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Beyond Ability: Effects of Caffeine and Impulsivity on Academic and Creative Performance

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BEYOND ABILITY: EFFECTS OF CAFFEINE AND IMPULSIVITY ON ACADEMIC AND CREATIVE PERFORMANCE

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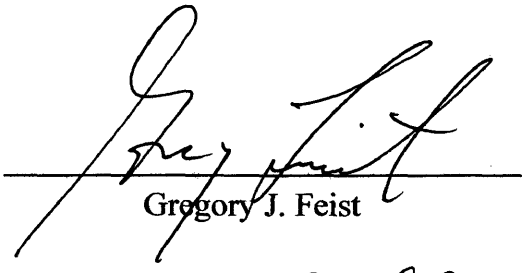

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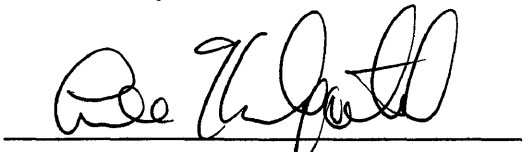

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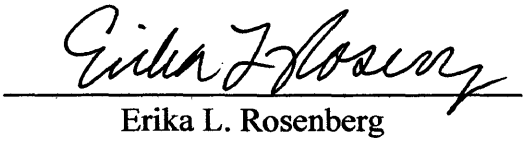

Erika L. Rosenberg

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ABSTRACT

Impulsivity, caffeine, and time of day have been shown to interactively affect academic performance, but little research has examined their effects on creative performance. The present investigation extends this line of research and examines how impulsivity, arousal, and time of day each effect and interact to effect academic and creative performance. Arousal has been shown to include facets of both energetic and tense-anxious arousal. Based on the general hypothesis that energetic arousal facilitates performance and tense-anxious arousal degrades performance, measures of anxiety were included as covariates in later analyses to find out if removing the effects of anxiety would strengthen any obtained impulsivity and caffeine interaction. Five hypotheses were tested. Seventy-one undergraduates received either 200 mg active caffeine or a placebo. Participants completed three self-report measures comprising the independent variables: the Eysenck Personality Inventory (EPI), the Positive and Negative Affect Scale (PANAS), and the Activation-Deactivation Adjective Check List (AD ACL). The two dependent measures included academic performance, consisting of 6 vocabulary items from a Graduate Record Exam (GRE) practice test, and creative performance, consisting of 5 items from the Remote Associates Test (RAT) test. The first hypothesis, that impulsivity would negatively correlate with academic performance and positively correlate with creative performance was not confirmed. As predicted by the second hypothesis, ANOVA results indicated that participants who were less reactive to caffeine or placebo were more creative. Results for the third hypothesis—that there would be an impulsivity by caffeine interaction for academic performance such that caffeine would help the performance of high impulsives but hinder the performance of low impulsives—approached significance, but the interaction was opposite the predicted direction. The fourth hypothesis, that the same interaction would be found for creative performance, was not confirmed. The fifth hypothesis, that any interactions obtained in the tests of hypotheses 3 and 4 would be stronger with the anxiety covariates added to the analyses, was confirmed for academic but not creative performance, based on descriptive examination of adjusted means and on F tests before and after the addition of the covariates. Based on the same criteria, a post hoc main effect for impulsivity was found for academic performance such that the impulsivity effect became stronger and significant when the covariates were added. For creativity, impulsivity remained significant and its effect size became stronger with the addition of the covariates. The low reactivity effect for creativity was interpreted as confirmatory evidence that creative people are more able to modulate their arousal to meet the needs of the creative task at hand. Possible reasons for the counter-to-predicted caffeine by impulsivity interaction were offered. The effectiveness of the anxiety covariates in strengthening the caffeine by impulsivity interaction may be consistent with Gray's theory that extraverts are more sensitive to cues for reward and introverts to cues for punishment. The practical implications for arousal and impulsivity on performance were discussed in terms of optimizing children's education in light of their particular arousal rhythms and impulsivity tendencies. Directions for future research were suggested, including the need for more biologically based research, and more replication of investigations involving the arousal-impulsivity interactions on performance.

BEYOND ABILITY: EFFECTS OF CAFFEINE AND IMPULSIVITY ON ACADEMIC AND CREATIVE PERFORMANCE

INTRODUCTION

Suppose the opportunity arose to ask a group of friends or acquaintances if they thought personality was related to cognitive ability. What would they say? They might acknowledge the possibility of a relationship. They might suggest that the relationship would be 'hard to prove'. Perhaps some debate about the moral merit of aligning personality and intelligence in the first place would ensue. Assuming the attempt to provoke discussion was successful, the conversation would probably be lively.

Among psychologists, questions about the relationship between personality and intellectual performance have been the subject of debate for years. Before delving into some of that discussion, working definitions for personality and intelligence are necessary. Over the years, psychologists have arrived at reasonable agreement that personality has to do with individual differences, on one hand, and behavioral consistency across both time and situation, on the other (see e.g., Feist,1999; Higgins, 1990; Sarason & Smith, 1971). For example, a person who scores high on the trait of sociability would be expected to behave in a socially outgoing manner in most situations most of the time.

Just as it is helpful to distinguish between the traits a person displays, and the temporal and situational consistency with which they display them, it is also helpful to delineate some parameters for intelligence. Eysenck and Eysenck (1985) proposed that there are three different types of intelligences: a genetically and physiologically mediated form of intelligence, an environmentally or socially mediated intelligence involving practical intelligence or social skills, and a hypothetical construct representing intelligence that can be measured with psychometric tests. More broadly, Guilford (1979)

defines intelligence in terms of the abilities and functions involved in various kinds of information processing. He states that intelligence is "a collection of abilities or functions for processing different kinds of information in various ways" and, "intelligence is thus concerned both with kinds of information and kinds of operations performed with information" (p. 35).

Eysenck's biological theory of personality, often called the PEN model, centers on three major dimensions of personality: psychoticism, extraversion, and neuroticism (Eysenck, 1967, 1981). According to Eysenck (1967,1990) and Eysenck and Eysenck (1985), these dimensions are physiologically mediated such that psychoticism involves enzymatic and gonadal hormone activities in the brain, extraversion can be attributed to cortical arousal, and neuroticism arises form visceral brain activation. Eysenck's (1967) conception of extraversion deals with cortical arousal via the ascending reticular activating system (ARAS). Activity in the ARAS is believed to stimulate the cerebral cortex, leading to higher cortical arousal. Introverts and extraverts are believed to differ along a continuum of ARAS activity such that "introverts are characterized by higher levels of activity than extraverts and so are chronically more cortically aroused than extraverts" (Eysenck & Eysenck, 1985, p. 197).

The Yerkes-Dodson law (Yerkes & Dodson, 1908) holds that arousal and performance have an inverted-U relationship such that task performance is impaired when arousal is either very low or very high, and performance is best during intermediate or "optimal" levels of arousal. Consistent with the Yerkes-Dodson law, Eysenck and Eysenck assume that, with respect to the hypothesized link between extraversion and

cortical arousal, "some intermediate level of arousal is optimal for performance" (Eysenck & Eysenck, 1985, p. 199).

The diurnal variation, or circadian rhythm of the arousal cycle is an important factor in studies that involve personality variables thought to be mediated by cortical arousal, such as extraversion. Blake (1967) and Wilson (1990) have each shown that arousal varies throughout that day and that this diurnal rhythm may show different patterns for introverts and extraverts. Blake (1967) demonstrated that the diurnal body temperature of introverts reaches its highest point sooner than extraverts. Both groups showed the same pattern, but the pattern began later in the day for extraverts than it did for introverts. Wilson (1990) found that introverts had higher skin conductance throughout the day, with the extraverts closing the gap toward the evening and the difference disappearing at midnight.

Integrating these lines of investigation, Revelle (1973, cited in Revelle, 1988) investigated the interactive effects of introversion-extraversion and arousal on performance. Revelle found that for introverts, performance declined as arousal increased, but for extraverts, performance was a curvilinear function of arousal with optimal performance at intermediate levels of arousal. A similar pattern was found by Revelle, Amaral, and Turriff (1976) in a study of the interactive effects of introversion-extraversion, caffeine, and time pressure (a presumed situational stressor) on performance. Introverts' performance was hindered by time pressure and caffeine, whereas extraverts' performance was facilitated under the same conditions. In a series of studies replicating and extending this work, and using the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1967), Revelle et al. (1980) found that the impulsivity

subscale, rather than the higher order factor of extraversion, more reliably accounted for the interaction between arousal (manipulated by caffeine administration) and extraversion. Results indicated that although high impulsives performed best with caffeine, the drug hindered the performance of low impulsives.

The present study replicates and extends the investigations of the effects of caffeine and impulsivity on performance that were previously undertaken by Revelle et al. (1980). The present design extends this model by adding measures of anxiety and state affect as covariates, and by adding a self-report measure of arousal as a covariate and manipulation check. In addition, performance measures were extended to include not only academic performance (practice vocabulary items from the GRE), but creative performance (Remote Associates Test, or RAT) as well. The addition of creativity to the design extends the work of Matthews (1986) who found that extraversion and arousal interactively affected creative performance.

Personality and Cognitive Performance

Intelligence researchers have focused on cognitive abilities believed to indicate general intelligence. For example, the widely-used Wechsler Intelligence Scales measure groups of aptitudes that have been shown through factor analysis to comprise the latent dimensions of verbal-propositional and spatial-performance (Wechsler, 1974). Also built upon factor analysis, personality researchers have focused on individual behavioral tendencies such as Eysenck's three-dimensional model of psychoticism, extraversion, and neuroticism (Eysenck, 1967, 1981) or the five-factor model that includes the dimensions Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to

Experience (McCrae & Costa, 1985; John, 1990). Although studies that combine dimensions of cognitive performance and personality do exist, they are relatively rare.

Donald Broadbent, for example, is one researcher who made a major contribution to the body of research on cognitive performance and personality. Broadbent's career has been recognized as "an exception to the rule that serious cognitive psychologists should treat individual differences as nuisance variables to be ignored" (Revelle, 1993, p. 1). Broadbent (1958) observed that some people "show larger decrements from prolonged performance than others do" (Broadbent, 1958, p. 140). Further, Broadbent (1958) proposed that dimensions of personality such as introversion-extraversion and stability-neuroticism could account for variations in performance.

Eysenck (1967) also hypothesized interactions between personality and intelligence, primarily with respect to the extraversion dimension. For example, Eysenck (1972, cited in Revelle, 1988) suggested that introverts are more easily conditioned than extraverts under certain circumstances. In as much as conditioning may relate to learning and intelligence, Gray (1987) has developed a theory predicting that introverts are more susceptible to cues for punishment, whereas extraverts are more susceptible to cues for reward. Thus, personality differences may predispose people to perform better or worse depending on the external cues for reward or punishment that are associated with the performance task. Other researchers have suggested that processing differences, mediated by personality variables, may underlie relationships between personality and intelligence. For example, Riding and Dyer (1980, cited in Lohman & Rocklin, 1995) investigated personality differences in preference for semantic versus imagery-based processing in children. Using scores on the Junior Eysenck Personality Inventory, they found that

introverted children were much more likely to prefer image-based elaboration in their answers to questions, whereas extraverted children preferred verbal or semantic elaboration. Thorndike, developer of an early and influential model of intelligence, acknowledged the probable link between personality and intelligence when he noted: "It is probably unwise to spend much time in attempts to separate off sharply certain qualities of man, such as his intelligence, from such emotional and vocational qualities as his interest in mental activity, carefulness, determination to respond effectively, persistence in his efforts to do so; or from his amount of knowledge; or from his moral or esthetic tastes." (Thorndike, 1921, p. 124, as cited in Lohman & Rocklin, 1995)

The Role of Arousal

Arousal is a frequent intersection point between components of personality and performance, transcending disciplines and turning up in the work of cognitive, personality, and biological psychologists alike. In the 18th century, German philosopher Immanuel Kant (1724-1804) advanced the concept of arousal as a factor of temperament by proposing that differences in temperament are characterized by life energy (*Lebenskraft*), which shifts along a continuum from drowsiness to excitability (Kant, 1912 cited in Strelau, 1985). Arousal was later defined by Corcoran (1965) as the inverse probability of falling asleep. More broadly, arousal is a latent construct that subsumes the behavioral effects of stimulant drugs, exercise, time of day, impulsivity, and time on task (Anderson, 1990).

Hebb (1955) reviewed studies of behavior under deprivation and derived three conclusions about the relation between arousal and personality. First, stimulation influences behavior in two ways: by effecting a cue (guiding) function and a drive

(arousal or vigilance) function. Second, the arousal system, which Hebb believed to be located in the brain stem, produces a generalized, non-directional drive or energy: "The drive is an energizer, but not a guide; an engine but not a steering gear" (1955, p. 249). Third, Hebb believed that there is an optimal level of arousal. Expanding on this third conclusion, Hebb (1955) developed the idea of the optimal level of arousal as a reward. When arousal is lower than optimal, stimulation (which increases arousal) is rewarding. Conversely, when arousal is higher than is optimal, a decrease in stimulation (which decreases arousal) is more rewarding. This idea is consistent with the previously established Yerkes-Dodson law, derived from studies demonstrating a curvilinear, or inverted-U, relationship between the intensity of stimuli and the efficiency of learning (Yerkes & Dodson, 1908).

Extraversion, neuroticism, and psychoticism, the individual differences that Broadbent (1958) proposed played a role in performance decrements—later became the cornerstones of Eysenck's theory of personality (Eysenck,1967, 1981). Eysenck (1967, 1976, 1981) suggests that the most pronounced difference between introverts and extraverts is their relative difference in basal arousal. His studies suggest that introverts have a higher level of basal arousal than extraverts. In an effort to increase their basal arousal to a level consistent with optimal performance, extraverts more actively seek arousal from their immediate environment than introverts who tend to eschew actively seeking arousal in order to regulate their already higher level of basal arousal. This explains why introverts avoid stimulating activities like socializing and parties, while extraverts seek them out.

Eysenck demonstrated the physiological basis for differences between introverts and extraverts and validated his measurement construct of extraversion through the use of a salivary "lemon test" (Eysenck & Eysenck, 1967). Using a test originally suggested by Corcoran (1964) to establish the validity and reliability of introversion measures, Hans J. Eysenck and Sybil B. G. Eysenck placed drops of lemon juice on the tongues of 93 participants and measured the amount of saliva that was produced. The 57-item Eysenck Personality Inventory was administered and salivary reactivity scores were intercorrelated with each of the 57 questionnaire items. Salivary reactivity had a -.74 factor loading on extraversion (introverts produced more saliva than extraverts, demonstrating that they were more susceptible to arousing stimuli). In addition, items that loaded high on extraversion had higher correlations with the lemon test than did items that loaded low on extraversion.

Broadbent (1958) elaborated the association between personality variables and their effect on performance in terms of stress and time factors. He proposed that introversion-extraversion was associated with performance decrements over time, whereas stability-neuroticism was associated with decrements following stress. Although Broadbent (1958) proposed that decrements in performance related to situational stress were related to the stability-neuroticism dimension, Geen (1984) suggested that situational stress seems to also vary in the degree to which it affects the arousal level of introverts versus extraverts. Geen (1984) found that while performing a learning task, introverts preferred lower noise levels (a form of situational stress) than did extraverts. In addition, in a yoked control design (each introvert who selected his own noise level was "yoked" to an extravert who was arbitrarily assigned to receive that same noise level, and

vice versa), skin resistance responses (SRRs) were recorded along with the chosen, or arbitrary, yoked noise level. Extraverts and introverts did not significantly differ in the arousal level (SRR index) that was elicited by the chosen noise level. Thus, the optimal level of arousal was found to be the same for introverts versus extraverts. What differed was the level of stimulation required for each group to reach that optimal level.

Physiological Basis of Arousal

There is wide agreement that physiology plays a strong role in determining and regulating levels of arousal and arousability (see e.g., Eysenck, 1967; Geen, 1995; Hebb, 1955, 1990; Thayer, 1978). Some of the most important biological components of arousal include the limbic system, the reticular formation, the cortex, the autonomic nervous system (ANS), and neurotransmitters (Strelau, 1985).

Gray (1964) proposed a distinction between arousal determinants, indices, and determinates of arousal. The first two are fairly obvious, with determinants setting arousal level and indices measuring arousal level. Determinates are the states and processes that an individual displays based on their level of arousal (e.g. alertness, efficiency of learning, response magnitude). Often, the determinates are the dependent variables of interest in studies that include arousal as an independent variable. Because arousal can fluxuate based on the application of a stimulus (an arousal determinant), Gray (1964) proposed the term arousability to signify the more stable propensity of a person to become aroused: "Individual differences in arousability are such that individuals low on this dimension respond to stimulation with relatively low degrees of nonspecific reticular bombardment of the cortex, whereas individuals high on this dimension respond to stimulation with relatively high degree of such bombardment (p. 307)."

Although the above describes Gray's (1964) conception of the relationship between cortical arousal and arousability, Strelau (1985) proposes that the concept of arousability be used more broadly: "Whatever the mechanisms that regulate the level of arousal, individual differences in their functioning occur, and they reveal themselves in the fact that in some individuals stimulation of a given intensity (S_n) results in a higher level of arousal (A_{n+x}), whereas in others, the level of arousal to the same intensity of stimulation is lower (A_{n-x})." (p.130)

Evidence for Personality, Arousal, and Time of Day Interactions on Performance

Over a number of years, Revelle and colleagues have examined the relationship between extraversion, impulsivity, time of day, and arousal on cognitive performance (see e.g. Revelle, 1973, cited in Revelle 1988; Revelle, Amaral, & Turriff, 1976; and Revelle, Humphreys, Simon, & Gilliland, 1980). In the first series of studies, undertaken for his doctoral dissertation, Revelle (1973, cited in Revelle, 1988) investigated how introversion-extraversion interacted with arousal to affect performance. Arousal was measured by skin conductance, and performance tasks included anagrams, digit symbol substitution, and maze performance. Situational stress was also manipulated using the "presumed stressors of group size, incentive motivation, and noise using an additive design" that produced six stress levels (Revelle, 1988, p. 311). It was expected that that performance would vary based on a task difficulty by stress by introversion interaction. Contrary to prediction, no interactions were found between personality and stress, nor between personality and arousal across any of the six stress levels. However, when situational stress was held constant, Revelle (1973, reported in Revelle, 1988) found an interaction between skin conductance and introversion-extraversion such that

"performance was a monotonically decreasing function of increases in SC [skin conductance] for introverts but a curvilinear function (an inverted U) for extraverts. That is, introverts performed best if they had low skin conductance, but extraverts performed best with moderate levels of skin conductance" (p.311).

