These remaining idea units were judged the most important to the theme of the passages while the set eliminated first were the least important. The mean importance rating was computed for each idea unit in every story. On the basis of these importance ratings, the experimenters rank-ordered the idea units of each story from least to most important and then divided them into three levels of importance. Approximately equal numbers of idea units were designated as high, medium, or low in thematic importance.

The Eysenck Personality Inventory (Eysenck, 1964) was utilized in order to measure subjects' level of impulsivity, sociability, and introversion/extraversion. This self-report questionnaire consists of 57 yes or no questions which describe ways of feeling of acting. Test-retest reliability for this instrument ranged from 0.84 to 0.94 when using a sample size of 92 subjects and a test-retest interval of one year. Split-half reliabilities ranged from 0.74 to 0.94 when testing groups of normals, neurotics, and psychotics (Eysenck, 1967).

The vocabulary subtest of the Wechsler Adult Intelligence Scale - Revised (WAIS-R) (Wechsler, 1981) was administered in order to assess individuals' verbal ability. This subtest consists of 35 English words that are progressively more difficult to define. Each subject received a raw score based on the number of words correctly defined: the maximum possible raw score is 70. Reliability of the vocabulary subtest, as determined by using the split-half technique, is 0.96. Performance on the

vocabulary subtest correlates 0.77 with the Full Scale IQ, 0.81 with the Verbal IQ, and 0.60 with the Performance IQ (Wechsler, 1981).

The Activation-Deactivation Adjective Checklist (AD-ACL) (Thayer, 1967), which consists of 50 adjectives describing feelings or moods, was also administered. The AD-ACL, which measures transient or state levels of activation, is scored for four independent dimensions of activation; General Activation, High Activation, General Deactivation, and Deactivation-Sleep. These dimensions represent four different points on a hypothetical activation continuum. Test-retest reliability coefficients were as follows: General Activation, 0.89; High Activation, 0.93; General Deactivation, 0.79; and Deactivation-Sleep, 0.89 (Thayer, 1978). This questionnaire was completed prior to the administration of caffeine and again 30 minutes after the administration of caffeine in order to assess differences in subjects' subjective level of activation as a result of treatment with caffeine.

A self-report caffeine consumption questionnaire was administered to discern subjects' average (chronic) level of caffeine consumption. Sources of caffeine such as coffee, tea, soft drinks, and medications (prescription and non-prescription) were assessed (See Appendix C). The Beck Depression Inventory (Beck, 1967), which consists of 21 self-report items, was utilized to measure the presence and severity of depression. Each item consists of four alternative statements which are scored from 0-3, with 3 indicating the most severe symptom of depression for each statement. Scores on this test can range between zero and 63. Pearson r between odd and even items yielded a reliability coefficient of 0.86. A Spearman-Brown correlation for attenuation raised this coefficient to 0.93 (Beck, 1974).

Finally, the Spielberger State-Trait Anxiety Questionnaire (STAI) Form 2 (Spielberger, Gorsuch, & Lushene, 1970) was administered to measure each subjects' level of trait anxiety. Trait anxiety refers to relatively stable individual differences in anxiety proneness. This questionnaire consists of 20 self-report items comprised of four

alternative statements which are scored from 1-4, with 4 indicating that the individual "almost always" endorses that particular item, and 1 indicating that the individual "almost never" endorses that item. In completing this questionnaire, subjects were instructed to indicate how they "generally" feel.

Procedure

In an attempt to control for the diurnal effects of arousal observed by Revelle, Humphreys, Simon, & Gilliland (1980), two hour experimental sessions were conducted between 8:00 a.m. and 1:00 p.m., The experiment used a double blind procedure. In order to reduce possible experimenter bias effects.

Upon arrival, subjects were briefly questioned and responded yes or no regarding their compliance with the pre-experimental instructions provided when they were scheduled to participate in this study. Subjects were dismissed as a result of any violation of pre-experimental instructions. Subjects' blood pressure was assessed, and individuals with a blood pressure above 140/90 were excused from the study. Subjects were again screened for medical complications, use of oral contraceptives, and day of menstrual cycle. Approximately half of the subjects participated during 1-5 of their menstrual cycle, while the others participated during days 9-13 of their menstrual cycle. Informed consent was obtained by subjects reading and signing a consent form which advised them of the possible risks of the experiment, the experimental procedure, and their right to withdraw from the study at any time. Subjects were then weighed, and demographic information was collected. Before receiving caffeine, subjects completed the Eysenck Personality Inventory (Eysenck, 1964) to measure rate of impulsivity, sociability, and introversion/extraversion. The data collected from subjects who scored six or greater on the Eysenck Personality Inventory lie scale were discarded from data analysis. Subjects then completed several other questionnaires including the WAIS-R vocabulary subtest, Thayer AD-ACL, STAI, BDI, and a caffeine consumption questionnaire. Upon

completing these questionnaires, subjects were randomly assigned to an experimental group. The dose of caffeine given was dependent upon subject weight and assigned experimental group. Subjects then received either 0, 2, or 4 mg/kg of caffeine dissolved in six ounces of Tang, an orange flavored breakfast drink. To allow caffeine to enter the bloodstream and reach peak plasma levels, a thirty minute absorption period was utilized (Bonati et al., 1982). Following the absorption period, subjects completed a second Thayer AD-ACL, and their blood pressure was again measured.

During the second hour of participation subjects read, at their own rate, six short passages (three expository and three narrative) from a computer terminal. Immediately following each story subjects wrote, in their own words, their recollection of the passages. When subjects completed their recall of the last passage presented, they were dismissed from the study and upon request informed of the experimental group to which they were assigned and the amount, if any, of caffeine they received.