Performance Differences: Evidence in Favor of the Impulsivity Sub-scale

In later work originating from Revelle's laboratory (Revelle, Humphreys, Simon, & Gilliland, 1980; Anderson & Revelle; 1994), the impulsivity subscale of extraversion, rather than the higher order extraversion scale has been the primary variable linked to arousal. Empirically, Gilliland (1977, reported in Revelle et al.,1980), supported the notion of impulsivity as the more primary component of arousal in his doctoral dissertation when he hypothesized, and found, an interaction between arousal (manipulated through administration of caffeine) and introversion (from the Eysenck Personality Inventory, Eysenck & Eysenck, 1967) on performance. Upon confirming this hypothesis, a post hoc analysis using both the impulsivity and sociability components of introversion was done. Impulsivity was found to be the primary contributor to the obtained interaction of arousal with introversion. Earlier, Carrigan (1960) and Guilford (1975; 1977) argued that Eysenck's extraversion (Eysenck & Eysenck, 1969) was best represented by its separate sub-scale components of sociability and impulsivity than by the higher order factor of extraversion. Finally, mounting evidence by other researchers reported in Anderson and Revelle, 1994 (e.g., Bowyer, Humphreys, & Revelle, 1983; Campbell, 1992; Frcka & Martin, 1987; and Stenberg, 1992) also supports impulsivity as a stronger correlate with arousal than the entire extraversion scale.

Key Assumptions

Revelle et al. (1980) propose that the inverted-U hypothesis first articulated by Yerkes and Dodson (1908) can be applied to studies of caffeine and cognitive performance using the following three assumptions: a) administration of caffeine increases arousal; b) if performance decreases after administration of caffeine, then subjects must have been already optimally aroused or over aroused; and, c) if performance increases after administration of caffeine, then subjects must have already been under aroused. In an explanation of the findings reported in Revelle et al. 1980, the authors further hypothesized that arousal follows specific diurnal patterns throughout the day and that these patterns differ for introverts versus extraverts (and by extension, for low impulsives versus high impulsives).

> Low impulsives achieve their peak arousal level earlier in the day than do high impulsives. This modified formulation suggests that in the morning, the low impulsives are optimally aroused without caffeine but that caffeine makes them too aroused and induces decrements in performance. High impulsives, on the other hand, are below their optimal level and become more aroused and more efficient with caffeine. In the evening, however, the arousal model only fits if the assumption is made that the low impulsives are now sub optimally aroused (on the down limb of their diurnal arousal curve) while the high impulsives are optimally aroused without caffeine. (p.21)

Based on these assumptions, Gilliland (1977, reported in Revelle et al.,1980) administered the EPI Introversion/Extraversion scale, two versions of a practice test from

the GRE, and either a high or low dose of caffeine or a placebo. Versions of the GRE practice test were given both pre-and post drug (or placebo) administration. Gilliland expected caffeine to harm the performance of introverts, in line with the inverted-U hypothesis of arousal and performance. He also expected caffeine to enhance the performance of extraverts under low doses of caffeine but to harm their performance at the higher caffeine dose. Somewhat contrary to his predictions, Gilliland found that introverts performed better at a low dose than they did without caffeine, but that their performance deteriorated at the higher dose. Extraverts performed better with increasing levels of caffeine. Finally, as mentioned previously, Gilliland broke the EPI extraversion scale into its impulsivity and sociability subscales, and found that the impulsivity dimension primarily accounted for the effects obtained from the introversion/extraversion analysis. Results were interpreted as a confirmation of the inverted-U hypothesis, but as not supportive of the unitary nature of the introversion/extraversion construct.

Diurnal Arousal Rhythms

Diurnal variation, discussed earlier in conjunction with the work of Gilliland (1976 reported in Revelle et al. 1980), has continued to play an important role in Revelle's theory (see e.g. Revelle , 1988) and in the interpretations of empirical results reported in Revelle (1988), and Anderson and Revelle (1994). However, results associated with individual differences in diurnal patterns are mixed. For example, Revelle at al. (1980) proposed that high and low impulsives do not differ so much in overall arousal but in the phase of their diurnal arousal rhythms. This proposal was based on a combination of results obtained from earlier work by Blake and colleagues(Blake 1967, 1971; Blake & Corcoran, 1972; cited in Revelle et al., 1980). Blake and his colleagues

showed that the diurnal body temperature of introverts reaches its highest point "several hours" sooner than extraverts (as described in Revelle et al., 1980). Both groups show the same pattern, but the extraverts show the pattern later in the day than introverts. Further, Revelle et al. (1980) extend the assumption about phase differences for extraversion to impulsivity, hypothesizing that high and low impulsives differ in a similar manner, such that the arousal of low impulsives would follow the pattern of introverts and peak earlier in the day as compared with high impulsives (or extraverts).

In addition, Eysenck and Folkard suggest that a study by Horne and Österberg (1977) provides a more thorough investigation of individual phase differences than does the work of Blake (1967). Horne and Österberg found phase differences of only 33 minutes between introverts and extraverts, as measured by body temperature. Calling into question the magnitude of the diurnal phase difference between introverts and extraverts suggested by Revelle et al., a re-analysis of some unpublished data from Folkard (reported in Eysenck and Folkard, 1980) failed to support a several hour phase difference in arousal. In this study, students recorded their temperature every three hours from 8:00 to 23:00, and were grouped based on high or low scores on impulsivity, introversion, and sociability. Although directionally supportive of the findings of Revelle et al. (1980), the trend of introverts having higher temperatures than extraverts in the morning, but lower relative temperatures later in the day, was non-significant. In addition, there was no support for a several hour phase difference between introverts and extraverts. Although acknowledging some support for the assumption that the phase difference associated with introversion is due to the impulsivity component, Eysenck and Folkard (1980) seem to

feel that such findings remain weaker than what would be necessary to warrant data interpretation on their basis.

Obtained patterns of circadian arousal also differ depending on the indices used. Body temperature was reported by Thayer (1978) to peak in the late afternoon, while self-reported levels of arousal peaked at 11:00. The same late morning self-report peak time was obtained by Clements, Hafer, and Vermillion (1976). These data suggest that self-report and temperature follow opposite activation patterns. A third measure of arousal, adrenaline secretion, has been shown to peak at midday, following the pattern shown by self-report measures (Akerstedt, 1977; Klein et al., 1977).

In summary, arousal plays an important role in performance and in individual differences in personality factors such as introversion/extraversion and impulsivity. Arousal is also an empirically useful variable in that it can be manipulated, allowing researchers to better understand its effects on performance.

Task Characteristics and Performance Effects

The present study was concerned with performance on two types of cognitive tasks, academic tasks and creative tasks. The key distinction between these two task types was the presence or absence of originality in participants' acceptable responses. For academic tasks, originality was not required. Rather, tacit knowledge and the ability to quickly apply that knowledge as specified by the problem was measured. For creative tasks, participants had to demonstrate originality, usually according to certain task-specific parameters. The presence or absence of the originality requirement as the distinction between creative and academic tasks was important for three reasons. First, the cognitive processes involved in each type of task differs. For example, Guilford

(1967) distinguishes between mental operations involving evaluation, memory and cognition (defined in the narrow sense as "how much the examinee knows or can readily discover on the basis of what he knows"), and those involving divergent and convergent production. Second, academic and creative tasks have been shown to be psychometrically independent (e.g. Guilford, 1967; Hargreaves, 1927; Wallach & Kogan, 1972). Third, creative and academic tasks may differ in their arousal requirements. For example, Mednick (1967) and Eysenck (1995) conceive of originality as arising from the ability to produce many associations from a given stimuli. Because high arousal narrows attention, it may impair this wide associative process necessary for producing novel ideas. On the other hand, narrow attention can be helpful when working on a math problem that requires one to attend closely to the problem until the correct answer is obtained.

Michael W. Eysenck and Simon Folkard (1980) point out that optimal academic performance appears to follow different diurnal patterns based on task type. Tasks requiring immediate processing of information show performance improvements throughout the day (Hockey & Colquhoun, 1972), whereas tasks that use working, or short-term memory have shown performance decrements over the day (Baddeley, Hatter, Scott, & Snashall, 1970; Blake, 1967b; Hockey, Davies & Gray, 1972; all cited in Eysenck & Folkard, 1980). These studies find that phase differences associated with task type are greater than those associated with individual differences. Based on the importance of these kinds of task distinctions, Eysenck and Folkard have criticized the lack of distinguishability between the tasks chosen by Revelle et al. Because Revelle used tasks that were not systematically chosen to represent different types of processing (such as by distinguishing among immediate processing and working memory), Eysenck and

Folkard deem them "lacking in theoretical relevance" (p. 37). Thus, although Revelle et al. found consistent patterns across two different experiments (one using an analogies test and one using a practice GRE), Eysenck and Folkard dismiss the relevance of the finding, stating that interpretation of the results would require an understanding of the "salient differences in processing demands of the two tasks" (p. 37).

Responding to this criticism, Humphreys and Revelle (1984) later modified some of their earlier assumptions by taking into account the properties of the performance tasks involved. In their revised theory, Humphreys and Revelle (1984) state that arousal effects depend on the type of processing involved. In tasks that only involve sustained information transfer (SIT), arousal increases performance. In addition, this effect is monotonic (not U-shaped), and occurs because arousal increases the number of resources available to sustain information transfer. The increased number of available resources, in turn, leads to ever-increasing improvements in performance on tasks that *only* involve SIT. On tasks that only involve Short Term Memory (STM), however, heightened arousal monotonically decreases performance. This is because some resources involved in short interval retention are reduced by heightened arousal. The diametrically opposite effects of arousal on SIT and STM task performance combine to produce a curvilinear (inverted-U) effect on most multicomponent tasks measuring creativity and cognitive ability. An example of such a multicomponent task is a multiple choice examination. "After attending to and reading the question, the subject must remember it while attending to and reading the answers. Performance depends on whether the question is still available or can be retrieved when the correct answer is encountered" (Humphreys & Revelle, 1984, p. 167).

In brief, then, the effects of arousal on performance may depend on the type of processing involved. Interactions with arousal appear to depend at least in part on task characteristics such as SIT and STM, with different effects found for tasks that involve either component in isolation, and for multicomponent tasks. Creativity tasks differ from academic tasks in their focus on originality. The task-specific characteristics of creativity or originality, and how these might be related to arousal, will be further elaborated in the section on creativity.

Anxiety and Performance

Anxiety cuts across behavioral scientists' disciplinary lines and taps into many important aspects of behavior. As such, the study of anxiety offers rich possibilities for discovering how personality, biology and environment interact to affect performance. Anxiety is significant both as a state-oriented measure (physiological arousal, specific emotional states such as worry) and as a trait measure of personality (e.g. neuroticism). The role of anxiety is a particularly important consideration when investigating the influence of arousal on performance for several reasons. First, anxiety may be a component of arousal, or a type of arousal. Second, anxiety may hamper performance by acting as a distracter. Third, anxiety can actually facilitate performance under some conditions. Fourth, anxiety can function as an impetus for the anticipation of either reward or punishment, which may in turn either facilitate or hamper performance. Finally, whether anxiety functions to signal reward or punishment may be mediated by the same biological structures and mechanisms that modulate extraversion. Thus, extraversion and anxiety response tendencies may be related.

Anxiety as a component of arousal

Several researchers have pointed to the importance of considering the potential effects of the tense/anxious components of arousal in addition to energetic/vigorous arousal effects when studying the effects of manipulated arousal. For example, Russell and Mehrabian (1977) found that anxiety is composed of 2 distinct components, arousal and pleasure/displeasure. Similarly, Thayer (1978) developed an adjective checklist measure of arousal that divides arousal into two components: Energetic Arousal (items include: energetic, peppy, wakeful, lively, vigorous) and Tense Arousal (items include: jittery, clutched-up, tense, and fearful).

Anxiety as an Inhibitor of Performance. Several researchers have noted the inhibitory effect of anxiety on performance. For example, anxiety can inhibit performance through distraction, attentional narrowing, or by initiating attempts at, or thoughts about, escape. Anxious people may use invaluable cognitive resources for worrying about performance rather than devoting them to the cognitive task. Bower (1994) noted, "very anxious or depressed people are notoriously poor learners because their working memory is so preoccupied or 'filled' with upsetting ruminations that few attentional resources are devoted to the learning or recall tasks being measured" (pp. 304-305). Larson (1989) suggests that anxiety hampers performance by narrowing attention, thereby limiting the number of elements that can be attended to at once. Geen (1987) found that participants high in test anxiety availed themselves of an opportunity to escape the testing situation more often than their low test-anxious counterparts. Matthews (1986) found that apprehensive anxiety (worry) decreased creative task performance, and theorized this was due to anxiety placing excess demand on attentional resources.

However, in the same study, Matthews found that another measure of anxiety (tension vs. relaxation) accounted for facilitative effects on creativity.

Anxiety as a Facilitator of Performance. Under some circumstances, anxiety may also facilitate performance. For example, Geen and Kaiser (1986, reported in Geen, 1987) found that highly test anxious participants who completed the Stroop Color Word Test were not only more cautious, but also committed fewer errors. In Revelle and Humphreys' (1983) review the effects of anxiety on cognitive performance depended on task difficulty and situation. They found that when either feedback is positive or the task was simple, high anxiety enhanced performance.

Anxiety, Performance, and Individual Differences in Sensitivity to Punishment Cues. As discussed above, anxiety affects performance in different ways, at times as a facilitator and at times as an inhibitor. Moreover, anxiety can affect performance at both the state (e.g. empirical manipulations of anxiety) and trait (e.g. participant scores on neuroticism scale) levels. In addition, anxiety and arousal are closely linked, and although their effects on performance differ, each has been shown to affect performance outcomes. Moving toward further integration of the effects of anxiety, personality, and performance, it is helpful to consider how, specifically, anxiety and personality may interact.

Gray (1982) contends that the manner in which an individual responds to anxiety reflects a biologically-based sensitivity to punishment cues and that "individuals differ reliably and systematically in their sensitivity to reward and punishment" (p. 498). Gray has proposed that these individual differences an reward and punishment sensitivity are modulated by two respective systems that he calls the Behavior Activation System (BAS)

and the Behavioral Inhibition System (BIS). The BIS—the system responsible for sensitivity to punishment—consists of the septo-hippocampal system (SHS), the Papez loop, ascending monoaminergic pathways that innervate the SHS, and neocortical structures that project to and from the SHS (Gray, 1987).

Revelle (1984, 1988) elaborates how the BIS-modulated differences in anxiety sensitivity might affect performance, suggesting that anxious individuals' greater sensitivity to punishment versus reward predisposes them toward slower performance. For these anxiety-prone individuals, slower performance is a favored strategy because the possibility of being punished for errors—and the desire to avoid this fate—overshadows the reward that might come from speedier performance. This "speed-accuracy tradeoff" (Revelle, 1987, p. 448) stems from some combination of the effort to be accurate or from off-task thoughts (worry and/or cognitive attempts at escape or avoidance). Examining this prediction, Leon and Revelle (1985) investigated the deleterious effect of anxiety on a task of analogical reasoning. They found that although more anxious participants were faster, they made more errors than less anxious participants. Performance differences among more anxious subjects were interpreted to imply differences in speed-accuracy trade-off strategies. Differences in processing abilities were not believed to play a role.

To date, Revelle and colleagues have not combined their findings concerning the effects of caffeine-manipulated arousal on performance and the above-mentioned affects of anxiety on performance into an empirical model that separates the energetic arousal effects of caffeine from its tense-anxious effects. Because caffeine is often used to manipulate arousal in investigations of arousal, personality, and performance; because it can produce both energetic arousal and tense arousal (Bullock & Gilliland, 1993); and

because these two types of arousal may differently affect performance; it is important to distinguish between the components of caffeine-initiated arousal when interpreting the effects of caffeine on performance. The present study is designed to separate energetic and tense arousal in the attempt to isolate the effects of energetic arousal on performance.

Creativity and Creative Performance

H.J. Eysenck (1995) defines creativity in terms of both the potential for creativity and the product or expression of creativity. Trait Creativity is a latent tendency that underlies creative behavior but is not sufficient to alone cause creative productivity. Achievement Creativity is the product of Trait Creativity, intelligence, and other components (e.g. technical skills, cultural factors, confidence) that results in novel and useful/socially acceptable products (Eysenck, 1995).

The definition of creativity put forth by Mednick (1962) does not contradict Eysenck's view, but it does go farther to elaborate the process. Similar to Eysenck, Mednick (1962) defines creativity in terms of the process by which creation happens, and the product or end-result obtained. But Mednick goes on to specify that creativity involves the ability to "form associative elements into new combinations which either meet specified requirements or are in some way useful. The more mutually remote the elements of the new combination, the more creative the process or solution" (p. 221).

Measures of Creativity

Eysenck (1995) suggests that tests of fluency are the most common Trait Creativity measure. Fluency measures the number of or the originality of answers given to problems with multiple solutions. Hargreaves (1927, cited in Eysenck, 1995) demonstrated the discriminate validity of fluency. He found that tests calling for a large

number of imaginative responses correlated highly together but were not identical to "g." The fact that this "divergent" problem solving ability tends to correlate with intelligence only up to IQ values of approximately 120 suggests to Eysenck (1995) that "a certain amount of intelligence is needed to lay a foundation in knowledge that enables trait creativity to make a genuine contribution – understand the fundamentals of the problem, interpret the rules, and give solutions that are socially acceptable" (p. 233).

Mednick (1962) developed the Remote Associates Test (RAT) of creativity based on his conception of creative thinking as the process by which novel or useful associations are made between elements that are not usually considered related. Mednick, like Eysenck, also saw creativity as overlapping somewhat with intelligence. In particular, he pointed out that some domain-specific knowledge is necessary in forming the associations needed to produce creative solutions. Although domain-specific knowledge may have a facilitative effect on associations, an over-reliance on domain specific knowledge may inhibit associations. For example, if one over learns a common or "correct" association, this may reduce the likelihood of making a remote association, thereby inhibiting a more creative response.

Psychoticism, Over-inclusion and Creativity

Martindale (1999), following other psychoanalytic theorists such as Kris (1952), suggests that two types of cognition, primary process thought and secondary process thought, are integral to understanding individual differences in creativity. Primary process thought is "autistic, free-associative, analogical"; whereas secondary process thought is "abstract, logical, reality-oriented" (Martindale, 1999, p. 138). Kris (1952) proposed that creativity is associated with a superior ability to alternate between primary

and secondary process thought. According to Kris, the inspiration stage of creativity involves regression to primary process thought while the elaboration stage involves a return to the usual waking state of secondary process thought.

The concept of free-associative primary process thinking is related to the associative view of creativity advanced by Eysenck (1995) and others (e.g. Martindale, 1999; Mednick, 1962). Eysenck (1995) proposed a testable and causal model of creativity in which creative thinking is a product of a flat associative hierarchy, combined with the ability to weed-out irrelevant or non-useful responses in order to form a creative and useful solution. A person who has a flat associative hierarchy allows for a "wider interpretation of relevance" in response to a stimulus (Eysenck, 1995, p. 239). For example, when asked to find words associated with "pencil" a less creative person, or one with a steep associative gradient, may only be able to generate a few responses, such as pen, write, and lead. A more creative individual, or a person with a flatter associative gradient, might produce additional and less common responses such as tree, poetry, and mustache. In addition, Eysenck (1995) proposes that the flat-associative hierarchy characteristic of creative thought can be explained in relation to processes that have been shown to be biologically mediated such as low arousal, latent inhibition, and negative priming. Each of these processes has been shown to be related to psychoticism and psychosis, with moderate psychoticism being on the "normal" end of the trait continuum and psychosis representing the maladaptive extreme. Eysenck's (1992) conception of psychoticism (cited in Eysenck, 1995) measures a continuum of emotional independence from very socially conformist characteristics (altruistic, socialized, empathetic,

conventional, conformist) to unconventional and rebellious characteristics (criminal, impulsive, hostile, aggressive, psychopathic, schizoid).

Several studies using word association tasks have positively linked psychoticism and trait creativity (e.g. McKinnon, 1962; Gough, 1976; Miller & Chapman, 1980; all reported in Eysenck, 1995; also see Feist, 1998 for a meta-analytic review of some of these findings). On tests of word association, persons rating high on psychoticism and persons with psychotic illnesses make many more varied associations than less creative people (Eysenck, 1995). The wider association horizon of creative and psychotic persons is postulated by Eysenck (1995) to be the result of these persons exercising less stringent criteria for relevance when giving word associations. In this way, the over generalized or over inclusive thinking of the psychotic or schizophrenic should be closely tied to creative thinking. Eysenck (1995) further explains that "overinclusive thinking may be the result of a disorder (failure) of the process whereby inhibition is built up to circumscribe and define the learned response (the word or concept). In short, such thinking could be an extreme degree of stimulus generalization." Eysenck postulates that the difference between highly productive creatives and psychopaths may lie in their differential abilities to suppress irrelevant responses. Individuals who measure high on scales of psychoticism and also measure high on ego strength do not usually succumb to psychotic illness, but do perform comparably to psychotic individuals on tests of creative associations (Farmer, 1974; Woody & Claridge, 1977; all cited in Eysenck, 1995, pp. 234 & 236).

Arousal and Creativity

As previously noted, Eysenck (1995) believed that the wider associative gradient linked with creativity and psychoticism was also linked with low arousal. Earlier, Easterbrook (1959) hypothesized that increased arousal narrows attention, thereby decreasing associations. This relates directly to the narrow "associative horizon" of low psychotic, low creative people as discussed by Eysenck (1995).

With respect to arousal and creativity, significant support has been found for two ideas that at first seem contradictory. On one hand, creative thinking appears to be associated with low cortical arousal (see e.g. Martindale, 1981; Martindale & Armstrong, 1974; Martindale, Hines, Mitchell, & Covello, 1984). On the other hand, creative individuals appear to have higher levels of cortical arousal than their less creative counterparts (Martindale, 1990, cited in Martindale, 1999; Martindale & Armstrong, 1974; Maddi & Andrews, 1966). In addition, creativity has been linked to introversion (Eysenck, 1973; Goetz & Goetz, 1979;), and introverts have been shown to have higher levels of basal arousal than extraverts (Eysenck & M. Eysenck, 1989; Strelau & Eysenck, 1987;). Martindale (1999) hypothesizes a way to reconcile the apparent discrepancy between the high basal arousal found in creative individuals and the low arousal found during creative thinking. He builds on an earlier hypothesis made by Kris (1952, cited in Martindale, 1999) that creative individuals are more able to alternate between primary process and secondary process thought. Martindale (1999) proposes, "if creative subjects are more variable on the primary-secondary process continuum, then they should also be more variable on the arousal continuum" (p. 140). Thus, although creative individuals have higher basal levels of arousal, they may have a more flexible arousal range and be

able to enter lower states of arousal when called upon to "be creative." Martindale and others have found support for this idea. Martindale (1977) found that more creative subjects showed greater galvanic skin response fluctuation; Martindale and Hasenfus (1978) obtained similar results in EEG alpha amplitude. Based on these results, Martindale (1999) distinguishes between two phases of creativity attributed initially to Helmholtz (1896): creative inspiration and creative elaboration. Martindale proposes that creative inspiration requires low cortical arousal while creative elaboration requires higher cortical arousal. Thus, to be most productive, creative people must flexibly alternate between the two states.

There appears to be substantial agreement that creativity, or useful originality, involves forming associations and combining them in novel ways. Creative people are said to have flat associative hierarchies and lower cortical arousal, traits they have in common with individuals high on Eysenck's Psychoticism dimension. Further, the inspiration involved is hypothesized to occur during states of low cortical arousal, while the elaboration of associations is hypothesized to involve higher cortical arousal states. The seeming contradiction between these hypotheses and findings is reconciled in Martindale's (1999) suggestion that productive creativity involves the flexible alternation between high and low arousal states.

Summary and Hypotheses

One of the more robust findings in all of psychology is that arousal affects performance such that "some intermediate level of arousal is optimal for performance" (Eysenck & Eysenck, 1985, p. 197). But it is clear that arousal affects performance differently depending on individual differences or differences in the performance task.

Research has also shown that variations in response to arousal manipulations are related to different rates of change in diurnal arousal rhythms between high versus low impulsives. The present study replicates the Revelle et al. (1980) studies on the interactive effects of impulsivity and arousal on performance, but simplifies the design by holding time of day constant (testing only in the morning).

As previously discussed, the literature also indicates that anxiety may influence the role of arousal in affecting performance (e.g., Leon & Revelle, 1985). Some researchers have suggested (Russel & Mehrabian, 1977; Thayer, 1978) that arousal can be divided into energetic arousal and tense-anxious arousal. In order to isolate the effects of energetic arousal on performance, the present study will covary measures of anxiety with the test of caffeine-manipulated arousal effects. The goal will be to observe energetic arousal apart from any extraneous or caffeine-induced anxiety effects.

Finally, to better understand how arousal and personality might affect creative performance, and to understand whether this differs from any observed effects on academic performance, the present study will add to the dependent measures of performance a measure of creative performance.

To summarize the present design, participants were administered the EPI (Eysenck & Eysenck, 1967) to obtain scores on introversion, impulsivity, neuroticism, and a lie scale. As a manipulation of arousal, participants were then administered either caffeine or a placebo. Following a waiting period and the administration of manipulation check, participants completed questions from a practice form of an academic (the Graduate Record Examination) or creative (the Remote Associates Test) problem-solving task. Several predictions were tested, based on an alpha level of .05:

1. The first prediction was that impulsivity would be negatively correlated with academic performance and positively correlated with creative performance.
2. My second prediction was that participants who were low in reactivity and low in impulsivity would be more creative than all other groups.
3. My third prediction was that there would be an impulsivity by caffeine interaction for academic performance, such that caffeine would help the academic performance of high impulsives, but would hinder the academic performance of low impulsives.
4. The same interaction was expected for creative performance, such that caffeine would help the creative performance of high impulsives, but would hinder the creative performance of low impulsives.
5. My final prediction was that any interactions obtained by the analyses used to test hypotheses 3 and 4 (whether or not they were directionally consistent with the prediction outlined in hypotheses 3 and 4) would be stronger when covariates representing anxiety and negative affect were included in the analysis.

Method

Participants

Participants were 71 (43 women and 28 men) introductory psychology students from the College of William & Mary. All participants were over the age of eighteen, and received 2 hours of research participation credit toward a course requirement.

Participant Selection

Participants were initially selected on the basis of two pre-selection measures: 1) The Positive and Negative Affect Scale (PANAS), and, 2) the Rational-Experiential Inventory (REI). For each of the two scales, a list of high, medium, or low scores with respect to the mean was generated. From that list, prospective participants signed up for the study in a manner that ensured an approximately equal distribution of scores from the high, medium, and low-scoring categories for each of the two pre-selection measures. This was done in order to create evenly distributed groups on these dimensions in the event that between groups comparisons were to be made based on these dimensions. However, these selection parameters are not likely to be important for the present analysis because these dimensions are not the dimensions of primary interest in the present analysis.

In addition, a prominent notice at the sign-up location informed students that they could not participate in the study if they were taking any medications known to interact with caffeine, or if they had any conditions that might interact adversely with caffeine. The notice also stated that participants should not have any caffeine or other stimulant for at least 6 hours prior to the study (see Appendix A). Finally, students were telephoned the day before the study to remind them not to have any caffeine, and to validate that they did

not have any of the conditions with adverse reaction potential (see verbatim script, Appendix B).

Materials

Tasks constituting the independent and dependent variables for the present study included three paper-based questionnaires measuring self-reported individual differences (Appendix C), two paper-based tasks (Appendix D), and one administration of either caffeine or a placebo (Appendix E). One additional questionnaire regarding typical caffeine use and other prior (6 hours before the study) caffeine and other drug use were also administered.

Eysenck Personality Inventory (EPI, form A); (Eysenck & Eysenck, 1967). The EPI is a 57-item personality inventory used to obtain scores for extraversion (24 items), neuroticism (24 items) and a lie scale (9 items). The EPI uses a yes-no rating scale. The extraversion scale contains subscales for sociability and impulsivity. Impulsivity items ask, for example, whether the respondent often longs for excitement, stops and thinks things over before doing anything, or often does things on the spur of the moment. Sociability items include questions about whether the participant: suddenly feels shy when wanting to talk to an attractive stranger, prefers reading to meeting people, or likes going out a lot. Neuroticism items ask whether participants, for instance: find it very hard to take no for an answer, find that their mood often goes up and down, or are sometimes bubbling over with energy and sometimes very sluggish. The lie scale includes items asking whether the participant: sometimes gossips, occasionally has thoughts or ideas they would not like other people to know about, or once in a while lose their temper and get angry. This inventory was selected because the extraversion dimension has been

shown to be a reliable and valid measure of impulsivity as well as sociability (Eysenck & Eysenck, 1967; Eysenck, 1977). In this respect, the EPI is often preferred over the more recent EPQ (Eysenck Personality Questionnaire), especially by William Revelle (Revelle, 1988; Revelle et al., 1980; Rocklin & Revelle, 1981; W. M. Revelle, personal communication, March 22, 1999) whose research is partially replicated in my study. [Appendix C]

Positive and Negative Affect Scale (PANAS); (Watson, Clark, & Tellegen, 1988). The PANAS, composed of two 10-item mood scales was developed to assess a variety of positive and negative affect tendencies. The inventory provides emotion adjectives for positive (e.g. interested, alert, excited, inspired) and negative (e.g. distress, ashamed, upset, nervous) states on which participants rate how typical that emotion is for them on a 5-point Likert scale (from 1 to 5: 1 = "very lightly or not at all"; 3 = "moderately"; 5 = "extremely") Two scores result, one each for Positive Affect (PA) and Negative Affect (NA), with a minimum of 10 and a maximum of 50. The scales are reported to be reliable: .86-.90 for PA and .84-.87 for NA; and valid (Watson, Clark & Tellegen, 1988). [Appendix C]

Activation-Deactivation Adjective Checklist (AD ACL; Thayer, 1978,1989). Thayer's 20-item adjective rating scale was developed to measure the two factors of energetic (10 items) and tense arousal (10 items). The measure is designed for use as a state measure and as such participants are asked to rate each adjective according to how they feel at the present moment. Adjectives for energetic arousal include: energetic, wide-awake, and lively. Adjectives for tense arousal include: jittery, fearful, and clutched-up. The AD ACL uses the same 5-point Likert scale as the PANAS (from 1 to 5: 1 = "very

lightly or not at all"; 3 = "moderately"; 5 = "extremely"). Adequate reliability and validity has been established and is reported in Thayer (1978; 1986). [Appendix C]

Graduate Record Examination (GRE) Practice Items; (Educational Testing Service). In total, 12 items from a practice version of the GRE were administered. Six of the items tested vocabulary, three items tested reading comprehension, and 3 items tested mathematical ability. Only the vocabulary sub-test will be used for the present analysis. Three of the vocabulary items involved verbal analogies and three involved responding to a given stimulus word by choosing its closest opposite. An example of a verbal analogy is an item that provided the stimulus word pair, ballast:instability and participants were to choose among 5 possible responses: bouy:direction; purchase:slippage; lathe:metal; pulley:leverage; or hoist:elevator. An example of an item that required the participant to choose the closest opposite provides the stimulus word, endemic and requires the participant to choose its closest opposite from among five possible words: exotic, shallow, episodic, manifest, and treatable. Based on my sample, inter-item reliabilities within the 6 vocabulary items ranged from .31 to .58, (N=71). Reliability and validity information for GRE tests in general can be obtained from the Educational Testing Service website: www.ets.org. [Appendix D]

Remote Associates Test (RAT); (Mednick & Mednick, 1967). The RAT was used to measure creativity. The RAT was created to measure creativity produced by remote but common associations between words. For each item, a row containing three stimulus words is provided (e.g., Cookies, Sixteen, Heart). Following these three words, a blank space is provided in which participants must generate a fourth word (e.g. Sweet) that shares an associative meaning with each of the three stimulus words. Five items from the

30-item test were used in my study. Participants received one point for each item for which they provided a correct answer, thus total scores for this test ranged from 0-5. The RAT has been established as an adequately reliable and valid measure of divergent thinking (Mednick & Mednick, 1967). [Appendix D]

Caffeine and Other Drug Use Questionnaire. This 7-item questionnaire, developed specifically for the present study, assessed participants' use of caffeine and other psychoactive substances prior to the experiment. The measure also asked about typical caffeine consumption. Participants were asked a combination of questions with yes or no or fill-in the blank responses, such as: "did you consume any caffeine during the 6 hours prior to this study? In other words, between 3:00 a.m. this morning and when you arrived in this room at about 9:00 a.m., did you consume any caffeinated beverage or any other form of caffeine?" And as a follow-up, "If you answered "YES" to the above question, please indicate what kind of caffeine you had and how much (e.g., a cup of coffee, a soda, etc.)". [Appendix E]

Caffeine and Placebo Treatments; (W.M. Revelle, personal communication, March 22, 1999; Revelle, 1988). Both a caffeinated beverage and a non-caffeinated placebo were used for the present study. Both the treatment and placebo beverages (8 fluid ounces each) were prepared according to the formulary specified by William Revelle and used in his laboratory for over 23 years. A documentation of this formulary, developed especially for the present study, appears in Appendix F, along with detailed instructions for laboratory preparation. Both beverages used an orange-flavored breakfast drink as their base. The caffeinated version used in this study contained 400 milligrams of Caffeine Citrate per participant (200 milligrams of active caffeine; about the

equivalent of 2 cola drinks). Flat quinine water was used in the placebo beverage to simulate the bitter taste of caffeine. [Appendix F]

Procedure

Data were collected in a large lecture hall at 9:00 A.M. on two different weekend mornings. To minimize arousal as a function of social interaction/anxiety, all participants were asked to seat themselves so that there were at least one or two seats on either side between themselves and the next participant.

On arrival, participants were provided with a consent form (Appendix G) and a caffeine and other drug questionnaire describing the possible side effects of caffeine and screening for contraindicated medical conditions. Prior to caffeine administration, all consent forms and caffeine and other drug questionnaires were reviewed to assure that consent had been freely given. No students indicated adverse medical conditions or declined to participate.

After a brief introduction to the forthcoming tasks, each participant received a paper cup filled with either an 8 ounce caffeinated or non-caffeinated orange beverage. Caffeine was administered using a double-blind procedure. Cup color (red or blue) was chosen to represent caffeine or placebo by one of the experimental assistants who did not reveal the color-coding to the other experimenters or to the participants until the end of the experiment. After the beverages were distributed, participants were asked to drink them. Additional fresh drinking water was provided. After participants drank their beverages, cups were passed to the aisles and discarded.

Next, a packet containing the first two personality questionnaires was provided to each participant. Questionnaire order was counterbalanced across the two experimental

sessions. Participants were allowed 25 minutes to complete their questionnaires and for the caffeine to take effect among the treatment group. After 25 minutes, Thayer's Dimensions of Arousal Scale was administered as an arousal/manipulation check. After all participants completed the first three questionnaires, the questionnaires were collected and the creative task packets were distributed.

As with the personality measures, the order of GRE and RAT tasks was counterbalanced across experimental sessions. Both sets of tasks were timed. Participants completed their tasks as a group, in the same sequence as their peers. Similar to standardized testing procedures, the experimenters timed each portion of each task with a stopwatch and indicated when participants could move on to the next task. The six GRE vocabulary items took about six minutes and the five RAT items took about five minutes (one minute per item on both the GRE and RAT tasks).

Once the GRE and RAT items were completed, the tasks were collected and participants were thanked and debriefed (see verbatim script, for details). Participants were also provided with a debriefing sheet to take with them [Appendix H].

Results

Hypothesis 1

My first prediction was that impulsivity would be negatively correlated with academic performance and positively correlated with creative performance. As shown in Table 1, results for academic performance were directionally consistent with prediction, such that impulsivity was negatively correlated with GRE vocabulary. However, this correlation was non-significant, r (71) = -.10. For creative performance, the correlation between impulsivity and creativity was non-significant, r (71) = -.19, and directionally opposite of prediction.

Hypothesis 2

My second prediction integrates two complimentary lines of theory and research discussed earlier. First, Martindale (1999) has suggested that when called upon to 'be creative', creative people are able to modulate their arousal to meet the needs of the creative task at hand. Second, Eysenck (1973) has suggested that introverts are more creative than extraverts. This has been related to the finding that introverts have higher levels of basal arousal than extraverts (Eysenck, 1985; Feist, 1999). However, Revelle et al. (1980) have shown that impulsivity, rather than extraversion is the variable most sensitive to personality differences in arousal that effect performance. Introversion and impulsivity are related in that impulsivity is a subscale of introversion and introverts tend to be low in impulsivity but high in cortical arousal (Eysenck, 1985).

Following from the two ideas above, then, my second prediction was that participants who were low in reactivity and low in impulsivity would be more creative

than all other groups. This hypothesis was tested by grouping participants into four groups based on their reactivity and impulsivity scores. The reactivity score was created by grouping together people who had caffeine but reported low levels of arousal (arousal score was less than or equal to -.5 standard deviation from the mean) and people who did not have caffeine but reported high levels of arousal (arousal score was greater than or equal to +.5 standard deviation from the mean) together into the "low reactive" group. Essentially, the low reactive group consisted of participants who reacted to the presence of caffeine in a manner counter to the normal effect of the drug. The "high reactive" group was created by grouping together people who had caffeine and reported high levels of arousal or who did not have caffeine and had low levels of arousal. The high reactive group, then, consisted of people who reacted as expected based on whether they had caffeine or placebo.

To simplify the analysis, a two (Reactivity: low vs. high) by two (Impulsivity: low vs. high) design was tested using a one way ANOVA in which four groups (low reactive/low impulsives; high reactive/low impulsives; high reactive/high impulsives; and low reactive/high impulsives) were first compared to see if a difference existed. Upon finding a difference, a planned contrast detected whether low reactive/low impulsives were more creative than all other groups. Planned contrasts also tested the additional question of whether there were main effects for reactivity and impulsivity.