Design

The design employed in this study consisted of two between subject factors and two within subject factors. The between subject factors were dose of caffeine (0mg/kg, 2mg/kg, 4 mg/kg) and phase of menstrual cycle (days 1-5 or days 9-13), while the within subjects factors were passage type (narrative and expository) and importance level of idea units (high, medium, and low).

CHAPTER III

RESULTS

All recall protocols were scored (blind) for the presence or absence of the gist of each idea unit. In addition, 20% of the protocols of each group were randomly selected and independently scored (blind) by a second rater. Interrater reliability was first calculated for each protocol by dividing the total number of agreements of whether an idea unit was recalled by the total number of agreements plus disagreements. The percent of agreements ranged from 74% to 100% with a mean of 90%. Memory for each passage was expressed as the proportion of idea units recalled at each of three levels of importance. These recall scores were then subjected to a 3 (dose) X 2 (passage type) X 3 (level of importance) X 2 (phase of menstrual cycle) mixed analysis of variance (ANOVA) with $\alpha = .05$. The means and standard deviations of the recall data are presented in Table 1 as a function of dose, passage type, importance level, and phase of menstrual cycle.

A significant main effect of level of importance, $F(2,202) = 754.91$, $p < .001$, was revealed. Mean recalls obtained were .754, .619, and .432, for idea units of high, medium, and low importance, respectively. Analysis of this main effect using the Tukey test ($\alpha = .05$) showed that recall decreased as a function of the importance level of idea units (High > Medium > Low).

A significant interaction of passage type X level of importance, $F(2,202) = 112.64$, $p < .001$, was found. The means and standard deviations as a function of passage type and level of importance are listed in Table 2.

A significant main effect of passage type, $F(1,101) = 220.88$, $p < .001$, was found in that narrative passages were recalled better than expository passages, with means of .663 and .541, respectively.

Table 1
Recall Means and Standard Deviations as a Function of Passage Type,
Importance Level, Dose, and Phase of Menstrual Cycle

Passage Type	Narrative			Expository		
	High	Med.	Low	High	Med.	Low
Phase 1						
Dose						
0 mg/kg	.855 (.073)	.623 (.111)	.420 (.141)	.572 (.140)	.558 (.149)	.403 (.161)
2 mg/kg	.883 (.051)	.695 (.102)	.453 (.118)	.678 (.119)	.557 (.123)	.454 (.131)
4 mg/kg	.893 (.111)	.749 (.091)	.453 (.119)	.654 (.135)	.547 (.185)	.439 (.167)
Phase 2						
Dose						
0 mg/kg	.890 (.051)	.694 (.091)	.433 (.093)	.644 (.077)	.546 (.101)	.471 (.122)
2 mg/kg	.858 (.072)	.655 (.068)	.386 (.078)	.656 (.111)	.542 (.146)	.397 (.120)
4 mg/kg	.849 (.070)	.704 (.108)	.456 (.127)	.632 (.085)	.564 (.092)	.432 (.117)

Note. Phase 1 = days 1-5 of the menstrual cycle, Phase 2 = days 9-13 of the menstrual cycle.

Further analysis of this interaction using the Tukey test ($\alpha=.05$) revealed that recall of narrative passages was significantly greater than expository passages for idea units of high and medium importance level, while no significant difference in recall was observed for idea units of low importance.

Table 2

Recall Means and Standard Deviations as a Function of Passage Type and Importance Level (standard deviations are in parentheses)

Importance Level	High	Medium	Low
Passage Type			
Narrative	.870 (.073)	.685 (.102)	.432 (.115)
Expository	.637 (.115)	.552 (.131)	.432 (.137)

A marginal interaction of Passage Type X Importance Level X Dose X Phase of Menstrual Cycle, $E(4,202) = 2.32, \geq = .058$, was revealed. Recall means as a function of importance level, passage type, phase of menstrual cycle, and dose are listed in Table 3. As indicated in Table 4, the pattern of effects differed for subjects tested during days 1-5 of their menstrual cycle (Phase 1) and those tested during days 9-13 (Phase 2) of their menstrual cycle. More specifically, the general pattern of effects for subjects tested during Phase 1 was that both the 2 mg/kg and 4 mg/kg doses of caffeine facilitated recall for narrative and expository passages, with the exception of expository passage idea units of medium importance. The pattern of effects observed for subjects tested during Phase 2 varied greatly as a function of dose, importance level, and passage type, with no real discernable pattern of effects being revealed.

Individual Differences

A series of 3 (dose) X 2 (phase of menstrual cycle) ANOVA's were computed using individual difference variables as the dependent measure.

Table 3

Recall Means as a Function of Importance Level, Passage Type, Phase of Menstrual Cycle, and Dose

Importance Level	High		Medium		Low	
	Nar	EXP	Nar	EXP	Nar	EXP
Phase 1						
Dose						
0mg/kg	.855	.572	.623	.558	.420	.403
2mg/kg	.883	.678	.695	.557	.453	.454
4mg/kg	.893	.654	.749	.547	.453	.439
Phase 2						
Dose						
0 mg/kg	.890	.644	.694	.546	.433	.471
2 mg/kg	.858	.656	.665	.542	.386	.397
4 mg/kg	.849	.632	.704	.656	.456	.432

Note. Nar = Narrative, Exp = Expository, Phase 1 = Days 1-5 of the menstrual cycle, Phase 2 = Days 9-13 of the menstrual cycle

Table 4

Pattern of Dose Effects as a Function of Importance Level, Passage Type, and Phase of Menstrual Cycle

Importance Level	High		Medium		Low	
	Nar	EXP	Nar	EXP	Nar	EXP
Phase 1						
Phase 1	4>2>0	2>4>0	4>2>0	0>2>4	4=2>0	2>4>0
Phase 2						
Phase 2	0>2>4	2>0>4	4>0>2	4>0>2	4>0>32	0>4>2

Note. Nar = Narrative, Exp = Expository, O = 0mg/kg, 2 = 2mg/kg, 4 = 4mg/kg, Phase 1 = Days 1-5 of the menstrual cycle, Phase 2 = Days 9-13 of the menstrual cycle

These analyses were conducted in order to discern if the recall effects noted were due to confounding of the individual difference variables

between groups. The means and standard deviations for these variables are presented in Table 5.

Table 5

Means and Standard Deviations for Subject Variables (standard deviations are in parentheses)

Menstrual Cycle	Phase 1			Phase 2		
	Dose 0	2	4	0	2	4
N	20	16	15	20	18	18
Age	21.6 (5.78)	23.2 (8.07)	21.3 (4.13)	22.8 (6.82)	20.0 (3.32)	21.6 (7.16)
Wt	162.8 (48.2)	152.1 (18.7)	153.8 (25.3)	163.9 (43.6)	138.7 (24.2)	139.9 (19.7)
BPS1	118.6 (9.77)	111.1 (14.4)	110.7 (6.36)	113.0 (10.4)	106.8 (10.9)	111.4 (7.19)
BPD1	71.05 (8.82)	66.19 (8.49)	68.73 (6.49)	67.05 (9.25)	63.61 (9.11)	67.89 (6.51)
BPS2	108.4 (10.8)	111.2 (10.4)	113.8 (7.52)	107.2 (9.12)	106.9 (10.1)	110.3 (9.98)
BPD2	66.45 (10.7)	72.25 (5.80)	72.67 (10.5)	65.30 (8.90)	66.17 (8.23)	66.83 (8.98)
Imp	4.450 (1.43)	4.313 (1.49)	5.200 (1.61)	4.100 (1.92)	4.222 (1.63)	4.667 (1.57)
IE	13.40 (4.10)	13.31 (3.91)	14.87 (3.40)	12.85 (3.36)	13.39 (4.82)	15.00 (3.44)
Voc	44.25 (9.00)	48.31 (10.8)	46.80 (7.50)	44.95 (8.27)	42.78 (8.33)	42.33 (8.15)
BDI	4.950 (3.86)	7.563 (6.27)	5.267 (5.16)	4.550 (3.68)	5.667 (4.27)	6.556 (5.17)
CC	249.4 (295)	309.4 (393)	157.5 (194)	145.1 (135)	368.2 (720)	218.0 (211)
TPre	15.05 (6.35)	14.00 (5.50)	14.93 (5.50)	14.85 (4.67)	13.19 (5.42)	16.72 (6.41)
TPos	16.65 (7.14)	14.69 (4.13)	15.20 (6.84)	14.90 (5.48)	17.31 (5.95)	19.22 (7.05)
TAnx	37.65 (8.97)	37.50 (11.1)	35.93 (8.89)	34.20 (7.47)	36.28 (8.01)	35.78 (7.64)

Note: BPS1= systolic blood pressure prior to caffeine, BPD1= diastolic blood pressure prior to caffeine, BPS2= systolic blood pressure after caffeine, BPD2= diastolic blood pressure after caffeine, Imp= impulsivity, IE= introversion/extroversion, Voc= WAIS-R vocabulary subtest, BDI= Beck Depression Inventory, CC= caffeine consumption, TPre= Thayer AD/ACL prior to caffeine, TPos= Thayer AD/ACL after caffeine, TAnx= trait anxiety.

A series of 3 (dose) X 2 (phase of menstrual cycle) ANOVA's computed on subjects age X WAIS-R vocabulary scores, introversion-extroversion, sociability, impulsivity, Thayer AD/ACL prior to caffeine administration, Thayer AD/ACL following caffeine administration, Beck Depression Inventory, caffeine consumption, diastolic blood pressure prior to caffeine administration, systolic blood pressure after caffeine administration, and trait anxiety, revealed no significant differences. Therefore, the above recall effects were not confounded by any of these measures.

A significant main effect of phase of menstrual cycle, $E(1,3) = 5.649$, $g = .019$, was revealed when using subjects' diastolic blood pressure after caffeine administration as the dependent variable. The mean post caffeine diastolic blood pressure (70.10) for subjects in days 1-5 of their cycle (phase 1) was significantly higher than the mean post caffeine diastolic blood pressure (66.07) for subjects in days 9-13 of their cycle (phase 2).

A significant main effect of dose, $F(2,3) = 4.413$, $P = .015$, was found when using subjects systolic blood pressure prior to caffeine administration as the dependent variable. Means obtained were 115.80, 108.82, and 111.09 for the 0 mg/kg, 2 mg/kg, and 4 mg/kg groups, respectively. Further analysis of this main effect using the Tukey test ($\alpha = .05$) revealed that subjects in the placebo group had a significantly higher pre caffeine systolic blood pressure than subjects in the 2 mg/kg and 4 mg/kg groups. No significant difference in pre caffeine systolic blood pressure was revealed between subjects in the 2 mg/kg and 4 mg/kg groups.

A significant main effect of dose, $F(2,3) = 3.464, p = .035$, was found when using weight as the dependent variable. Means obtained were 163.35, 145.03, and 146.24 for the 0 mg/kg, 2 mg/kg, and 4 mg/kg groups, respectively. Analysis of this main effect using the Tukey test ($\alpha = .05$) revealed that the weight of subjects in the placebo group was significantly higher than the weight of subjects in the 2 mg/kg and 4 mg/kg groups. No significant difference in weight was revealed between subjects in the 2 mg/kg and 4 mg/kg groups.