Figure 1 presents a plot of these means, using separate lines for high and low impulsives, and shows that results are directionally consistent with prediction. That is, low reactive/low impulsives had a higher mean creativity score than any of the other three groups. There was a significant difference between the four groups, $\underline{F}$ (3,67) = 3.28,

$p = .026$, $\eta^2 = .128$. In addition, the planned contrast between low reactive/low impulsives and all other groups revealed a significant difference, $t\ (67) = 2.63$, $p = .011$. Finally, the planned contrasts for the reactivity and impulsivity revealed a significant main effect for reactivity, $t\ (67) = 2.23$, $p = .029$, but not for impulsivity, $t\ (67) = 1.75$, $p = .085$.

Hypothesis 3

For academic performance, I predicted an impulsivity by caffeine interaction, such that caffeine would help the performance of high impulsives, but would hinder the performance of low impulsives. A two-way independent groups ANOVA was performed to test this hypothesis. The EPI lie scale, a measure of participants' propensity to answer EPI questions dishonestly—or possibly a measure of the degree to which the participant is committed to socially desirable responding—was used as a covariate. This was done to try to control for response bias in the impulsivity scale, thereby obtaining a purer measure of impulsivity. In addition, participants' usual daily caffeine intake and their weight were also used as covariates to account for differences in dosage due to weight (all participants who had caffeine were given the same amount) and to account for habituation effects. The means for vocabulary test scores, grouped by impulsivity and caffeine, and adjusted to account for the covariate, are plotted in Figure 2, and form an interaction. The interaction is in the opposite direction of prediction, however, with caffeine apparently helping low impulsives and hindering the performance of high impulsives. This opposite to predicted interaction was also significant, $F\ (1,64) = 4.43$, $p = .039$, $\eta^2 = .065$.

Hypothesis 4

For creative performance, the same interaction was expected as was expected for academic performance. I predicted that caffeine would enhance the performance of high impulsives, but would hinder the creative performance of low impulsives. A two-way ANOVA with the EPI Lie Scale, daily caffeine intake and body weight covariates was again used to determine results. The means for creativity test scores, grouped by impulsivity and caffeine, and adjusted to account for the covariate, are presented in Table 2. As shown in Figure 3, these means do not suggest an interaction, as was predicted. As is apparent from means plotted in Figure 3, no interaction can be detected, F (1,64) = .100, p = .752, η^2 = .002.

A post hoc main effect for impulsivity was detected when creativity was the dependent variable, however. This main effect is illustrated by the parallel lines in Figure 3, and confirmed in the ANOVA results, F (1,64) = 4.07, p = .048, η^2 = .060. Again, the prediction that caffeine would help the performance of high impulsives was not borne out. Rather, caffeine appears to help both groups, but it helps low impulsives more than high impulsives.

Hypothesis 5

My final prediction was that any interactions obtained by the analyses used to test hypotheses 3 and 4 (whether or not they were directionally consistent with the prediction outlined in hypotheses 3 and 4) would be stronger when covariates representing anxiety and negative affect were added to the design. This strengthening of effect was expected for both academic and creative performance, and was based on the assumption that it is the energetic effects of arousal, rather than the anxiety component, that most reliably

accounts for enhanced performance. This assumption was based in part on findings by other researchers indicating that arousal is not a unitary construct but is composed of two distinct types of arousal, one reminiscent of wakeful energy and the other of anxiety or displeasure (see e.g., Russell & Mehrabian, 1977; Thayer, 1978). As discussed earlier in this paper, other researchers (e.g., Bower, 1994; Geen, 1987; Larson, 1989) have found that anxiety has an inhibitory effect on performance.

I hypothesized, therefore, that the impulsivity by caffeine (arousal) interaction would be heightened if the "energetic" component of arousal could be parceled out from the anxious/displeasure components. In order to achieve a more pure measure of energetic arousal, I used Negative Affect (PANAS N), Neuroticism (EIP N), and Tense Arousal (Thayer's TA) as additional covariates (besides the EPI lie scale, daily caffeine intake, and body weight covariates that were also used in hypotheses 3 and 4). As shown in Table 3, each of these measures correlate fairly highly with each other and with caffeine, suggesting that they are likely to share variance associated with anxiety.

My final hypothesis was tested in exactly the same way as hypotheses 3 and 4, except that this time I repeated each of those two analyses (for academic and then creative performance) with the addition of the anxiety covariates. The fifth hypothesis was tested primarily on a descriptive basis, by examining whether adjusted means were different when the covariates were added to the analysis. F-test results for each scenario (for the ANCOVA with and without the anxiety covariates) are also provided for reference, but it is important to note that these are not direct tests of the *difference* in test results before and after the addition of the covariates.

The means for vocabulary and creativity test performance, adjusted for the four covariates, are presented in Table 4. For academic performance, the means are plotted in Figure 4. A comparison of this figure to Figure 2 (means plots without the anxiety and negative affect covariates) reveals that in both the caffeine and placebo conditions, low impulsives do better when their covariate-adjusted means are used, and high impulsives do worse. Based only on a visual comparison between these two plots, it is hard to detect any greater intensity in the interaction in Figure 4, but it does seem that taking anxiety out of the equation slightly improves the performance of low impulsives, but slightly hampers the performance of high impulsives.

In fact, the ANOVA results for the interaction showed a significant result for hypothesis 3, $\underline{F}(1,64) = 4.43$, $\underline{p} = .039$, $\eta^2 = .065$, and a still significant effect with a stronger effect size when the covariates were included, $\underline{F}(1,64) = 6.68$, $\underline{p} = .012$, $\eta^2 = .099$. In addition, and not surprisingly based on our earlier examination of the mean plots, the impulsivity effect achieved signficance when the covariates were added to the design, $F(1,64) = 6.31$, $p = .015$, $\eta^2 = .094$.

For creative performance, the covariate-adjusted means are presented in Table 4. Figure 5 plots these means. Again the means before (Figure 3) and after (Figure 5) they have been adjusted for the anxiety and negative affect covariates can be compared to see any increase in interaction can be detected. Looking at Figure 3, no evidence of any interaction is present, and this is consistent with the lack of interaction reported in the results for hypothesis 4. Looking at Figure 5, the two mean creativity scores for the low impulsive groups have increased, both raising and flattening the line for low impulsives. For high impulsives, the mean is lower for those who had caffeine, but about the same for

those who did not. Thus for high impulsives the line begins to switch direction, but only very slightly. Indeed, the interaction for creative performance remains non-significant, despite the addition of the covariates, $F(1,61) = .45$, $p = .50$. The effect for impulsivity was stronger than it was without the covariates (effect size with out covariates was $\eta^2 = .060$) and still significant, $F(1,61) = 6.79$, $p = .011$, $\eta^2 = .100$.

Discussion

The primary purpose of this study was to clarify the relationship between impulsivity and arousal in affecting performance. Both independent variables were tested in terms of their effects on academic and creative performance. In addition, for creativity, the dimension of reactivity was investigated to examine whether individuals who were less-reactive to arousal manipulations would score higher on measures of creativity. Broadly stated, four significant findings emerged from this study: 1) low-reactivity to the arousal manipulation appeared to positively impact creative performance; 2) impulsivity appeared to have consistent and robust effects on both academic and creative performance; 3) impulsivity and arousal interacted to affect academic, but not creative performance; and 4) the interactive effects of impulsivity and arousal on academic performance were most apparent when anxiety and negative affect were controlled for.

Reactivity and Creative Performance

Results supported the second hypothesis, that participants who were low in reactivity and low in impulsivity would be more creative than all other groups. The low reactivity effect is important because it suggests that creative individuals may be better able to subdue their responses to external arousers in order to become more responsive to the needs of the task at hand (with creative tasks often requiring low cortical arousal for optimal performance, see e.g. Martindale, 1981; Martindale & Armstrong, 1974; Martindale, Hines, Mitchell, & Covello, 1984). It is particularly interesting that the most creative individuals were not only the least reactive, but also the least impulsive. The low-impulsive, low reactive combination seems counterintuitive at first because low impulsive individuals often have higher resting levels of arousal, and yet Martindale

(1999) and Martindale and Hines (1975) have shown that creative tasks often favor low arousal for optimal performance. On the other hand, Eysenck (1967) has noted that individuals often become adept at regulating their arousal. Although Eysenck focused on behavioral differences between introverts and extraverts, similar generalizations are likely to be true of impulsivity, particularly if one agrees with Revelle et al. (1980) that impulsivity is a more accurate index of the relationship between arousal and performance. Low impulsives, for example, may be adept at downgrading their arousal, becoming proficient at entering lower states of arousal when needed. Wilson (1990) has shown that people engage in behavior that changes arousal. For example, Wilson reported that when measuring arousal via skin conductance, introverts showed higher skin conductance (indicating higher arousal) throughout the day than extraverts but that this discrepancy disappeared at midnight. In examining the behavior of each group, Wilson learned that the arousal of extraverts approached that of introverts in the evening when they engaged in arousing social activities. It could be that creative individuals were lower in reactivity than others or it could be that the low impulsive individuals were particularly likely to do well on creative tasks because they were already adept at entering the state necessary to do well on creative tasks. If the latter is the case, it might be true that high impulsive individuals perform better on a task that required high states of arousal for optimal performance because of the "practice effect" of getting themselves into the facilitative state most consistent with their temperamental leaning.

Another factor that may help explain the higher creative performance of the low-reactivity, low-impulsivity group may have to do with the biological phenomenon of augmenting versus reducing discussed by Zuckerman (1994). In the seconds following a

stimulus (e.g., a bright light or a tone), augmenters characteristically show higher cortical reactivity as evidenced by an increasing slope in cortical evoked potentials over a period of several seconds. Under the same circumstances, reducers show the opposite pattern (as evidenced by a decreasing slope in cortical evoked potentials). Zuckerman's measure of Disinhibition (Dis) from the Sensation Seeking Scale (Zuckerman, Eysenck, & Eysenck, 1978) purportedly measures "the seeking of novelty and excitement through other people, as in uninhibited parties and varied sexual experience" (Zuckerman, 1994, p. 231). In a study in which the visual evoked potentials (a measure of arousal) were taken in the seconds following a light stimulus, low and high disinhibitors differed such that high disinhibitors were augmenters, showing higher cortical evoked potentials following the stimulus, whereas low disinhibitors tended to be reducers. Low impulsives may be reducers, and this may predispose them to entering the lower states of arousal needed for creative inspiration. In fact, impulsivity has been related to augmenting of evoked potentials (Barrat, Pritchard, Faulk, & Brandt, cited in Zuckerman, 1994). Further research would be needed to see whether the reactivity dimension obtained in the present study is related to augmenting and reducing, and if so, if the present results could be replicated among groups categorized by impulsivity and augmenting/reducing.

Future research might also attempt to discover whether the effect obtained here has to do with a temperamental ability to enter the state most facilitative of creativity. It would also be interesting to see if this is true for other tasks that require different states (e.g. high arousal) for optimal performance.

Impulsivity and Academic and Creative Performance

Although the hypothesized results for impulsivity involved interactions, which were not supported, post hoc main effects for impulsivity were obtained across several analyses. As such, this dimension deserves discussion as an important factor in both academic and creative performance.

When creativity was the dependent variable and impulsivity and arousal were the independent variables, low impulsives outperformed high impulsives. In addition, when academic performance was the dependent variable and the anxiety and negative affect covariates were added to the analysis, low impulsives significantly outperformed high impulsives. From these data, it appears that low impulsives appear to have some performance advantage over high impulsives. This may be consistent with Eysenck's (1967) arousal theory when we consider that the parameters of the tasks were relatively unarousing (boring) in and of themselves. Arousal theory predicts that under relatively boring conditions, the higher arousal level of introverts should produce attentiveness, accounting for their superior performance. It is hard to say, however, how boring or under-arousing the study tasks were since there was an element of time pressure for both the creative and academic tasks. Still, on the weekend morning in Spring that they participated in the current study, low impulsives (known to have higher basal arousal) may have been able to be more attentive than high impulsives. Whether this had to do with the intrinsically arousing (or not) qualities of the tasks, or whether high and low impulsives were in systematically different states of mind on the morning they participated, however, cannot be known. Yet, it is worth pointing out that if, as Wilson (1990) found, extraverts are more likely to engage in social activities at night in order to

elevate their arousal level, and since extraverts are more likely to also be high impulsives, the high impulsives in my study may have simply been more tired on the weekend morning that they participated than were low impulsives.

On the other hand, I did not find a significant difference between the performance of low and high impulsives across all analyses. For creativity, no main effect for impulsivity was detected when the other independent variable was reactivity (rather than caffeine). For academic performance, the impulsivity main effect only emerged when the anxiety and negative affect covariates were added to the analysis. Although it is difficult to explain these inconsistencies, the differential effects when the covariates were or were not present could be consistent with arousal theory. For example, anxiety could polarize the performance of high and low impulsives such that high impulsives do better with a bit of extra anxiety and low impulsives do worse. Thus, controlling for the effects of anxiety may allow the impulsivity effects to emerge in some cases.

As mentioned above, one unusual aspect of impulsivity in relation to creativity that cannot be easily explained is that the significance of the main effect for the impulsivity dimension changed depending on which additional independent variable it was paired with in the ANOVA. For creativity, I found a post hoc main effect for impulsivity when EPI Lie scale, daily caffeine intake, and body weight were added as a covariate and when caffeine was tested as the other factor (to test hypothesis 4), but not when a covariate was not included and when the other factor was reactivity. In order to see whether this was a function of the covariate, I also ran the reactivity and impulsivity analysis with the EPI lie scale, daily caffeine intake, and body weight covariates, and again obtained no significant main effect for impulsivity. Although it is difficult to know

for sure why a main effect would emerge when impulsivity was paired with one variable (caffeine), but not another (reactivity), one speculation is that the difference is partly due to unequal sample sizes. The caffeine groups were relatively equal, differing by only 5 participants (33 participants received caffeine and 38 received placebo). The impulsivity, and reactivity variables used for these analyses were based on median spits (obtaining groups of high and low reactives or high and low impulsives). For impulsivity, there were 35 low impulsives and 36 high impulsives, making these groups essentially equal in number. For reactivity, however, group size was skewed toward the low reactives by 15 participants (43 low reactives and 28 high reactives). Garson (2001) points out that equal sample sizes help maintain the robustness of ANOVA with respect to violations of the assumptions of normality and homogeneity of variance and that for two-way ANOVA, "unequal sample sizes will confound interpretation of main effects." In this particular case, when reactivity was included as the other variable, it may have overshadowed impulsivity in accounting for variance, partly because the reactivity groups were so different in size. In addition, it is possible that reactivity and impulsivity were overlapping variables with shared variance so that impulsivity could not emerge as accounting for sufficient variance on its own when it was paired with reactivity. However, the correlation between impulsivity and reactivity was not significant, $r = .16$, $p = .18$.

Interaction Between Impulsivity and Arousal

My predictions in hypotheses 3 and 4 regarding the direction of the interaction between impulsivity and arousal—which were based on the arousal theory of Eysenck (1967) and the earlier findings of Revelle et al. (1980)—were not supported. However, I

did find interactions between impulsivity and arousal that were counter to the predicted direction. To review, I predicted that high impulsives would be helped by caffeine and low impulsives would be hindered. The opposite pattern was obtained, which was evident before the anxiety and negative affect covariates were added to the analysis. Specifically, the interaction for academic performance was significant before the covariates were added to the design, and effect size was moderate. Once the covariates were added to the design, this effect remained significant, and effect size was stronger, showing that the performance of low impulsives was helped by caffeine and the performance of high impulsives was hindered by caffeine. The interaction for creative performance was non significant both with and without the anxiety covariates added to the design.

Main effects and interactions differed somewhat based on whether the dependent variable was academic or creative performance. For example, a comparison of the results the results for hypotheses three and four (the analyses without the anxiety covariates added to the design) reveals that the caffeine main effect was non significant regardless of which dependent variable was used, the impulsivity main effect was significant when creativity but not academic performance was the dependent variable, and the interaction was significant when academic but not creative performance was the dependent variable. This might lead one to think that there is a significant difference in the effects of the independent variable depending on which dependent variable was used. This would be a false assumption, however, because running two separate tests with two separate dependent variables and obtaining different results does not allow for conclusions about differences between the two dependent variables. For this a specific test would have to be done to see if the results differ based on which independent variable is used. To test

whether there was a significant difference based on which dependent variable was used, a post hoc mixed ANCOVA was run and the dependent variables were specified as a single two-level within subjects variable called "Test Type" with RAT as one level and GRE Vocabulary as another level of Test Type. The tests for the interaction of Test Type with Impulsivity, Caffeine and the Impulsivity by Caffeine interaction revealed no significant interactions in any of the three cases. Thus, the results for creativity and academic performance in the case where no anxiety covariates are added to the analysis cannot be seen as significantly different.

At least two questions are suggested by the obtained counter-to-prediction interaction. First, what can be made of the fact that my result does not support the ability of Eysenck's (1967) arousal theory or the Yerkes-Dodson law to account for the relationship between personality, arousal and performance? Second, if the theory upon which my prediction was based cannot account for my results, what can?

The first question was explored fairly extensively by Matthews (1985), who undertook to test the utility of Eysenck's (1967) arousal theory and the Yerkes-Dodson law in accounting for the effects of extraversion and arousal on performance. Matthews found a three-way interaction between arousal, time of day, and extraversion on performance. The pattern he obtained was conceptually consistent with the earlier findings of Revelle et al. (1980), in that in the morning extraverts performed better when aroused and introverts performed worse and these results reversed in the evening. Revelle et al. explained their results in terms of a phase difference in arousal rhythm, such that low impulsives are only higher in arousal in the morning, but are less aroused in the evening. However, even though Matthews' results were consistent with Revelle's, he

does not think that arousal theory, even with the modification suggested by Revelle, can account for his findings. This is for two reasons. First, Matthews measured the relationship between arousal and performance, and found no direct relationship. This contradicts the Yerkes-Dodson law, which states that arousal is curvilinearly related to performance by an inverted-U function of task difficulty. Second, Matthews contends that the three-way interaction itself fails to support the Yerkes-Dodson law because it suggests that the relationship between arousal and performance cannot be characterized by a single curve. According to Matthews' (1985) conclusions, one thing that can be made of the failure of arousal theory to account for my results is that arousal theory may not be the ideal method for describing the relationship between extraversion (or impulsivity), arousal, and performance. In fact, Matthews suggests that introverts and extraverts (or high and low impulsives) may actually respond differently under the same level of arousal and that this may be the key to understanding the interactive effects of extraversion and arousal. Thus, Matthews suggests that further research on different dimensions of performance should be carried out within groups of introverts and extraverts.