Finally, a series of 3 (dose) X 2 (phase of menstrual cycle) X 3 (level of importance) X 2 (passage type) analyses of covariance were conducted with trait anxiety, state activations depression, caffeine consumption, impulsivity, weight, and systolic and diastolic blood pressure prior to caffeine administration as the covariates in separate analyses. The results indicated the same pattern in each analysis with the interaction of Dose, Passage Type, and Importance Level significant when adjusted for the covariate. The means for these analyses are presented in Table 6.

A subsequent analysis of this interaction (Tukey test) revealed that for expository texts, significantly higher recalls were observed at the 2 mg/kg dose relative to the 4 mg/kg or placebo for idea units of high and medium importance, while no dose effect was observed for idea units of low importance. For narrative texts, significantly higher recalls were observed at both the 2 mg/kg and 4 mg/kg dose levels relative to the

Table 6

Recall Means and Standard Deviations as a Function of Passage Types
Importance Level, and Dose (standard deviations are in parentheses)

Passage Type	Narrative			Expository		
	High	Medium	Low	High	Medium	Low
Importance Level						
Dose						
0 mg/kg	.873 (.064)	.658 (.06)	.426 (.118)	.608 (.117)	.552 (.126)	.437 (.145)
2 mg/kg	.929 (.362)	.747 (.390)	.465 (.316)	.765 (.589)	.751 (.118)	.413 (.143)
4 mg/kg	.869 (.092)	.724 (.102)	.455 (.121)	.642 (.109)	.556 (.140)	.435 (.140)

placebo for idea units of high and medium importance, while no dose effect was observed for idea units of low importance.

CHAPTER IV

DISCUSSION

At the onset of the present study it was hypothesized that caffeine would facilitate recall of prose passages, and that the facilitation effects observed would vary as a function of the phase of menstrual cycle during which subjects were tested. The primary finding of the present study was that caffeine facilitated the recall of information of high and medium importance for both expository and narrative passages. Although the four way interaction of Dose, Passage Type, Level of Importance, and Phase of Menstrual Cycle was marginally significant, no significant effects of phase of menstrual on recall were demonstrated, As indicated in Table 4, the effects of caffeine on recall were consistently more variable when subjects were tested during days 9-13 of their menstrual cycle.

Results of the present study are similar to those found by Arnold (1989) in that a complex pattern of effects involving caffeine dose and phase of menstrual cycle was revealed. Direct comparison of results from the present study and those found by Arnold (1985) is precluded due to the use of different experimental tasks (i.e. recall of prose passages versus recall of word lists) as well as the different manipulations of endogenous hormonal levels utilized (i.e., non-oral contraceptive using females in days 1-5 or 9-13 of their menstrual cycle versus oral and non-oral contraceptive using females in days 1-5 or 9-13 of their menstrual cycle).

Although direct comparison cannot be made, it is interesting to note that results of Arnold (1989) indicated that large differences between caffeine and placebo groups were revealed primarily for subjects who theoretically had higher estrogen levels at the time of testing (i.e., oral contraceptive users tested during days 1-5 of their menstrual cycle and non-oral contraceptive users tested during days 9-13 of their menstrual cycle). The general pattern of effects observed in the present study, however, indicates that greater differences between placebo and caffeine groups occurred for subjects tested during days 1-5 of their menstrual cycle. In other words, consistent caffeine effects predominantly occurred in subjects who were tested during times at which their estrogen level was relatively low. Thus, the pattern of effects observed in the present study differed from those reported by Arnold (1989) in that caffeine more consistently facilitated recall for subjects who theoretically had lower levels of estrogen.

Contrary to what was expected, no significant effects of phase of menstrual cycle were observed in the present study. One possible explanation for the failure to demonstrate expected results, is that the experimental method employed to manipulate estrogen levels was flawed. Subjects were chosen to participate in the present study based upon self-reported abstinence from oral contraceptives, and they were assigned to experimental groups based upon their self-reported first day of their menstrual period. Although attempts were made to verify self-report data (i.e., subjects were asked to identify the date on which their menstrual period began at the time of scheduling the experimental session, and again upon their arrival to the session) concern is still warranted regarding the accuracy of self-report data used in this study.

The precision of methods used to assess and subsequently experimentally manipulate estrogen levels may have been further compromised by variation among subjects in the length of their menstrual cycle. Subjects participated in the experiment either during days 1-5 or 9-13 of their menstrual cycle. These times were chosen based upon the

theoretical 28-day cycle described by Asso (1983). According to the theoretical model of a 28-day cycle, estrogen is at its lowest level during days 1-5 and at its highest level during days 9-13. It is highly doubtful, however, that each subject tested had a menstrual cycle consistent with the theoretical 28-day cycle. Due to variation in length of their menstrual cycle, subjects who participated during days 9-13 of their cycle may not have actually been tested during a time in which their estrogen was at peak levels. According to Asso (1983), the time of ovulation (which follows the estrogen peak within a day or two) can be determined only by counting backward from the onset of the next menstrual period. Thus, for a subject with a 49-day cycle, her estrogen peak likely occurred on Day 33 of her cycle, whereas for a subject with a 20-day cycle, her estrogen peak likely occurred on Day 5. Because all subjects were tested at prescribed times (days 1-5 or days 9-13), it is likely that the estrogen peak was missed for some subjects. The method used in the present study to experimentally manipulate estrogen levels undoubtedly did not do so accurately for all subjects tested, thus potentially confounding the results obtained. It is a logical assumption, however, that most subjects tested during days 9-13 of their menstrual cycle had higher estrogen levels than those tested during days 1-5 of their menstrual cycle.

An additional shortcoming of the present study relating to the accuracy of methods used to measure and experimentally manipulate estrogen levels is that no attempt was made to identify subjects who had anovulatory cycles (a condition that indicates possible irregular levels of estrogen). Using basal body temperatures, a study conducted by Broverman et al. (1981) reported that 24% of the college sample tested had anovulatory cycles. Based upon this study, it is likely that the sample of subjects used in the present study included individuals with anovulatory cycles, thus raising further concern regarding the accuracy of methods used in the present study to manipulate estrogen levels.

Recall data from the present study was initially subjected to a 3 (dose) X 2 (passage type) X 3 (level of importance) X 2 (phase of

menstrual cycle) mixed analysis of variance. This analysis revealed only a marginal interaction effect involving caffeine. When recall data was subjected to a series of analyses of covariance using several individual difference variables as covariates, a significant three way interaction of Dose, Passage Type, and Level of Importance was consistently revealed. The use of analyses of covariance (ANOVA's) provides for a more powerful assessment of treatment effects in that it affords statistical control for one or more concomitant variables, removing their influence from the comparison of groups on the experimental factor.

Examination of the means displayed in Table 6, reveals consistent facilitatory effects of caffeine on the recall of idea units of high and medium importance for both narrative and expository passages. This pattern of results is consistent with those reported by Hager et al. (1986) and Brouse (1990, 1992) in that overall, caffeine facilitated the recall of prose passages. Results of the present study are also consistent with those demonstrated by Brouse (1990) in that recall declined as a function of the level of importance of idea units (high > medium > low) and narrative passages were recalled significantly better than expository passages.

The facilitatory effects of caffeine demonstrated in the present study are inconsistent with the theoretical propositions of Humphreys and Revelle (1984). These authors purported that caffeine facilitates performance of sustained information or vigilance tasks, yet decreases performance of tasks utilizing short-term memory. Prose recall requires the manipulation of stimuli prior to response and relies heavily on short-term memory. Thus, according to Humphreys and Revelle (1984), caffeine should inhibit the recall of prose. The facilitatory effects of caffeine on prose recall demonstrated in the present study clearly contradict the theoretical model proposed by Humphreys and Revelle (1984).

A clear explanation regarding which specific components of prose processing were influenced by caffeine ingestion is difficult to discern. Caffeine ingestion may have affected subjects' perception, motivation,

attention, encoding of the prose passages, consolidation of material in memory or a combination thereof. Thus, based upon data gathered in the present study, it would seem impossible to tease out the specific component(s) of memory that is being influenced by caffeine, resulting in the enhanced recall effects observed.

Recommendations for Future Research

Throughout the past two decades research investigating the effects of caffeine on cognitive performance has yielded conflicting results, with some investigations demonstrating facilitatory effects and others demonstrating detrimental effects. The lack of consistency in results obtained attests to the complex nature of assessing the effects of caffeine. In order to elucidate the effects of caffeine on cognitive performance, the following recommendations are offered.

Research has indicated that the rate at which the body metabolizes caffeine may be modulated by the influence of a host of factors such as nicotine, estrogen, liver disease, environmental chemicals, and medications (Pillette, 1983; Kalow, 1985; Abernethy & Todd, 1985). This research has strong implications regarding the methodology used to manipulate caffeine in the experimental setting in that a multitude of variables influence the rate at which caffeine is metabolized and thus must be controlled for. The greatest asset to any future study aimed at investigating the effects of caffeine on memory would be to assay blood levels of caffeine at various points throughout the experimental procedure. By assaying blood levels, researchers could much more precisely manipulate levels of caffeine and control for the potential confounding of various other substances that influence its metabolism. Although the use of blood samples imposes considerable demands in terms of cost and discomfort of participants, this method is the only truly accurate means of manipulating caffeine levels.

Additionally, the use of blood sampling techniques would also allow future studies to more accurately measure and subsequently manipulate estrogen levels and other hormone levels in the blood. The use of blood

subjects at various phases of the menstrual cycle, which may provide for a more comprehensive picture of the cyclical variability of caffeine-influenced memory performance.

Finally, previous research has utilized a number of different tasks to assess the effects of caffeine on cognitive performance. Although the use of diverse tasks provides for comparative analysis, it would appear more imperative and prudent at this time for future research efforts to focus on the consistent replication of studies. By doing so greater clarity will be gained regarding the effects of caffeine on cognitive performance as measured by a particular task (i.e., prose memory). Subsequently, there will be a stronger foundation of knowledge from which future comparative studies can be generated.

In conclusion, results of the present study demonstrated that overall, caffeine facilitated the recall of prose passages. Although a marginal interaction involving phase of menstrual cycle was observed, no significant effects were revealed as was expected, possibly due to a lack of precision in terms of the experimental method used to manipulate estrogen levels. Thus, the use of blood samples in future studies likely represents the primary means by which a clearer understanding of the complex interaction effects of caffeine and estrogen will be discerned.