The second question posed by the interaction I obtained is how, in the absence of a direct fit with arousal theory, can I explain the fact that low impulsives who had caffeine performed better than high impulsives who had caffeine? One possibility is that caffeine had a different effect on low vs. high impulsives. For example, Tecce and Cole (1974) found that amphetamine induced drowsiness in some individuals. Perhaps caffeine did not actually arouse the low impulsives as much as it did the high impulsives. I tested this using a one-way ANOVA and there was no detectable difference in self-reported

arousal between low and high impulsives who had caffeine, F (1,31) = .081, p = .78. Another possible explanation is that although caffeine does not differ it its ability to induce arousal among high and low impulsives, it has a qualitatively different effect on the performance of low impulsives. For example, maybe caffeine focuses low impulsives toward the task at hand, but scatters high impulsives. This possibility is pure conjecture at this point, but could be tested by adding measures aimed at assessing the qualitative effects of caffeine to the design. Another possibility is that the diurnal differences in arousal found by Blake (1971) between introverts and extraverts and generalized by Revelle et al. to explain the differences they found between high and low impulsives, may occur as early as 10:00 in the moring, the approximate time that my participants completed their performance tasks. My data are consistent with the evening, but not the morning, findings of Revelle et al. (1980), and Matthews (1985). It could be that there was some difference in the stage of the diurnal arousal rhythym that my participants were in. This seems unlikely, given that my participants were tested an hour after the Revelle et al. (1980) participants and two hours before the Matthews (1985) participants. Another possibility is that the significant main effect for impulsivity, which favored low impulsives for both academic and creative performance (with the addition of the anxiety and negative affect covariates), was exacerbated by caffeine. In other words, the poor performance of high impulsives and the good performance on low impulsives may have been enhanced by caffeine. This is consistent with the finding that high and low impulsives tend to employ different strategies on academic performance tasks. High impulsives tend to favor speed and low impulsives tend to favor accuracy (Revelle, 1988). Perhaps caffeine serves to enhance each tendency, causing more comission errors

for high impulsives and allowing low impulsives to attend more methodically to the task at hand. Although it may be possible to find post hoc explanations for these findings, it is more difficult to explain why my findings differ from most studies that have tested the impulsivity (or extraversion), arousal, and time of day effects on performance.

Effects of Anxiety and Negative Affect Covariates

My final prediction, which was supported by the data, was that adding covariates representing anxiety and negative affect to my design would strengthen, at least descriptively, any interactions obtained during the analyses for hypotheses 3 and 4. This prediction was borrowed from the notion that arousal is not a unitary construct but combines components of energetic and tense arousal as proposed by Thayer (1978). The covariates were added to the design because I thought it was likely that the most helpful form of arousal would be energetic arousal. Thus, in cases where caffeine was expected to enhance performance, I wanted to control for its tendency to also induce anxiety, in the hopes of obtaining a purer measure of performance-enhacing arousal.

As discussed in the results section, a comparison of the means plots for academic performance with (Figure 4) and without (Figure 2) the covariate adjustments, reveals that the means for the caffeine condition became more extreme when the means were adjusted for the covariates. The group that performed best in the caffeine condition (low impulsives), performed even better when the covariate-adjusted mean was used; and the group that performed worst with caffeine (high impulsives) performed worse still when their covariate-adjusted mean was used. For the placebo condition, the group that had performed best (high impulsives) performing worse based on covariate-adjusted means; and the group that had performed worst (low impulsives) performing better. The resulting

interaction turned out to be significant, and the impulsivity main effect got stronger when the additional covariates were added.

What is interesting about this finding is that anxiety/negative affect seems to affect high and low impulsives differently. When anxiety/negative affect is removed from the equation, the adjusted academic performance means for low impulsives become larger and the adjusted means for high impulsives become smaller. Consistent with Gray's (1987) theory that extraverts are more sensitive to cues for reward and introverts are more sensitive to cues for punishment, this may suggest that anxiety had a facilitative effect for high impulsives, but an inhibitory effect for low impulsives. Assuming that impulsivity generalizes to introversion and extraversion, high impulsives would be, presumably, more sensitive to cues for reward and low impulsives would be, presumably, more sensitive to cues for punishment. If low impulsives are more sensitive to cues for punishment, they may also be more susceptible to trait anxiety. Indeed, present data indicate fairly strong correlations between impulsivity, neuroticism, and negative affect (see Table 5). Thus, removing the effects of anxiety could help low impulsives. There may also be a facilitative effect for mild anxiety for high impulsives (possibly enhancing arousal and facilitating focused attention).

As mentioned in the previous section, obtaining different results for different dependent variables does not allow us to conclude that there is a difference in the function of the independent variables depending on which dependent variables they are paired with. For the analyses that were done with the covariates, a post hoc mixed ANCOVA was again run to see whether there were significant differences in the obtained results for the impulsivity and caffeine main effects or their interaction. Again, no

differences could be attributed to the interaction of either main effect or the interaction with the within subjects factor of Test Type—all three interactions were non significant.

Other Methodological Issues

There are a few methodological issues that may have affected the results of the present study. Possible areas for methodological improvement include: the choice of dependent measures or their brevity, controlling for systematic population differences in arousal inherent to college students (e.g. sleep deprivation), the time of day for testing, and the choice of arousal manipulation.

The dependent measures used for the present study were six vocabulary items from a practice test of the GRE (academic performance) and five items from the RAT (creative performance). In both cases, a more reliable and valid estimate of the dependent variable might have been obtained had more items been used from each measure. For creativity, it may have been possible to find a purer measure of originality. For example, Wallach (1971) has pointed out that the RAT correlates between .30 to .40 with intelligence tests. The Guilford Consequences Test may be a better measure of originality because it allows respondents to come up with open-ended responses that are rated for originality by experienced raters. The limitation of the Guilford Consequences is that it is very cumbersome to score. In fact, data for the Guildford Consequences were collected and scored along with the present study. However, completing the process of comparing the ratings of three independent raters, and re-examining discrepancies, proved too time-consuming to justify including the Guildford along with, or instead of, the RAT as a creativity measure in the present design.

A population issue associated with using college students in a study of arousal may include sleep deprivation. The present study was conducted near the end of the semester when undergraduates at The College of William & Mary may have been sleeping relatively few hours in order to meet course deadlines and study for final exams. It is also possible that sleep deprivation may affect different personality types differently. For example, if the basal arousal levels of high and low impulsives already differ, then the manner in which sleep deprivation affects each group, might also differ, adding an extra element of variability to the results. Looking at the body of research that was reviewed for this study and in which college students were the participants, none reported or analyzed time in semester. One of the studies reported in Revelle et. al. (1980) did report and analyze time in year (by recording which of the four quarters during the year the participants took part in the study). However, this is not relevant to the present speculation because it is not clear at what part of the quarter (or semester) the study was conducted.

If it is true that high and low impulsives differ significantly in the phase difference of their diurnal arousal rhythm, then the time of testing would be an important factor in isolating these differences. For example, Eysenck and Folkard (1980) suggested that a morning testing time of 8:00 a.m. would be the most likely time in which a time of day effect could be expected, if in fact such a difference exists. Although the present study began at 9:00 a.m, participants took their caffeine or placebo at about 9:30 and completed their dependent variable tasks at about 10:00 a.m., which may not have been an extreme enough morning time in which to detect differences between high and low impulsives.

In terms of the arousal manipulation, one potential issue should be noted. Participants who received caffeine all received the same 400 milligram dose of caffeine citrate (200 milligrams of active caffeine). Providing doses specific to participant body weight, although much more complex methodologically, may have provided better results in terms of accurately manipulating arousal. Because body weight was obtained for each participant during mass testing, it was possible to obtain a ratio of caffeine to body weight in pounds for my sample. The dosage level ranged from 1.96 to 4.00 milligrams of active caffeine per kilogram of body weight. In one of the studies reported in Revelle et al. (1980), caffeine was administered according to body weight and a moderate and a high dosage of caffeine were used. The moderate dosage was 2 milligrams per kilogram body weight and the high dosage was 4 milligrams per kilogram. By this measure, some of the participants in the present study who received caffeine received a moderate dose and some received a high dose. In the study cited above, Gilliland (1977, reported in Revelle et al., 1980) found that the performance on introverts became better at moderate doses when compared to placebo, but began to decline at the higher dose. Thus, the variability of caffeine dose to body weight may have affected my results, obscuring systematic differences in arousal effects between high and low impulsives.

Practical Implications

Although the nature of the relationship is not completely clear, there is significant empirical support for the notion that arousal and performance are related. Understanding the variables that affect performance is important because performance—both academic and creative—can affect life outcomes. At the extremes, children who perform poorly in school are often deprived of educational and career opportunities that can make a

difference to their financial, social, and psychological well-being. Clearly, performing as well as possible in any given situation is the most desirable outcome. In the context of the present study, the most influenceable variable is arousal. Although empirical absolutes about what type of people (e.g. high impulsives vs. low impulsives) perform best at what level of arousal are hard to come by, that there is a relationship appears very likely.

Toward the goal of helping individuals perform their best academically and creatively, it is important that behavioral and social scientists continue to probe the question of how personality, performance and arousal are related. For example, further studies should be done using different indices of arousal and different levels of caffeine or other arousal manipulations. Continued efforts to determine associations between arousal, performance, and personality variables—those investigated here as well as others—are also crucial to moving closer to a more reliable and consistent model of the arousal-performance relationship.

At the practical level, parents and educators can pay attention to children's or students' individual temperaments in order to understand the child's own arousal rhythms and how they affect his or her performance. Some children may be better able to concentrate on their homework early in the morning rather than late at night. Some may do better after physical exercise, or when frequent short breaks are taken between study sessions. In addition, a better understanding of an individual's arousal and performance relationship can have implications for class scheduling. In addition to enhancing performance as much as possible it is important to take into account individual propensities toward different types of performance and allow for variety—not every person is good at everything, but most are good at some things. More creative children

can be encouraged to develop their creativity so that they can benefit from their flatter associative hierarchy.

Additional Directions for Future Research

Because arousal is so biologically complex, more physiologically based studies are needed to understand the physiological and even biochemical underpinnings of arousal. For example, the kind of arousal produced by caffeine—and the associated performance outcomes and interactions that go with it—seem likely to differ from the outcomes associated with other chemically different drugs or arousal manipulations. Animal research and other forms of biological, biochemical, and neurological research are therefore important to understanding arousal more fully.

Moreover, studies like the one conducted here, and by Revelle and colleagues, should be replicated to better detect patterns of consistency or inconsistency that may form the basis of solid theoretical assumptions. Once assumptions can be made on firmer ground, then researchers can more confidently extend the work to add additional variables or manipulations. In this manner, the research community can evolve toward a more precise model of the personality-arousal-performance relationship.

Concluding Remarks

The most obvious limitation of the present research—and conceivably one of its strengths—is its breadth and ambitiousness. The bodies of research and theory that supports current understandings of personality and performance are extensive and undeniably complex. Previous findings and the theories on which they are based are by no means parsimonious, making this an important but often difficult area of inquiry. Arousal itself is difficult to pin down. Different arousal measures often obtain different

levels of arousal within the same individual. In addition, self-report measures of arousal often correlate with physiological measures to a greater degree than the physiological measures correlate with each other, indicating the possibility of multiple arousal systems (see e.g. Eysenck, 1985; Geen, 1995; and Matthews, 1985 for relevant discussions). In addition, major theoretical disagreements (e.g. between Revelle et al., 1980 and Eysenck & Folkard, 1980) make it difficult to choose candidate theories on which to either base research or upon which to base the explanation for obtained results. Nonetheless, the lures for investigating performance in terms of personality and arousal are many, including but not limited to: the intuitive appeal of individual differences in performance based upon personality, the ability to directly manipulate arousal, the variety of performance categories available for study, and the multidisciplinary nature of a topic that spans biological, personality, and cognitive research specialties.

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Table 1

Intercorrelations Between Impulsivity, Academic Performance, and Creative Performance

	Measure	1	2	3
			(N = 71)	
1.	Impulsivity	--	-.03	-.18
2.	GRE Vocabulary		--	.14
3.	RAT Creativity			--

Table 2

Mean Performance Scores as a Function of Impulsivity and Caffeine, Adjusted for EPI Lie Scale, Daily Caffeine Intake, and Body Weight Covariates

Group	n	m
	vocabulary test	
Caffeine		
Low impulsivity	17	5.67
High impulsivity	16	4.84
Placebo		
Low impulsivity	18	5.05
High impulsivity	20	5.26
	creativity test	
Caffeine		
Low impulsivity	17	4.22
High impulsivity	16	3.53
Placebo		
Low impulsivity	18	3.79
High impulsivity	20	3.29

Table 3

Intercorrelations Between Negative Affect, Neuroticism, Tense Arousal and Caffeine

	Measure	1	2	3	4
			(N = 71)		
1.	Negative Affect	--	.50**	.21	.10
2.	Neuroticism		--	.25*	.20
3.	Tense Arousal			--	.34**
4.	Caffeine				--

* p < .05. ** p < .01

Table 4

Mean Performance Scores for Academic and Creative Performance Grouped by Impulsivity and Caffeine Intake and Adjusted for Six Covariates

Group	n	m
	vocabulary test	
Caffeine		
Low impulsivity	17	5.84
High impulsivity	16	4.53
Placebo		
Low impulsivity	18	5.25
High impulsivity	20	5.19
	creativity test	
Caffeine		
Low impulsivity	17	4.30
High impulsivity	16	3.21
Placebo		
Low impulsivity	18	3.98
High impulsivity	20	3.30

Note. Mean values represent vocabulary and creativity test scores for each group adjusted for the addition of four covariates: EPI Lie Scale, Daily Caffeine Intake, Body Weight, PANAS N, EPI Neuroticism, and AD ACL.

Table 5

Intercorrelations Between Negative Affect, Neuroticism, Tense Arousal and Impulsivity

	Measure	1	2	3	4
			(N = 71)		
1.	Negative Affect	--	.50**	.21	-.41**
2.	Neuroticism		--	.25*	-.21
3.	Tense Arousal			--	.14
4.	Impulsivity				--

* p < .05. ** p < .01

Figure Captions

Figure 1. Mean RAT creativity scores grouped by impulsivity and reactivity.

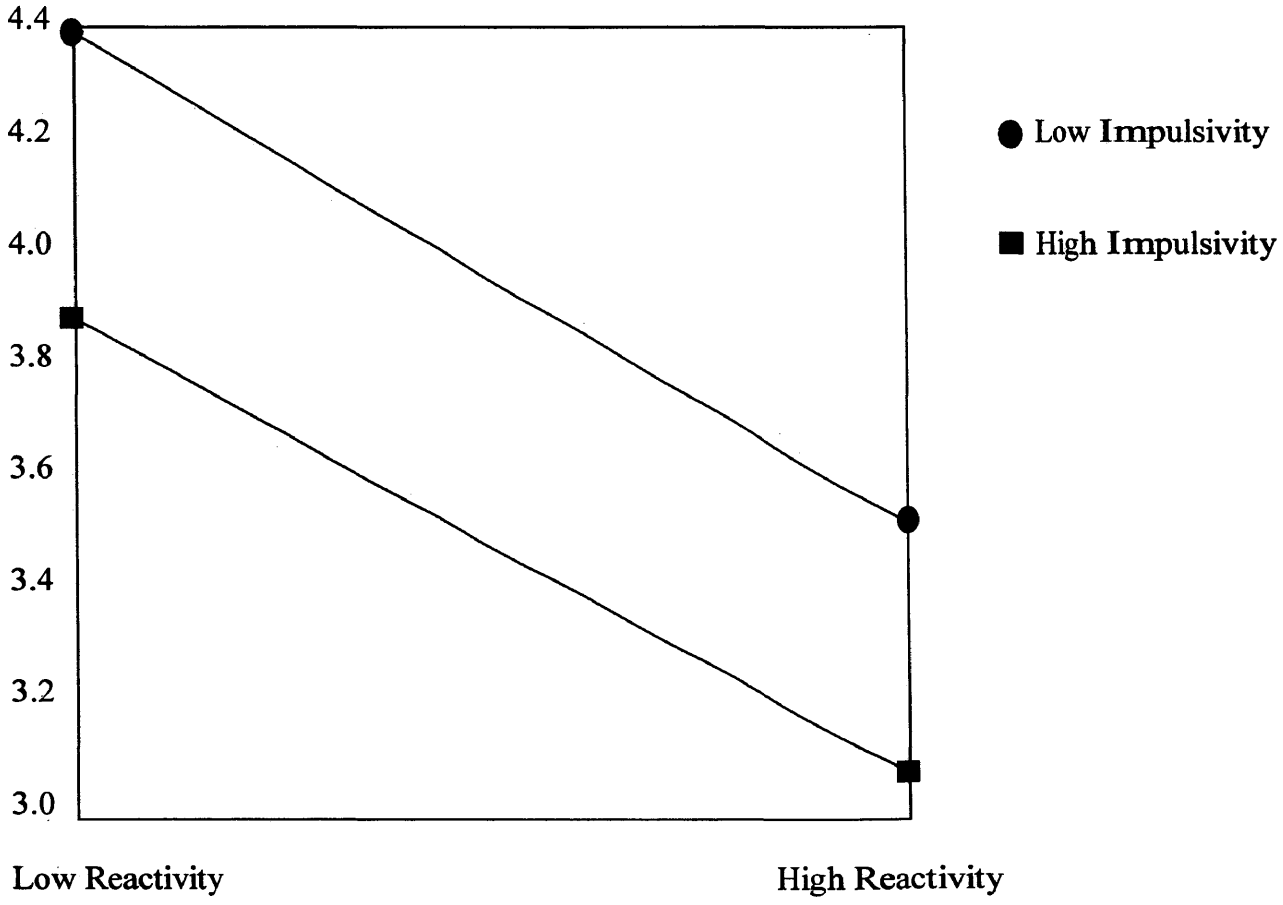
Figure 2. Mean GRE vocabulary scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, and body weight covariates.

Figure 3. Mean RAT creativity scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, and body weight covariates.

Figure 4. Mean GRE vocabulary scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, body weight, PANAS N, EPI Neuroticism, and AD ACL covariates.

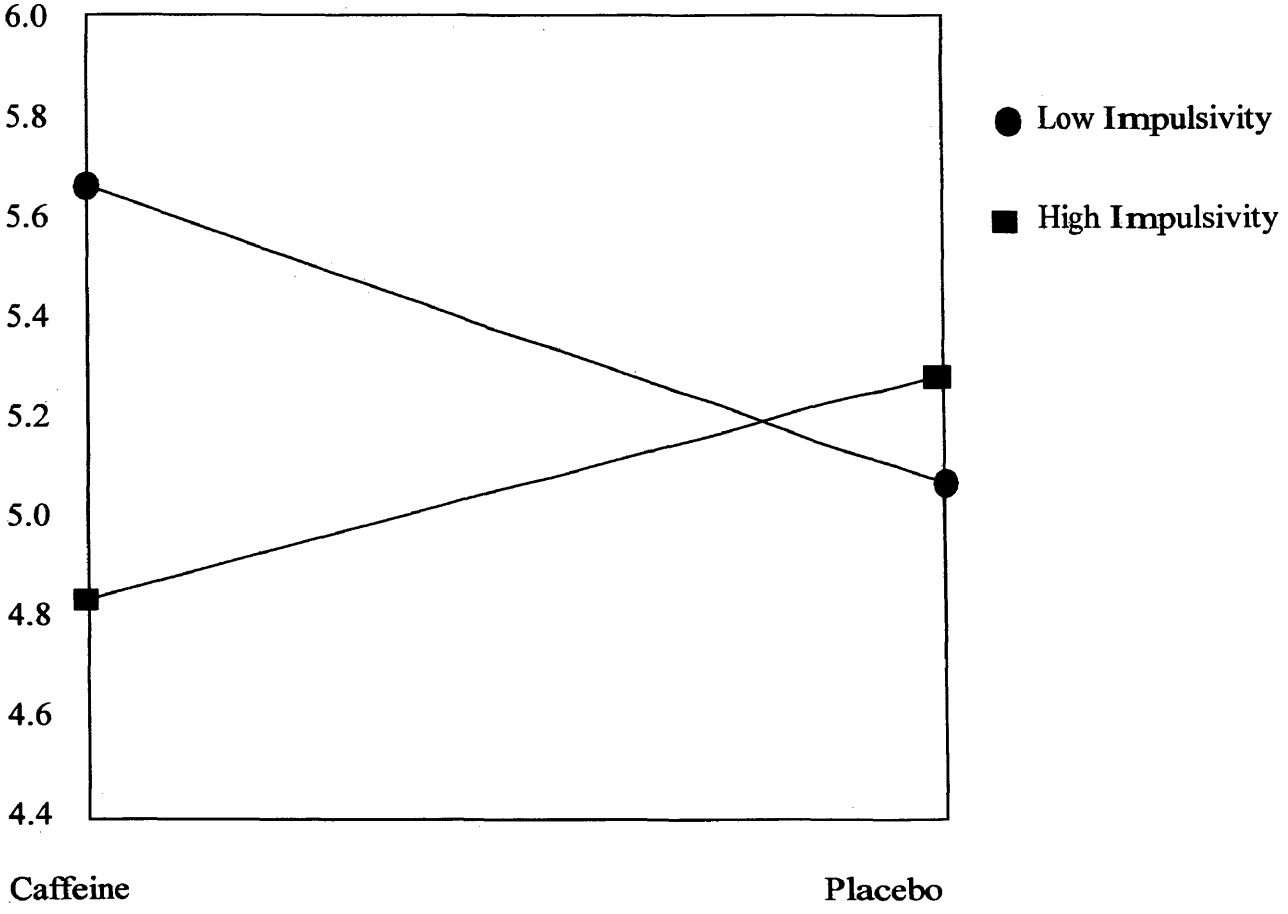
Figure 5. Mean RAT creativity scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, body weight, PANAS N, EPI Neuroticism, and AD ACL covariates.

Figure 1



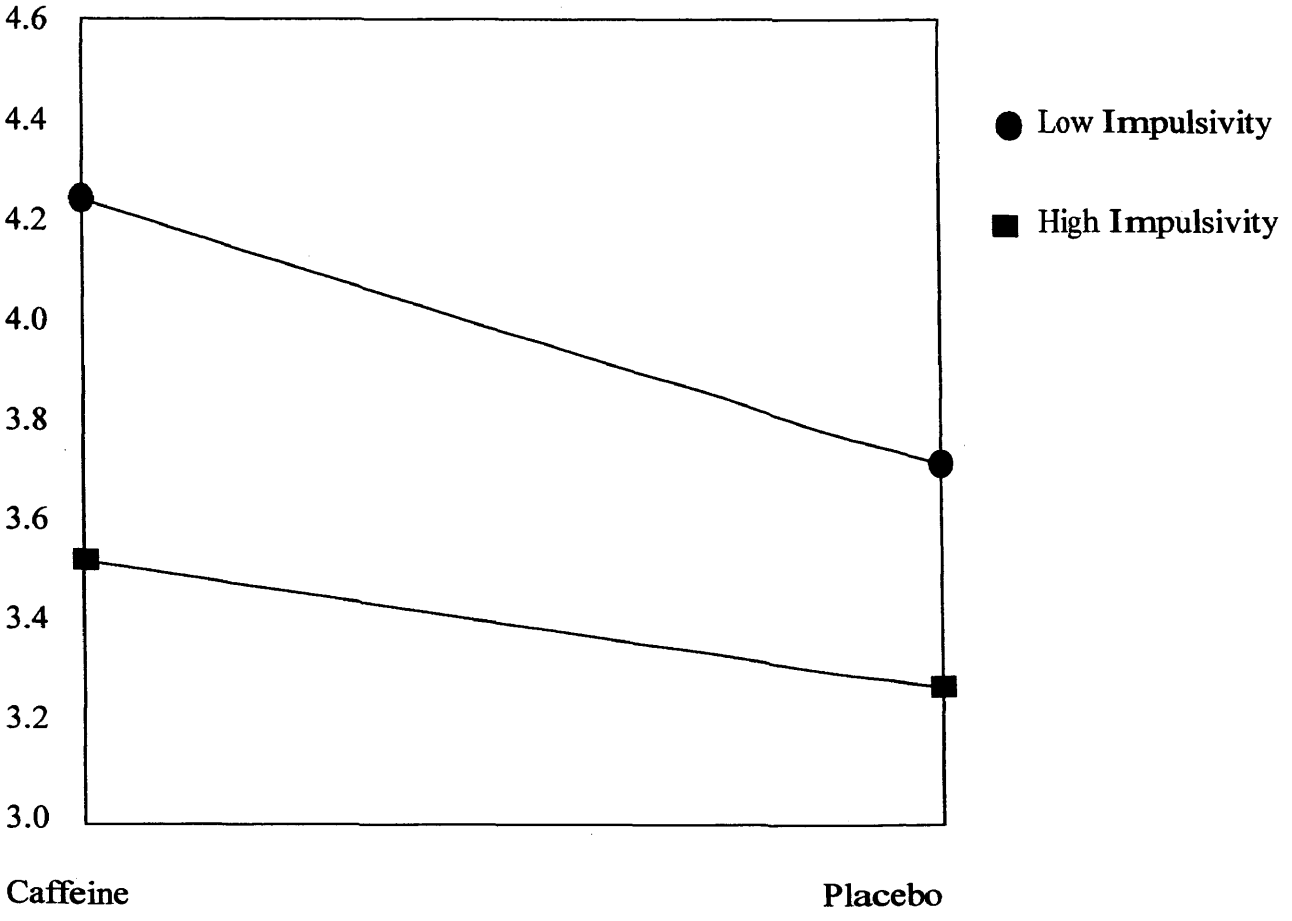
Mean RAT creativity scores grouped by impulsivity and reactivity

Figure 2



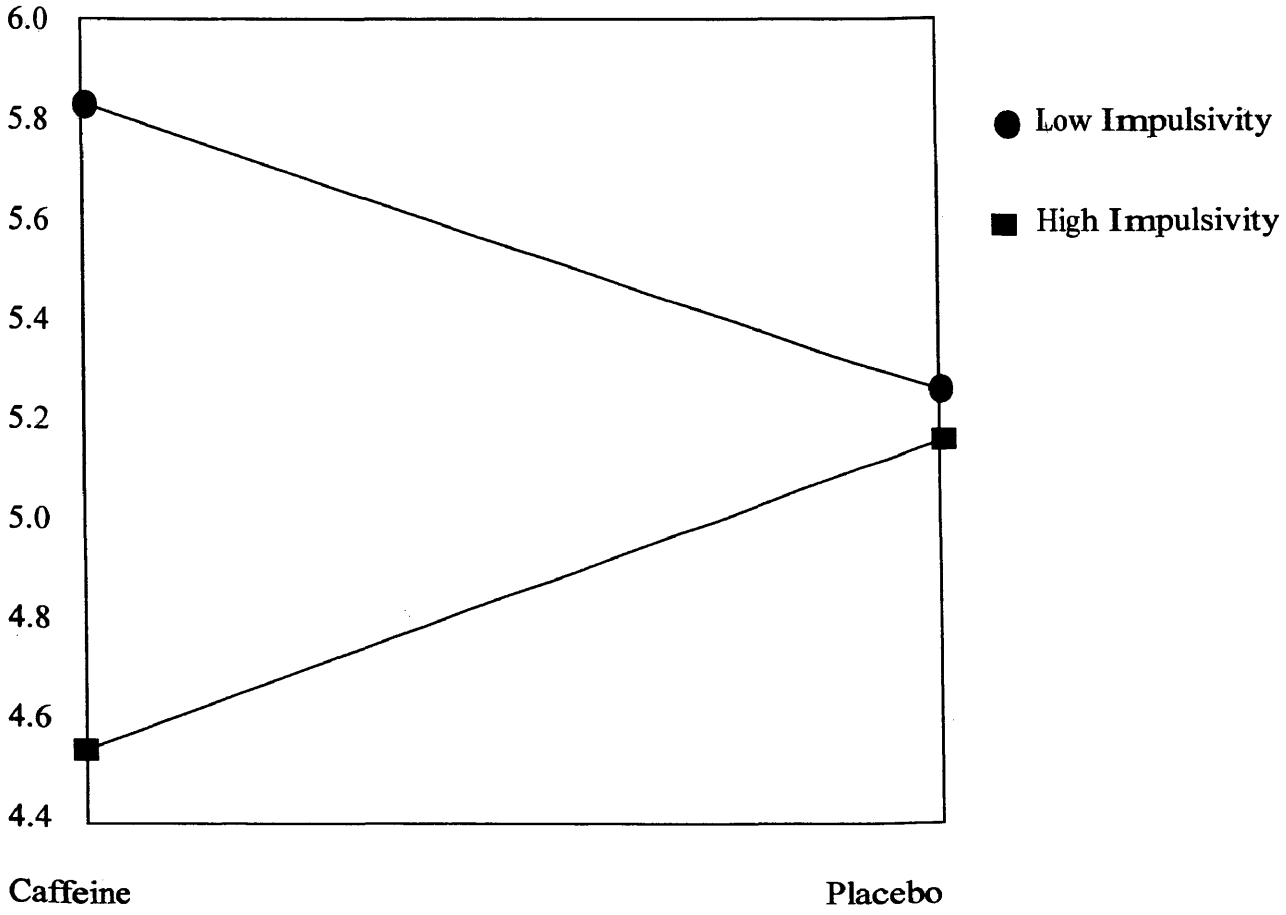
Mean GRE vocabulary scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, and body weight covariates

Figure 3



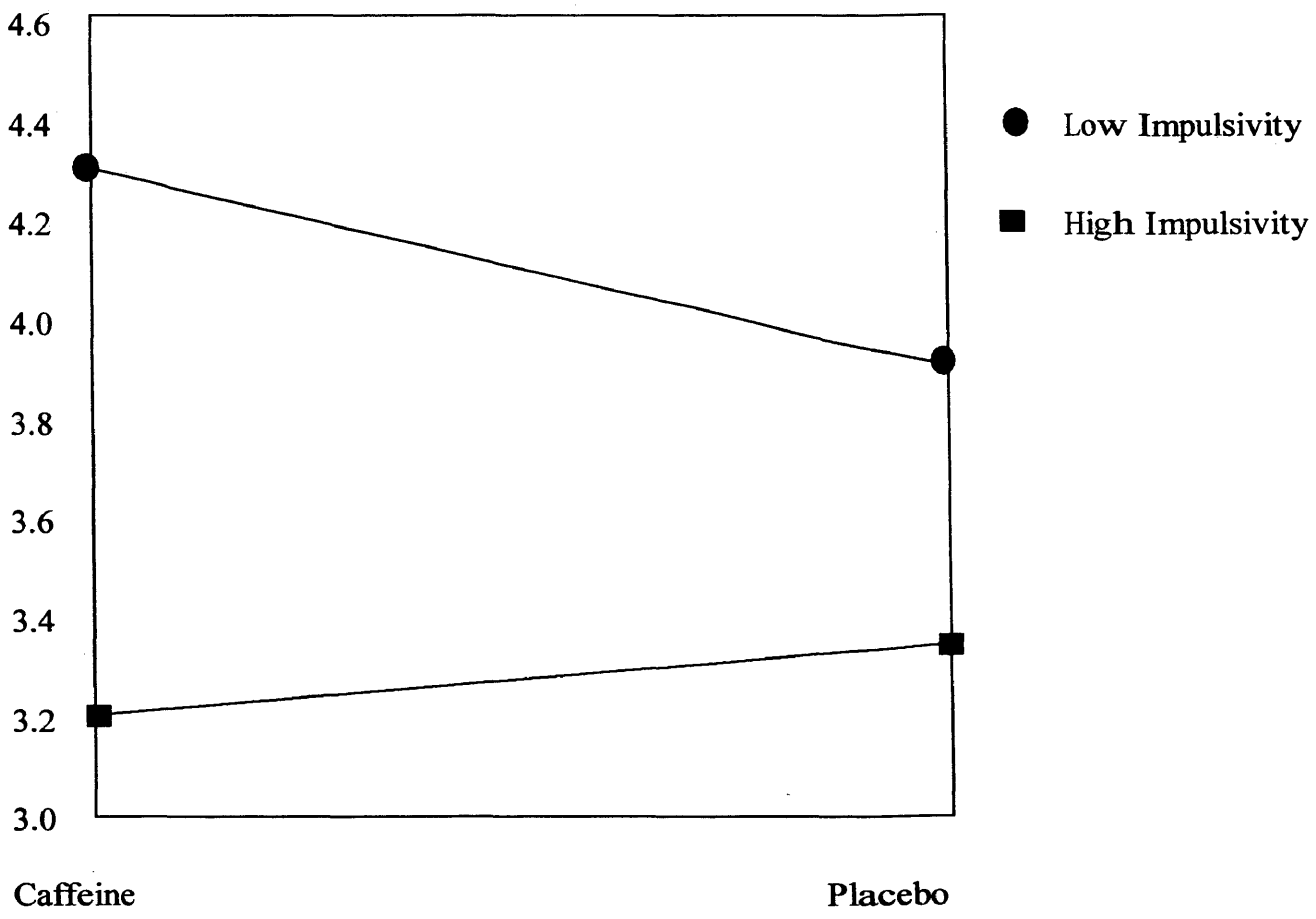
Mean RAT creativity scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, and body weight covariates

Figure 4



Mean GRE vocabulary scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, body weight, PANAS N, EPI Neuroticism, and AD ACL covariates

Figure 5



Mean RAT creativity scores grouped by impulsivity and caffeine intake, adjusted for EPI lie scale, daily caffeine intake, body weight, PANAS N, EPI Neuroticism, and AD ACL covariates

Appendix A

Posted Information for Participant Review Before Sign-Up

Important!!! You must read ALL of this information before signing up for this study. Next to your name on the sign-up sheet, please provide your initials if you have read, understood, and certify that you meet all of the below requirements.

This experiment will involve randomly assigning half of the participants to receive a caffeinated beverage and half of the participants to receive a placebo. ***To participate in this experiment you must be willing to be assigned to the caffeine condition, should you be so assigned.***

Side-effects have been reported by caffeine users. These side effects include:

- dizziness
- fast heart beat
- irritability
- nervousness
- nausea
- vomiting
- diarrhea
- tremors
- trouble sleeping

3) The following medications may have negative interactions with caffeine. If you are currently using any of these medications or drugs, please do not participate in this study.

- Stimulants or amphetamines, such as Ritalin, Cylert, Adderal, Dexedrine, or Desoxyn
- Appetite suppressants (diet pills) of any kind
- Medications that contain caffeine
- Cocaine
- Nabilone (e.g., Cesamet)
- Asthma, hayfeaver, allergy, or cold-medication, including nose drops or sprays
- Amantadine (e.g., Symmetrel)
- Chlophedianol (e.g., Ulone)
- Monoamine oxidase (or, MAO) inhibitors such as the antidepressants Furoxone, Marplan, Nardil, Matulane, Eldepryl, or Parnate.

4) Certain medical conditions may interact negatively with caffeine. ***If you have***

any of these conditions you should not participate in this study:

- allergic reactions to caffeine or caffeine containing products such as soda, tea, coffee, chocolate, or aspirin
- anxiety requiring medical attention
- agoraphobia
- heart disease
- high blood pressure
- panic attacks
- insomnia
- liver disease
- If you are pregnant or nursing a baby, you should not participate.

Participation in this study requires that you are:

a) willing to participate given that there is a 50% chance you will be assigned to the caffeine condition, but will be "blind" as to which condition you are in, and are
b) willing and able to avoid caffeine or any other psychoactive drug for at least 6 hours before the experimental session.

By signing-up for this experiment and providing your initials on the sign-up sheet, you certify that you meet al.l of the aforementioned criteria for participation in this study. You further certify that you are aware of the side-effects of caffeine, that you are not taking any contraindicated medications or drugs, and that you do not have any contraindicated medical conditions.

Appendix B

Verbatim Script

Telephone Scheduling

Hello, may I speak to [prospective participant's name]? . . . . Hi, [prospective participant's name], my name is Sara Chambers/Christine Sylvest/Erin Williams and I am calling to confirm your participant in the personality and performance study scheduled for [date and time] at [location]. Do you have a couple of mintutes to go over a few aspects of the study?

[If not, arrange a convenient time to call back].

Great. First, I just need to be sure that you are still planning on participating in the study. Are you still planning to participate?

[If not, politely end the call].

Okay, and did you read all of the information about the study that was posted on the board?

[if yes, see below; if no, see phone script Addendum, below]

So you read about the side effects of caffeine, and the health and medication contraindications?

[if yes, see below; if no, see phone script Addendum, below]

Great, and based on that information, you are qualified to participate, right?

[if yes, see below; if no, see phone script Addendum, below]

Okay, great. That's really all I called to confirm. Are you clear on where the study is?

[if yes, end call, if no explain location of study].

Phone Script Addendum (if student answers "no" to any of prompts)

If student answers "no" to any of the above prompts, the interviewer will review with them the relevant portion of information from the posted information [see Appendix A]. If necessary, all of this information will be reviewed with the student and the student will be informed of the potential side-effects of caffeine and screened for all contraindicated consitions.

Experimental Session

Hi, my name is Sara Chambers. Let me also introduce you to Christine and Erin, who will be assisting me today. Thank you for choosing to participate in my study. Let me fill you in on a couple of details before we begin. First, in general terms, this study is about how personality and performance interact. I will tell you more about the study and its purpose when we conclude.

After we do consent forms, which we'll pass out in a minute, I will be giving you a few different personality questionnaires. After you do the questionnaires, we'll transition into doing a series of paper-based tasks, which we'll complete as a group. In other words, everyone will do one task for a certain amount of time, and then everyone will switch to the next task, and so on.

As you know from talking to either me or Christine or Erin on the phone, this study also involves your receiving a beverage that either does or does not contain caffeine. Let me describe how that will work. It is important to the results of my study that they not be biased in any way. Therefore, this will be a double blind study. Most of you probably know what that is, but for those who don't, let me explain it. Double blind just means that neither the experimenter, nor the participants know who is getting the treatment (in this

case caffeine) and who is not. We've worked it out so that half of the cups in front of you [if using law school class room, if not, "the cups in front of me, which we will pass out shortly"] contain caffeine and half do not. It is very important that you do not drink your orange beverage until we tell you to do so. If you are thirsty, there are extra cups and water pitchers available for you.