APPENDICES

APPENDIX A
NARRATIVE PROSE PASSAGES

BAREFOOT BOY

1. ONE DAY A TALL, BAREFOOT BOY
2. AND HIS DOG
3. RAMBLED LEISURELY THROUGH A FOREST GLADE.
4. IT WAS VERY HOT
5. AS THE SUN WAS BLAZING OUT OF THE EASTERN SKY.
6. THE YOUNGSTER WAS TESTING A NEW SLINGSHOT,
7. WHEN HE SPOTTED A HARE
8. MANEUVERING THROUGH THE DENSE UNDERGROWTH.
9. SEIZING UPON THE OPPORTUNITY TO PROVIDE THE FAMILY'S SUPPER
10. HE SET IN PURSUIT OF THE HARE.
11. HE PERSISTED IN HIS CHASE FOR A MILE,
12. WHEN HIS QUARRY SUDDENLY DASHED INTO A CAVE.
13. THE BOY HESITATED FOR A MOMENT
14. BECAUSE HE HAD BEEN TOLD NOT TO ENTER THIS DANGEROUS CAVE.
15. HE WANTED THE HARE SO MUCH
16. THAT HE DID NOT HEED HIS PARENT'S WARNING.
17. NO SOONER HAD HE ENTERED THE CAVE'S INTERIOR
18. THAN SOME HUGE ROCKS CAME TUMBLING DOWN
19. SEALING OFF THE ENTRANCE
20. AND TRAPPING HIM INSIDE.
21. FORTUNATELY, HIS DEVOTED DOG WAS NOT DAUNTED.
22. SENSING HIS MASTER'S PLIGHT,
23. IT SCURRIED HOME,
24. BARKING IN DESPERATION.
25. THE BOY'S PARENTS KNEW
26. THAT SOMETHING WAS WRONG AND SOUGHT THE HELP OF THEIR NEIGHBORS.
27. THE DOG LED THEM TO THE CAVE,
28. WHERE THEY WORKED FEVERISHLY
29. TO FREE THE YOUNG BOY.
30. AFTER THREE HOURS OF DIGGING,
31. THEY FOUND THE BOY TO BE SHAKEN,
32. BUT UNHURT.

BAREFOOT BOY CONTINUED

- 33 AS THEY BEGAN TO WALK HOME,
34. THE HARE DASHED OUT OF THE CAVE
35. AND SCAMPERED INTO THE WOODS

DRAGON

1. FAR AWAY IN A DISTANT COUNTRY
2. THERE WAS A FEROCIOUS DRAGON

3. WHO LIVED IN A MOUNTAIN CAVE.
4. WHENEVER CHILDREN WERE TOLD ABOUT THIS HORRIBLE CREATURE

5. THEY WERE FRIGHTENED,
6. EXCEPT FOR ONE LITTLE BOY

7. WHO DID NOT FEAR THE DRAGON.
8. THE DAY BEFORE HIS BIRTHDAY,

9. THE BOY DECIDED TO INVITE THE DRAGON TO HIS PARTY.
10. HE WALKED UNTIL HE REACHED THE DRAGON'S CAVE.

11. WHEN THE BOY REACHED HIS DESTINATION
12. HE INVITED THE DRAGON TO HIS BIRTHDAY PARTY.

13. AT FIRST THE DRAGON WAS RELUCTANT TO BELIEVE THE BOY
14. AND BEGAN TO ROAR AT HIM.

15. BUT THE BOY WAS NOT INTIMIDATED
16. AND REPEATED HIS OFFER.

17. EVENTUALLY, THE DRAGON UNDERSTOOD THAT THE INVITATION WAS SINCERE,
18. SO HE STOPPED ROARING

19. AND BEGAN TO CRY.
20. "WHAT A HAPPY THING TO HAVE HAPPEN TO ME."

21. THE DRAGON SOBBED.
22. "I NEVER HAD A KIND INVITATION FROM ANYONE BEFORE."

23. THE DRAGON'S TEARS FLOWED
24. UNTIL THEY BECAME A RIVER.

25. "COME CLIMB ON MY BACK
26. AND I'LL GIVE YOU A RIDE HOME".

27. SAID THE DRAGON.
28. THE BOY CLIMBED BRAVELY ON THE BACK OF THE FEROCIOUS DRAGON,

DRAGON CONTINUED

29. AND THE DRAGON SWAM DOWN THE RIVER
OF HIS OWN TEARS.
30. AS HE SWAM,
31. HIS BODY RAPIDLY CHANGED SHAPE.
32. SUDDENLY THE BOY WAS SAILING DOWN THE
RIVER
33. TOWARD HOME
34. AS THE CAPTAIN OF A DRAGON STEAMBOAT.

CARVINGS

1. LONG AGO THERE WAS A RICH LORD.
2. WHO COLLECTED CARVINGS OF ANIMALS
3. ONE DAY HE SUMMONED TWO SKILLED
CARVERS
4. AND SAID, " I WANT EACH OF YOU TO
CARVE A MOUSE
5. SO REALISTIC THAT MY CAT WILL THINK IT
6. IS A REAL MOUSE AND POUNCE ON IT.
7. WE'LL PUT THEM DOWN TOGETHER AND
8. OBSERVE WHICH MOUSE THE CAT POUNCES
ON FIRST.
9. TO THE CARVER OF THAT MOUSE
10. I'LL AWARD THIS POUCH OF GOLD."
11. THE FIRST CARVER CREATED A CARVING
THAT LOOKED EXACTLY LIKE A MOUSE.
12. THE SECOND CARVER USED SOME FLAKY,
UNUSUAL MATERIAL.
13. CONSEQUENTLY THE QUALITY OF HIS CARVING
WAS QUITE POOR.
14. THE CAT WAS BROUGHT IN
15. AND IMMEDIATELY PROCEEDED TO POUNCE ON
THE SECOND CARVING.
16. THE LORD HAD NO ALTERNATIVE BUT TO AWARD
THE GOLD TO THE UNSKILLED CARVER.
17. THE LORD THEN INQUIRED,
18. "HOW DID YOU DO IT?"
19. "IT WAS EASY, MY LORD"
20. REPLIED THE UNSKILLED CARVER.
21. "I CARVED IT FROM DRIED FISH.
22. THAT IS WHY THE CAT POUNCED UPON IT SO
SWIFTLY."
23. THE LORD LAUGHED WHEN HE HEARD THIS.
24. "WELL," SAID THE LORD FINALLY,
25. "THEN I WILL HAVE TO AWARD TWO BAGS OF
GOLD;
26. ONE TO THE CRAFTSMAN WHO CARVED SO
SKILLFULLY,

CARVINGS CONTINUED

27. AND ONE TO YOU WHO CARVED SO CLEVERLY.

28. I WILL KEEP THE WOODEN MOUSE,

29. AND WE'LL LET THE CAT HAVE THE OTHER ONE."

APPENDIX B
EXPOSITORY PASSAGES

PARAKEETS

1. PARAKEETS MAKE NICE PETS
2. FOR PEOPLE WHO HAVE LIMITED SPACE,
3. TIME AND MONEY
4. THE LACK OF A YARD OR A BIG HOUSE IS NOT A PROBLEM WITH PARAKEETS,
5. AS IT IS WITH SOME OTHER PETS,
6. LIKE LARGE DOGS.
7. A PARAKEET'S CAGE TAKES UP VERY LITTLE ROOM.
8. WHEN HE IS LET OUT TO FLY
9. EVEN A SMALL APARTMENT WILL GIVE HIM ENOUGH SPACE FOR EXERCISE.
10. IT DOES NOT COST VERY MUCH TO HOUSE AND FEED A PARAKEET.
11. CAGES MAY BE EXPENSIVE
12. BUT THEY CAN OFTEN BE FOUND AT GARAGE SALES
13. FOR ONLY A FEW DOLLARS.
14. FEEDING A PARAKEET IS ALSO INEXPENSIVE.
15. PARAKEETS CAN GET THE NECESSARY MINERALS, PROTEIN, AND CARBOHYDRATES FROM BIRD SEED
16. AND OTHER FOOD THAT IS AVAILABLE IN MOST HOMES.
17. FOR EXAMPLE, THE BIRD CAN OFTEN GET CALCIUM IF YOU FEED IT BREAD AND MILK ONCE IN A WHILE.
18. ALSO, DOG FOOD IS A GREAT SOURCE OF PROTEIN FOR THE PARAKEET.
19. THE NECESSARY CARBOHYDRATES AND FATS ARE FOUND IN BIRD SEED.
20. THE PRICE OF A PARAKEET IS ABOUT TEN TO FIFTEEN DOLLARS,
21. DEPENDING UPON IT'S COLOR.
22. THE CHEAPEST PARAKEET IS THE GREEN BIRD WITH A YELLOW FACE.
23. THE MOST POPULAR COLOR OF PARAKEETS IN THE UNITED STATES IS BLUE.

PARAKEETS CONTINUED

24. THERE ARE OVER 66 DIFFERENT COLORS OF
PARAKEETS AVAILABLE,
25. BUT ALL COLORS OF THESE BIRDS MAKE EQUALLY
FINE PETS.

SURGERY

1. MANY ADVANCES IN MEDICINE HAVE BEEN MADE OVER THE YEARS,
2. YET, MOST OPERATIONS ON THE HUMAN BODY ARE STILL DANGEROUS PROCEDURES.
3. HOWEVER, A NEWLY INVENTED KNIFE HAS HELPED TO MAKE SURGERY SAFER
4. BY REDUCING THE CHANGE OF EXCESS BLEEDING
5. AND DAMAGE TO HEALTHY TISSUES.
6. THE KNIFE, WHICH IS NOW WIDELY USED BY MANY DOCTORS
7. TOOK YEARS TO DEVELOP AND PERFECT.
8. THE HANDLE OF THE KNIFE IS FULLY INSULATED
9. WITH ONLY THE TIP OF THE KNIFE LEFT UNCOVERED.
10. BODY CELLS THAT ARE TOUCHED BY THE TIP OF THE KNIFE ARE FROZEN INSTANTLY
11. BY LEAVING THE KNIFE IN PLACE,
12. THE SURGEON CAN LET THE FREEZING SPREAD TO NEARBY CELLS
13. JUST AS FAR AS IS NEEDED.
14. THIS FREEZING KILLS THE CELLS.
15. AND EVENTUALLY THEY BREAK UP
16. AND ARE CARRIED OFF BY THE BLOODSTREAM.
17. THE KNIFE IS MADE OF A HARD METAL
18. AND LOOKS LIKE A LARGE NEEDLE.
19. INSIDE THE KNIFE ARE MANY CHANNELS
20. THROUGH WHICH LIQUID NITROGEN FLOWS.
21. NORMALLY NITROGEN IS A GAS AT ORDINARY TEMPERATURES,
22. BUT IT FLOWS THROUGH THE KNIFE AS A LIQUID AT A TEMPERATURE OF -320.
23. THE NEW KNIFE HAS ALREADY SHOWN SOME BENEFITS.
24. THE AMOUNT OF BLOOD NEEDED DURING MOST OPERATIONS HAS BEEN GREATLY REDUCED.
25. ALSO, THE SCARS LEFT BY THE INCISION ARE NOW SMALLER
26. AND HEAL MUCH QUICKER.