Okay, back to the double-blind procedure. Whether your orange beverage does or does not contain caffeine is indicated by the color of cup you have. Notice that there are red cups and blue cups. As a group, we will not find out which cup color means caffeine and which means no caffeine until the end of the study. I have had a person besides myself, Erin, and Christine fill up these cups. That person has written down which color of cup contains caffeine and which does not on a piece of paper inside of this envelope.

[hold up envelope]

At the end of the study, after all the questionnaires and tasks are completed, I will open up this envelope and tell you who got caffeine and who didn't.

Are there any questions so far?

After the big moment of truth, I will explain more fully what the study was about.

[If session #1: "Before I do that, I am going to ask Christine and Erin to leave the room so that their knowledge of my hypotheses does bias their interactions with the next group of participants in any way"].

After I give you this verbal debriefing, you will be given an opportunity to ask questions, and I'll tell you how you can obtain a summary of the group's results if you wish. After that, you will be free to leave. As you exit we will be handing out a written explanation of

what the study is about for your records. That sheet will also contain contact information for me in case you have further questions, or want to request results.

Finally, here is the legal copy. I need to let you know that your participation in my study is voluntary and that you may terminate your participation at any time. Further, and this is very important, on the consent form that we are about to pass out, we ask some information about your current health. As we mentioned on the phone, caffeine should not be used by people who have any of the following conditions:

- allergic reactions to caffeine or caffeine containing products such as soda, tea, coffee, chocolate, or aspirin
- anxiety requiring medical attention
- agoraphobia
- heart disease
- high blood pressure
- panic attacks
- insomnia
- liver disease

[for women only:]

- Are you pregnant or nursing a baby?

It is very important that if you have any of these conditions you indicate that on the consent form. If this applies to you, you need to come up here and talk with us briefly before the experiment begins.

In addition, there are several medications that can have adverse interactions with caffeine. These medications are listed on your consent form. They include medications or drugs

such as: stimulants or amphetamines, such as Ritalin, Cylert, Adderal, Dexedrine, or Desoxyn, appetite suppressants of any kind, Cocaine, asthma, hayfeaver, allergy, or cold-medication, and Monoamine oxidase (or, MAO) inhibitors such as the antidepressants Furoxone, Marplan, Nardil, Matulane, Eldepryl, or Parnatel. Please read the complete list on your consent form to be sure that you are not currently taking any medications that might be adversely affected by caffeine. Again, if any of these apply to you, you need to talk with us before you participate. [Note: The consent forms will be reviewed prior to the study in order to screen for any health issues contraindicated for caffeine, and/or for the current use of any contraindicated medications. Any participant who indicates such a condition and/or the use of a relevant medication or drug will be asked to come to the front of the room. That person will be given a choice to either: 1) continue to participate although their results will not be analyzed and they will not be given the treatment beverage, 2) to leave. In the event that they choose to leave, they will be informed that they will still receive two hours of credit for showing up. They will also be given a debriefing sheet and will be asked not to share its contents with anyone else who might participate.]

Finally, before we pass out the consent forms, I need to let you know that if you are dissatisfied with any aspect of this study, you can report your dissatisfaction to the Psychology Department Chair, Dr. Robert Johnston. His phone number is on the consent form.

[Does anyone have any questions before we pass out the consent forms?]

Okay, so that is the basic run-down. Christine and Erin are going to pass out consent forms now. Again, please do not drink your orange beverages until we collect your consent forms and indicate that you can drink them.

[Cue Christine and Erin to pass out forms. They do so.]

When you have completed your consent forms, please pass them toward the aisles and wait for further instructions.

[When all the consent forms have been collected and reviewed, continue.]

Okay, thanks for filling those out. Please wait a few moments while we review your consent forms to make sure they are complete before we go further. [Review consent forms. If any one did not sign the consent form and/or indicated on consent forms that they have a health condition that is contraindicated for caffeine intake, ask them to come up to the front of the room at this time.]

Okay, now a word about the orange beverage in front of you. This drink is not meant to be yummy. We have added quinine water (also known as tonic water) to the mixture because it has a bitter taste that masks the caffeine. Everyone's drink is going to be a little bitter. Other than this bitter taste, you should just taste an orange drink flavor.

Are there any questions at this point?

Okay, then go ahead and drink your beverage. Please drink all of the contents of your cup. Again, there is water if you'd like some after you have your orange drink. When everyone is finished with their drinks, we'll collect the colored cups and pass out the personality questionnaires.

[When everyone is done with their caffeine/placebo drinks, set a timer for 25 minutes. Then collect the colored cups, and clean up any spills on the tables. Next, distribute packet of 2 personality questionnaires.]

Okay, everyone should have a packet of 2 personality questionnaires in front of you. Please complete the questionnaires in order. You will have 25 minutes to complete them. If you finish in advance, please just wait until 25 minutes are up. Please be sure to mark every item. If you are unsure of which item to choose, just make your best guess. After 25 minutes, we'll pass out 2 more questionnaire, which you can add to your stack. You'll have about 10 minutes to complete those questionnaires. Then, we'll make sure everyone has finished everything and we will collect all the forms together.

Are there any questions?

[After 25 minutes . . .]

Okay, we are going to pass out the last 2 questionnaire now. They should take you about 10 minutes to complete. After 10 minutes we'll make sure everyone is done with all 4 questionnaires and then we'll collect everyone's pile. Because one of these 2 questionnaires contains questions about your consumption of caffeine and certain other drugs, this questionnaire may seem redundant with some of the information on your consent forms. This questionnaire has a different purpose, however. Instead of screening for contraindicated medical conditions or medications in the interest of your safety, this questionnaire will help us be sure that nobody's results are biased by any kind of other medication or drug. So this questionnaire is more for methodological purposes, whereas the one on the consent form was for your own safety.

[Hand out last 2 questionnaires including: 1) The Activation and Deactivation Check List (Appendix C), and 2) the Caffeine and other Drugs Questionnaire (Appendix E) questionnaire]

[After 10 minutes . . .]

Is everyone finished?

[When everyone is finished, collect all 4 questionnaires]

Okay, during the next phase of the study, we are going to complete some tasks as a group. All of the tasks are paper-based tasks that you will complete at your desks. The tasks will be given to you in the order that we will complete them, but it is very important that you not read ahead in your packet. That is why at the bottom of each page it says, "Stop here. Wait for further instructions." Each page of tasks will be timed such that everyone has the same amount of time to complete each page. When the time is nearly up on the multiple choice items, we will indicate that there is one minute left, and you must fill in any items you have not yet filled in on your Scantrons during that time. Please do not leave any items blank, guessing if and when you need to. When we say, "time is up, please turn to the next page and then turn your packet face down," please do so. We will then give you instructions for the next page of items verbally. The same instructions are at the top of each page. When we have read the instructions to you, we will say, "you may turn your packet over and begin the next page," at which point you may begin. Be sure to follow all instructions and to mark an answer for all items.

Okay, we are going to pass out the packets now, when you receive your packet and Scantron, please place your packet face down on your desk, and begin filling in your Scantron. As before the information we need on your Scantron is the Key ID number,

which in this case will be _____, your participant ID number, and today's date, which is _____. Please be sure to also include your participant ID number on each questionnaire itself.

Are there any questions before we pass out the task packets?

[Pass out the task packets. Packets will be counterbalanced for task order, so the following instructions will also be counterbalanced to coordinate with the two task orders].

Okay, does everyone have their packet face down in front of them and their Scantron filled out with Key ID number, which in this case will be _____, your participant ID number, and today's date, which is _____?

Great, now I will read the instructions for the first task in your packet. Please do not turn your packet over until I tell you to do so.

The first task in your packet is a series of three antonym problems. You will have three minutes to complete these three problems. Here are the directions for the task.

[Read directions from antonym task, see Appendix D]

Now go ahead and turn your packet over and begin on the first page with the antonym problems.

[For this example, GRE tasks will be first and creative tasks second. This order will be reversed for the second study session. For the first study session, GRE order will be: 1) antonyms, 2) reading comprehension, 3) analogies, and 4) quantitative problems. This order will be reversed for the second experimental session. For the creative tasks the order for the first session will be: 1) RAT items, 2) Guilford Consequences items. This order will also be reversed for the second study session].

Okay, there is one more minute left for you to complete the antonym problems.

[at the 3 minute mark . . .]

Okay, that's it for the antonym problems, please turn to the next page in your packet and then turn your packet face down while I read the next set of instruction.

The next task in your packet is a series of three reading comprehension questions. You will have 10 minutes to read the passage and answer the three questions. Here are the directions for the task.

[Read directions from reading comprehension task, see Appendix D]

Now go ahead and turn your packet over and begin on the reading comprehension problems.

[at the 9 minute mark]

Okay, there is one more minute left for you to complete the reading comprehension problems.

[at the 10 minute mark . . .]

Okay, that's it for the reading comprehension problems, please turn to the next page in your packet and then turn your packet face down while I read the next set of instruction.

The next task in your packet is a series of three vocabulary analogy problems. You will have three minutes to do the analogy problems. Here are the directions for the task.

[Read directions from analogy task, see Appendix D]

Now go ahead and turn your packet over and begin on the analogy problems.

[at the 2 minute mark]

Okay, there is one more minute left for you to complete the analogy problems.

[at the 3 minute mark . . .]

Okay, that's it for the analogy problems, please turn to the next page in your packet and then turn your packet face down while I read the next set of instruction.

The next task in your packet is a series of three quantitative math problems. You will have 10 minutes to do these three problems. Here are the directions for the task.

[Read directions from quantitative task, see Appendix D]

Now go ahead and turn your packet over and begin on the math problems.

[at the 9 minute mark]

Okay, there is one more minute left for you to complete the math problems.

[at the 10 minute mark . . .]

Okay, that's it for the math problems, please turn to the next page in your packet and then turn your packet face down while I read the next set of instructions.

The next task in your packet is a series of 5 problems in which you are given three words and are asked to find a fourth word that is related to the other three. You then write the fourth word in the space provided. Let me give you a few examples, since this is not a task that you probably do everyday. If you were given the three words, cookies, sixteen, and heart, can you think of a word that is related to these three words? Take a minute and think to yourself about what word you could write down. The words again are cookies, sixteen, and heart. I am going to give you about 30 seconds to think about this to yourselves and then I'll tell you the answer.

[after 30 seconds . . .]

Okay, how many of you (raise your hands) think you know the answer?

Okay, the answer in this case is sweet. Cookies are sweet; sweet is part of the phrase sweet sixteen, and it is part of the word sweetheart. Let's try one more example. Again

I'll tell you the three words. Repeat them, and then give you about 30 seconds to think about it, and then I'll tell you the actual answer.

The words this time are poke, go, and molasses. Again, that's poke, go, and molasses. Go ahead and think about it to yourself.

[after 30 seconds]

Okay, the answer that time was "slow." As in, slow poke, go slow, and slow as molasses. As you can see the fourth word may be related to the other three for various reasons.

These same instructions are on the top of the next page, but I wanted to run through them with you to help you get the idea. When you turn the page (not quite yet!) you'll see that there are 5 such problems for you to do. You'll have a total of 5 minutes to do all 5. Please try to make a guess for each one even if you are not sure. Okay, now you can turn your papers over. I will cue you when the five minutes are up.

[at 5 minute mark]

Okay, that's it for those problems. Now please turn the page to the next set of problems. For this one you can keep your papers face up because this page contains only instructions.

For this task there are three problems for you to do and you will have 2 minutes to do each one. I will read these instructions to you out loud and then I'll indicate when it is time to begin. For this task, I will cue you when two minutes is up and then you must turn the page and go on to the next problem until we have done all three problems. I'll now read the instructions.

[Read instructions from page 1 of the Guilford Consequences task instructions].

Are there any questions on this one before we turn the page and begin?

Okay, everyone turn the page and start.

[after 2 minutes]

Two minutes is up, please turn the page and start the next one.

[after 2 minutes]

Two minutes is up, please turn the page and start the next one.

[after 2 minutes]

Okay, that is all for those tasks. Please close your packets and make sure that your participant ID number is on the front of your task packet and on your Scantron. We'll collect those now and then tell you what's next. We are almost finished!

[Collect task packets]

Okay, this is the moment you've all been waiting for. We get to open the envelope and find out who got caffeine. Just out of curiosity who thinks they got caffeine? Let's see a show of hands. Okay, who thinks they did not get caffeine? Okay, let's find out.

[Open envelope and indicate which cup color had caffeine]

Okay, now I'd like to see a show of hands again, how many of you were right about whether or not you got caffeine? How many of you were wrong?

Okay, interesting. Now let me tell you a little about the study. The same information will be on your debriefing sheets, but I want to make sure you hear this and also have a chance to ask questions.

The purpose of my study was to investigate the effects of psychological arousal and personality on both academic and creative performance. Psychological arousal is essentially your level of energy or awakeness. If you are very, very aroused you are likely to be hyper and jittery, if you are not aroused at all you are likely to be asleep. Obviously,

caffeine is a way to manipulate arousal, which is what I was trying to do with the caffeine. But people vary individually in their levels of arousal as well. One of the questionnaires I gave you assesses impulsivity and neuroticism. Both of those constructs are thought to be associated with arousal. Another questionnaire I gave you was called the Action Control Scale. That measure assesses the extent to which you are either action or state oriented. Action oriented people tend to think less about things before they do them, whereas state oriented people will often ruminate about things or hesitate for quite a bit before taking action on something. It turns out that anxiety levels tend to be higher for state-oriented people than for action oriented people. The other personality measure you did assessed where you fall on a number of emotion-related adjectives. This measure has to do with how you responded to the caffeine manipulation or lack thereof and/or what your arousal state was coming in to the experiment. Finally, all of you who are here completed two questionnaires in mass testing that I used to select you on for participation in this study. One of those was an emotion adjective checklist similar to the one you filled out today, except that it measures how you typically are, rather than how you felt today after you had caffeine. That measure has more to do with your basic emotional traits than with arousal or anxiety-type stuff. The other measure you did in mass testing was called the Rational Experiential Inventory. It measured the extent to which you tend to think in a very linear and rational manner, on one hand, or the extent to which you make decisions and think based more on your experience.

So that's a whole lot of measures. My hypotheses are pretty complex, so I am not going to go into great detail about them. If anyone is curious, feel free to e-mail or talk to me personally and I can tell you more about my specific hypotheses. Essentially, though,

theory predicts that people who have traits that indicate that their baseline level of arousal is low will perform better on tasks that are administered in the morning and that caffeine will enhance this effect. On the other hand, people who tend toward high morning arousal would tend to not do as well on these kinds of tasks in the morning, especially when they have also been given caffeine. This pattern should be slightly different depending on whether the task in question is more academic or creative.

So, that's the basic rundown. I know that is a lot of information, but remember you can also email me or talk to me in person if you want a lot more detail. Also please be sure not to share any of this information about the nature of the study with anyone else who might participate. Are there any questions anyone has right now?

[Answer any questions]

Okay, please be sure and pick up a debriefing sheet on your way out. That sheet has information on how you can obtain results if you wish. Thanks for participating in my study!

Appendix C

Personality Scales

1. Eysenck Personality Inventory (EPI)
2. Positive and Negative Affect Scale (PANAS)
3. Activation and Deactivation Adjective Check List (AD ACL)
4. Eysenck Personality Inventory (EPI)

Your Participant ID#_____

Personality Questionnaire #2:
Please answer the following questions in terms of how you typically are. Choose either "**A**" or "**B**", out of the two possible choices ("**A**" for "**Yes**"; "**B**" for "**No**" on your scantron), choose the best-fit response for you. Please respond to every item. There are no right or wrong answers. Use the scantron form to mark your answers.

Question:	**Scantron Response**	
	A	**B**
1. Do you often long for excitement?	**Yes**	**No**
2. Do you often need understanding friends to cheer you up?	**Yes**	**No**
3. Are you usually carefree?	**Yes**	**No**
4. Do you find it very hard to take no for an answer?	**Yes**	**No**
5. Do you stop and think things over before doing anything?	**Yes**	**No**
6. If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so?	**Yes**	**No**
7. Does your mood often go up and down?	**Yes**	**No**
8. Do you generally do and say things quickly without stopping to think?	**Yes**	**No**
9. Do you ever feel 'just miserable' for no good reason?	**Yes**	**No**
10. Would you do almost anything for a dare?	**Yes**	**No**
11. Do you suddenly feel shy when you want to talk to an attractive stranger?	**Yes**	**No**
12. Once in a while do you lose your temper and get angry?	**Yes**	**No**
13. Do you often do things on the spur of the moment?	**Yes**	**No**
14. Do you often worry about things you should not have done or said?	**Yes**	**No**
15. Generally, do you prefer reading to meeting people?	**Yes**	**No**
16. Are your feelings rather easily hurt?	**Yes**	**No**
17. Do you like going out a lot?	**Yes**	**No**
18. Do you occasionally have thoughts and ideas that you would not like other people to know about?	**Yes**	**No**
19. Are you sometimes bubbling over with energy and sometimes very sluggish?	**Yes**	**No**
20. Do you prefer to have few but special friends?	**Yes**	**No**
21. Do you daydream a lot?	**Yes**	**No**
22. When people shout at you, do you shout back?	**Yes**	**No**
23. Are you often troubled about feelings of guilt?	**Yes**	**No**
24. Are *all* your habits good and desirable ones?	**Yes**	**No**
25. Can you usually let yourself go and enjoy yourself a lot at a lively party?	**Yes**	**No**
26. Would you call yourself tense or 'high-strung'?	**Yes**	**No**
27. Do other people think of you as being very lively?	**Yes**	**No**

Question:	**Scantron Response** A	B
28. After you have done something important, do you often come away feeling you could have done better?	**Yes**	**No**
29. Are you mostly quiet when you are with other people?	**Yes**	**No**
30. Do you sometimes gossip?	**Yes**	**No**
31. Do ideas run through your head so that you cannot sleep?	**Yes**	**No**
32. If there is something you want to know about, would you rather look it up in a book than talk to someone about it?	**Yes**	**No**
33. Do you get palpitations or thumping in your heart?	**Yes**	**No**
34. Do you like the kind of work that you need to pay close attention to?	**Yes**	**No**
35. Do you get attacks of shaking or trembling?	**Yes**	**No**
36. When traveling, would you always declare everything at Customs, even if you knew that you could never be found out?	**Yes**	**No**
37. Do you hate being with a crowd who play jokes on one another?	**Yes**	**No**
38. Are you an irritable person?	**Yes**	**No**
39. Do you like doing things in which you have to act quickly?	**Yes**	**No**
40. Do you worry about awful things that might happen?	**Yes**	**No**
41. Are you slow and unhurried in the way you move?	**Yes**	**No**
42. Have you ever been late for an appointment or work?	**Yes**	**No**
43. Do you have many nightmares?	**Yes**	**No**
44. Do you like talking to people so much that you never miss a chance to talk to a stranger?	**Yes**	**No**
45. Are you troubled by aches and pains?	**Yes**	**No**
46. Would you be very unhappy if you could not see lots of people most of the time?	**Yes**	**No**
47. Would you call yourself a nervous person?	**Yes**	**No**
48. Of all the people you know, are there some whom you definitely do not like?	**Yes**	**No**
49. Would you say that you are fairly self-confident?	**Yes**	**No**
50. Are you easily hurt when people find fault with you or your work?	**Yes**	**No**
51. Do you find it hard to really enjoy yourself at a lively party?	**Yes**	**No**
52. Are you troubled with feelings of inferiority?	**Yes**	**No**
53. Can you easily get some life into a rather dull party?	**Yes**	**No**
54. Do you sometimes talk about things you know nothing about?	**Yes**	**No**
55. Do you worry about your health?	**Yes**	**No**
56. Do you like playing pranks on others?	**Yes**	**No**
57. Do you suffer from sleeplessness?	**Yes**	**No**

Positive and Negative Affect Scale (PANAS)

Directions: The following scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate box on the answer sheet. Indicate to what extent you generally feel this way, that is, how you feel on average. Use the following scale when answering:

1 (A): very lightly or not at all
2 (B): a little
3 (C): moderately
4 (D): quite a lot
5 (E): extremely

1. interested
2. irritable
3. distress
4. alert
5. excited
6. ashamed
7. upset
8. inspired
9. strong
10. nervous
11. guilty
12. determined
13. scared
14. attentive
15. hostile
16. jittery
17. enthusiastic
18. active
19. proud
20. afraid

Activation and Deactivation Adjective Checklist (AD ACL)

Directions: The following scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate box on the answer sheet. Indicate to what extent you currently feel this way, that is, how you feel today, at this moment. Use the following scale when answering:

1 (A): very lightly or not at all
2 (B): a little
3 (C): moderately
4 (D): quite a lot
5 (E): extremely

1. energetic
2. quiet
3. wide-awake
4. clutched-up
5. drowsy
6. calm
7. full-of-pep
8. intense
9. jittery
10. tired
11. still
12. wakeful
13. quiescent
14. sleepy
15. lively
16. placid
17. vigorous
18. at-rest
19. fearful
20. active

Appendix D

Academic and Creative Performance Measures

1. Practice Items from the Graduate Record Examination (GRE)

2. Remote Associates Test (RAT)

Graduate Record Examination (GRE) Practice Items

Your Participant ID#_____

Directions: In each of the following questions, a related pair of words or phrases is followed by five lettered pairs of words or phrases. Select the lettered pair that best expresses a relationship similar to that expressed in the original pair.