DECIBELS

1. SOUNDS ARE MEASURED IN UNITS CALLED DECIBELS.
2. ONE DECIBEL IS THE SMALLEST SOUND
3. THAT CAN BE HEARD BY SOMEONE WITH GOOD HEARING.
4. EIGHTY DECIBELS IS THE LOUDEST COMFORTABLE LEVEL OF NOISE FOR THE AVERAGE PERSON.
5. NOISE BEGINS TO IRRITATE THE EAR AT 80 TO 85 DECIBELS.
6. IT IS ALSO AT THIS LEVEL THAT SOUND BEGINS TO CAUSE DAMAGE TO THE EAR.
7. EVERY DAY PEOPLE IN THE UNITED STATES HEAR MANY SOUNDS LOUDER THAN 80 DECIBELS
8. A POWERFUL MOTORCYCLE ROARS BY AT 115 DECIBELS.
9. A JET PLANE AT CLOSE RANGE REGISTERS 150 DECIBELS.
10. DOCTORS ARE LEARNING MORE ABOUT THE EFFECTS OF NOISE ALL THE TIME.
11. RECENT STUDIES HAVE SHOWN THAT VIOLENT NOISE,
12. SUCH AS A SONIC BOOM,
13. MAY CAUSE PERMANENT DAMAGE TO UNBORN BABIES.
14. MANY THINGS CAN HAPPEN TO THE BODY WHEN A SUDDEN NOISE HITS THE EAR,
15. THE HEART WILL BEGIN TO BEAT RAPIDLY,
16. THE BLOOD VESSELS WILL CONSTRICT,
17. AND THE PUPILS WILL DILATE.
18. THE STOMACH AND INTESTINES ARE ALSO EFFECTED BY NOISE.
19. PEOPLE PUT UP WITH NOISE
20. BECAUSE THEY DON'T REALIZE THAT SOMETHING CAN BE DONE ABOUT IT.
21. HOWEVER, IF MORE PEOPLE WERE MORE AWARE OF THE DAMAGE THAT NOISE CAN CAUSE
22. THEY COULD TAKE ACTION TO PREVENT THIS DAMAGE.

APPENDIX C
CAFFEINE CONSUMPTION QUESTIONNAIRE

CAFFEINE CONSUMPTION QUESTIONNAIRE

COFFEE

1. On the average, how many cups of coffee do you drink per day? 0 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. How many cups of the following types of coffee do you usually drink daily? regular perked coffee regular instant coffee decaffeinated coffee

3. On the average, how many cups of coffee do you drink at each of the following times?

Before Breakfast _____ With Breakfast _____ Between Breakfast and Lunch _____ With lunch _____ Between Lunch and Dinner _____ With Dinner _____ After Dinner _____

TEA

1. On the average, how many cups of tea do you drink per day? 0 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. How many cups of the following types of tea do you usually drink daily?

Caffeinate Tea _____
Decaffeinated Tea _____
Herbal Tea _____

3. On the average, how many cups of coffee do you drink at each of the following times?

Before Breakfast _____ With Breakfast _____ Between Breakfast and Lunch _____ With lunch _____ Between Lunch and Dinner _____ With Dinner _____ After Dinner _____

SOFT DRINKS

1. On the averages how many 12 oz servings of soft drinks do you drink per day?

0 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. How many cups of the following types of soft drinks do you usually drink daily?

Caffeinated (i.e., Coke, Pepsi, Mountain Dew) _____
Decaffeinated (i.e., 7-up, Sprites Root Beer) _____

3. On the average how many soft drinks do you drink at each of the following times?

Before Breakfast _____ With Breakfast _____ Between Breakfast and Lunch _____ With lunch _____ Between Lunch and Dinner _____ With Dinner _____ After Dinner _____

4. What brands of soft drinks do you USUALLY drink?

CHOCOLATE CANDY

1. On the average, how many candy bars do you consume per day?

0 1 2 3 4 5 >5 (circle one)

9. What brand(s) of candy bar do you usually eat?

CHOCOLATE BEVERAGES

1. On the average, how many cups of hot or cold chocolate beverages do you drink daily?

0 1 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. What type of chocolate beverage do you usually drink?

MEDICATIONS

Pain Medications (i.e., Aspirin, Tylenol, Motrin, Fiorinal ...)

1. On the average, how many pain medication pills do you take daily?

0 1 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. What type(s) of pain medication pills do you usually take?

Diet Aids (i.e., Dexatrim, Dietac, Control, Ayds, Appress)

1. On the average, how many diet aid pills do you take per day?

0 1 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. What type(s) of diet aid medication do you usually take?

Cold/Allergy Medication (i.e., Sinarest, Dristan, Actifed ...)

1. On the average, how many cold/allergy medications do you take per day?

0 1 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. What type(s) of cold/allergy medications do you usually take?

Stimulants (i.e., Nodoz, Vivarin, Appedrine, Caffedrine, Amostat ...)

1. On the average, how many stimulant tablets do you take per day?

0 1 2 3 4 5 6 7 8 9 10 >10 (circle one)

2. What brand(s) of stimulant do you usually take?

APPENDIX D
CONSENT FORM

CONSENT FORM

EFFECTS OF CAFFEINE ON MEMORY FOR PROSE

You are invited to participate In a research study that is designed to explore the effects of caffeine on memory for prose. Voluntary participation includes completion of several questionnaires, consumption of either 0, 2, or 4 mg/kg of caffeine, reading several short stories presented on a computer screen, and recalling the passages presented. The maximum amount of caffeine given in this experiment is a safe dose amounting to the caffeine contained in approximately 2 to 3 cups of coffee or 3 to 4 cans of soft drink.

Any information collected in this study which may be used to identify you will be held in strictest confidence and will be used for research purposes only. In return for your participation, you will receive class credit according to the amount of time spent in the experiment. If you decide to participate, you are free to discontinue participation at any time. A decision not to participate in this study will not prejudice your future relations with UND or the psychology staff, You will be offered a copy of this form to keep,

Your signature indicates that you have read the information provided above and have decided to participate

Signature

Date

Signature of Investigator

Date

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