1. BALLAST : INSTABILITY
   (A) buoy : direction
   (B) purchase : slippage
   (C) lathe : metal
   (D) pulley : leverage
   (E) hoist : elevator

2. MUFFLE : SOUND
   (A) assuage : grief
   (B) maul : object
   (C) extract : flavor
   (D) endure : agony
   (E) conceal : secret

3. MITIGATE : SEVERE
   (A) compile : available
   (B) restore : new
   (C) contribute : charitable
   (D) venerate : reverent
   (E) qualify : general

Directions: Each question below consists of a word printed in capital letters, followed by five lettered words or phrases. Choose the lettered word or phrase that is most nearly opposite in meaning to the word in capital letters.

1. INCHOATE:
   (A) sordid
   (B) modern
   (C) improvised
   (D) exceptionally quick
   (E) completely formed

2. ENDEMIC:
   (A) exotic
   (B) shallow
   (C) episodic
   (D) manifest
   (E) treatable

3. REDOUBTABLE:
   (A) unsurprising
   (B) unambiguous
   (C) unimpressive
   (D) inevitable
   (E) immovable

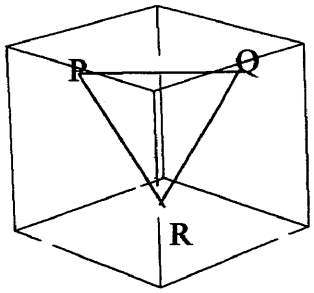
Directions: This passage is followed by questions based on its content. After reading the passage, choose the best answer to each question following the passage. Answer each question on the basis of what is stated or implied in the passage.

Extraordinary creative ability has been characterized as revolutionary, flying in the face of what is established and producing not what is acceptable but what will become accepted. According to this formulation, highly creative activity transcends the limits of an existing form and establishes a new principle of organization. However, the idea that extraordinary creativity transcends established limits is misleading when it is applied to the arts, even though it may be valid for the sciences. Differences between highly creative art and highly creative science arise in part from a difference in their goals. For the sciences, a new theory is the goal and end result of the creative act. Innovative science produces new propositions in terms of which diverse phenomena can be related to one another in more coherent ways. Such phenomena as a brilliant diamond or a nesting bird are relegated to the role of data, serving as the means for formulating or testing a new theory. The goal of highly creative art is very different: the phenomenon itself becomes the direct product of the creative act. Shakespeare's *Hamlet* is not a tract about the behavior of indecisive princes or the uses of political power nor is Picasso's painting *Guernica* primarily a propositional statement about the Spanish civil War or the evils of fascism. What highly creative artistic activity produces is not a new generalization that transcends established limits, but rather an aesthetic particular. Aesthetic particulars produced by the highly creative artist extend or exploit, in an innovative way, the limits of an existing form, rather than transcend that form.

This is not to deny that a highly creative artist some-times establishes a new principle of organization in the history of an artistic field; the composer Monteverdi, who created music of the highest aesthetic value, comes to mind. More generally, however, whether or not a composition establishes a new principle in the history of music has little bearing on its aesthetic worth. Because they embody a new principle of organization, some musical works, such as the operas of the Florentine Camerata, are of signal historical importance, but few listeners or musicologists would include these among the great works of music. On the other hand, Mozart's *The Marriage of Figaro* is surely among the masterpieces of music even though its modest innovations are confined to extending existing means. It has been said of Beethoven that he toppled the rules and freed music from the stifling confines of convention. But a close study of his compositions reveals that Beethoven overturned no fundamental rules. Rather, he was an incomparable strategist who exploited limits—the rules, forms, and conventions that he inherited from predecessors such as Haydn and Mozart, Handel and Bach—in strikingly original ways.

1. The author considers a new theory that coherently relates diverse phenomena to one another to be the
   (A) basis for reaffirming a well-established scientific formulation
   (B) byproduct of an aesthetic experience
   (C) tool used by a scientist to discover a new particular synthesis
   (D) underlying a great work of art
   (E) result of highly creative scientific activity
2. The author implies that Beethoven's music was strikingly original because Beethoven
   (A) strove to outdo his predecessors by becoming the first composer to exploit limits
   (B) fundamentally changed the musical forms of his predecessors by adopting a richly inventive strategy
   (C) embellished and interwove the melodies of several of the great composers who preceded him
   (D) manipulated the established conventions of musical composition in a highly innovative fashion
   (E) attempted to create the illusion of having transcended the musical forms of his predecessors
3. The passage states that the operas of the Florentine Camerata are
   (A) unjustifiably ignored by musicologists
   (B) not generally considered to be of high aesthetic value even though they are important in the history of music
   (C) among those works in which popular historical themes were portrayed in a musical production
   (D) often inappropriately cited as examples of musical works in which a new principle of organization was introduced
   (E) minor exceptions to the well-established generalization that the aesthetic worth of a composition determines its importance in the history of music

Directions: Each question has five answer choices. For each of the questions, select the best of the answer choices given.



1. The volume of the cube in the figure above is 64. If the vertices of $\triangle PQR$ are midpoints of the cube's edges, what is the perimeter of $\triangle PQR$?

(A) 6

(B) $6\sqrt{2}$

(C) $6\sqrt{3}$

(D) 12

(E) $12\sqrt{2}$

2. 3×10^4 is greater than 4×10^3 by what percent?

(A) 25%

(B) 75%

(C) 133%

(D) 650%

(E) 750%

3. A phone call from City X to City Y costs \$1.00 for the first 3 minutes and \$0.20 for each additional minute. If r is an integer greater than 3, a phone call r minutes long will cost how many dollars?

(A) $\frac{3r}{5}$

(B) $\frac{r-10}{5}$

(C) $\frac{r-3}{5}$

(D) $\frac{r+2}{5}$

(E) $\frac{r+15}{5}$

Remote Associates Test (RAT)

Your Participant ID#_____

Instructions: In this test you are presented with three words and are asked to find a fourth word that is related to the other three. Write this word in the space to the right. For example, what word do you think is related to these three?

cookies	sixteen	heart	_____

The answer in this case is *sweet.* Cookies are sweet; sweet is part of the phrase *sweet sixteen*, and it is part of the word *sweetheart.*

Here is another example:

poke	go	molasses	_____

You should have written "slow" in the space provided. Slow poke, go slow, slow as molasses. As you can see, the fourth word may be related to the other three for various reasons. Now try these.

1.	mountain	up	school	_____
2.	madman	acorn	bolt	_____
3.	cream	bulb	heavy	_____
4.	up	knife	Band-Aid	_____
5.	slugger	belfry	ball	_____

Appendix E
Caffeine and Other Drug Questionnaire

Your Participant ID #: _____

Directions: Please answer the following questions honestly. Your truthful response will help us to accurately analyze the results of this study. Your response will not affect your participation credit for this study. (Remember, your responses will be kept confidential and your name will not be associated with your responses when these data are analyzed.)

1. Did you consume any caffeine during the 6 hours prior to this study? In other words, between 3:00 a.m. this morning and when you arrived in this room at about 9:00 a.m., did you consume any caffeinated beverage or any other form of caffeine? (please circle one)

YES.....NO

2. If you answered "YES" to the above question, please indicate what kind of caffeine you had and how much (e.g., a cup of coffee, a soda, etc.).

_____

_____

3. Did you use or consume any other psychoactive drug or substance prior to this study?
(please circle one)

YES.....NO

4. If you answered **"YES"** to the above question, please indicate below what kind of drug or substance you used. (check any that apply)

- ❑ Stimulant or amphetamine (other than caffeine)
- ❑ Nicotine (in cigarette or other form)
- ❑ Alcohol
- ❑ Sleep aid
- ❑ Marijuana or other psychedelic
- ❑ Opiate
- ❑ Depressants (includes alcohol, anti-anxiety drugs, and some prescription pain medication)
- ❑ Prescription antidepressant

❑ Other/clarification:_____

5. Do you routinely drink coffee or use caffeine in any form? (please circle one)

YES.....NO

6. If you answered **"YES"** to the above question, about how much coffee or other caffeine do you drink/use? Please write the amount below (for example: "three 8 oz cups coffee/day," or "two 16 oz caffeinated soda drinks/day")

_____

_____

7. If you answered **"YES"** to question #5, when during the day do you typically prefer to have coffee or caffeine?

❑ in the morning

❑ in the afternoon or evening

❑ all day

❑ no preference

Thank you for your honest responses!

Please wait for further instructions.

APPENDIX F

Caffeine and Placebo Preparation and Dosing

Introduction to Preparation Procedure

The procedure used in the present study, and documented here, is a replication of the caffeine dosing method used by Professor William Revelle, Ph.D. and colleagues at the Northwestern University Department of Psychology over repeated studies using undergraduate participants. These studies have been replicated multiple times over the past 23 years. Revelle, a personality psychologist, has used this paradigm to study aspects of personality, arousal, and performance. Caffeine dosage levels for undergraduate participants in his lab have ranged from 200 to 800 milligrams of caffeine citrate (100-400 milligrams of active caffeine). The midrange, and most common amount used appears to be 200 milligrams of active caffeine or 400 milligrams of Caffeine Citrate per participant (equivalent of approximately 2 cups of brewed coffee). This is the amount that is proposed for the present study (see e.g., Revelle, Humphreys, Simon, & Gilliland, 1980; Revelle, 1998; Anderson and Revelle, 1994).

Active Ingredient
Caffeine Citrate (also known as Citrated Caffeine)
Inactive Ingredients
- Orange Flavored Breakfast Drink Mix (e.g., Tang®)
- Filtered drinking water
- Flat quinine water (tonic water)

Caffeine dosage per caffeine-condition participant
- 400 milligrams Caffeine Citrate (equivalent to 200 milligrams active caffeine)

Comparison dosages for typical caffeine containing beverages and foods (according to USPC, United States Pharmacopeial Convention, Inc., 1999)
- Coffee, brewed: 40 to 180 milligrams per cup
- Tea, brewed American: 20 to 90 milligrams per cup
- Tea, brewed Imported: 25-110 milligrams per cup
- Cola and other soft drinks: 36 to 90 milligrams per 12 ounces
- Chocolate, bittersweet: 25 milligrams per ounce

Ingredients for caffeine treatment beverage (per participant)
- 400 milligrams caffeine citrate (200 milligrams active caffeine)
- 8 ounces filtered water
- 1 tablespoon orange flavored breakfast drink mix

Ingredients for control beverage (per participant)
- 8 ounces flat quinine water (tonic water)
- 1 tablespoon orange flavored breakfast drink mix

Preparation of caffeine beverages
Single-serving measurement trial
a) Measure out 400 milligrams of Caffeine Citrate (200 milligrams of active caffeine)

b) Dissolve Caffeine Citrate in 1 ounce of water in a plastic screw-top container.
c) Shake mixture until caffeine is dissolved.
d) Using funnel, pour solution into small glass milliliter-marked beaker.
e) Mark on beaker, and note on paper, the level the solution reaches on the beaker.
f) Pour solution into 12 ounce plastic cup.
g) Mark line on cup where solution reaches.
h) In clean container, mix 7 ounces of filtered drinking water with 1 tablespoon of orange flavored breakfast drink.
i) Shake mixture until orange mix is dissolved.
j) Pour mixture into a second glass beaker with milliliter increments and mark the fill line for the orange mixture on the beaker.
k) Pour solution into the plastic cup that has the caffeine solution.
l) Mark top fill line, to which the newly-added orange mixture reaches.
m) Set aside as a comparison for the fill-lines of the bulk-mixed batch.

Bulk-serving mixture procedure (yield, 60-8 ounce servings)

a) Measure out 400 milligrams of Caffeine Citrate (200 milligrams of active caffeine) per person, multiplied by 30, the maximum number of caffeine condition participants who could arrive for a single session. This is a total of 400 X 30 milligrams or 12,000 milligrams of Caffeine Citrate.
b) Using a large plastic beverage serving container with a screw-top lid, dissolve Caffeine Citrate in 30 ounces (one ounce per person) of filtered drinking water.
c) Shake solution until all caffeine is completely dissolved.
d) Using funnel, pour 1 ounce of solution into marked beaker to the same milliliter level as indicated by the measurement trial.
e) Pour solution from beaker into 12 ounce plastic beverage cup.
f) Mark beverage cup and compare fill line to measurement trial cup (they should be the same).
g) Repeat this process until 30-12 ounce plastic beverage cups are filled with solution.
h) Be sure to shake the solution well between each pour.
i) Now measure 10 tablespoons of orange drink mix into another large plastic beverage serving container with a screw-top lid.
j) Measure 70 ounces of filtered drinking water into the large container.
k) Shake this mixture until orange drink mix is well-dissolved.
l) Measure 7 ounces of the orange mixture into the previously-marked orange mix glass beaker.
m) Pour this into a 12-ounce plastic cup that already contains the ounce of caffeine solution.
n) Mark a top fill line where the orange mixture reaches on the plastic cup.
o) Compare this top fill line to the measurement trial cup, they should be the same.
p) Repeat this process, shaking the orange mixture, and measuring it by beaker each time, until the other 9 plastic cups for this batch are filled.

q) repeat steps a) through bb) 2 more times until all 30 cups are filled for all possible caffeine-condition participants.
r) Stir this mixture with a glass stirring implement just prior to administration.

Preparation of Control Beverages

Control Beverage Measurement Trial

a) Measure 8 ounces of flat quinine water into a glass beaker.
b) Measure 1 tablespoon of orange drink mix into the beaker.
c) Mix the mixture thoroughly inside the beaker.
d) Mark a single-serving fill line at the top of the orange mixture on the glass beaker.

Control Beverage Batch Mixture

a) Measure 80 ounces of flat quinine water into a large plastic beverage serving container with a screw-top lid.
b) Measure 10 tablespoons of orange flavored drink mix into the large plastic container.
c) Close lid and shake mixture well.
d) Using previously marked glass beaker, measure this mixture into 12-ounce plastic cups, 10 cups at a time.
Repeat procedure 2 more times to fill all 30 control beverage cups.

APPENDIX G

The College of William & Mary
Psychology department Consent Form (Form D)

The general nature of this personality and performance study conducted by Sara Chambers has been explained to me. I understand that I will be asked to complete a variety of questionnaires and complete several tasks. I also understand that there is a 50% chance that I will be selected at random to receive a caffeinated beverage as part of this study. By agreeing to participate in this study, I also give my consent to receive and ingest the caffeine beverage if I am randomly selected to do so. I understand that this is a double-blind study procedure. As such, I understand that I will not find out whether or not I have received a caffeinated or a non-caffeinated beverage until the end of the study. Further, the potential side effects of caffeine, the contraindicated medical conditions, and contraindicated medication and drug interactions have all been explained to me.
By signing this form I acknowledge that I understand the following side effects have occurred in some people who have used caffeine:

- ❑ dizziness
- ❑ fast heart beat
- ❑ irritability
- ❑ nervousness
- ❑ nausea
- ❑ vomiting
- ❑ diarrhea
- ❑ tremors
- ❑ trouble sleeping

I further the understand that if I have any of the following conditions, I am advised not to participate in this study. BY SIGNING THIS FORM I AM INDICATING THAT NONE OF THE CONDITIONS LISTED BELOW APPLY TO ME:

- ❑ allergic reactions to caffeine or caffeine containing products such as soda, tea, coffee, chocolate, or aspirin
- ❑ anxiety requiring medical attention
- ❑ agoraphobia
- ❑ heart disease
- ❑ high blood pressure
- ❑ panic attacks
- ❑ insomnia
- ❑ liver disease
- ❑ pregnant or nursing a baby

Finally, I understand that the following medications may have negative interactions with caffeine. BY SIGNING THIS FORM I CERTIFTY THAT I AM NOT TAKING ANY OF THESE MEDICATIONS:

- ❑ Stimulants or amphetamines, such as Ritalin, Cylert, Adderal, Dexedrine, or Desoxyn

- ❑ Appetite suppressants (diet pills) of any kind
- ❑ Cocaine
- ❑ Nabilone (e.g., Cesamet)
- ❑ Asthma, hayfeaver, allergy, or cold-medication, including nose drops or sprays
- ❑ Amantadine (e.g., Symmetrel)
- ❑ Chlophedianol (e.g., Ulone)
- ❑ Monoamine oxidase (or, MAO) inhibitors such as the antidepressants Furoxone, Marplan, Nardil, Matulane, Eldepryl, or Parnate.

I understand that my anonymity will be preserved and that my name will not be associated with my responses or with any of the results of this study.

As a voluntary participant in this study, I understand that I may refuse to answer any questions asked and that I may discontinue participation at any time. I also understand that any credit for my participation will not be affected by my responses or by my exercising any of my rights. In addition, I know that I may report dissatisfaction with any aspect of this study to the Psychology Department Chair, Dr. Robert Johnston (at extension 1-3871).

I am aware that I must be at least 18 years of age to participate. My signature below signifies my voluntary participation in this study.

_____ _____

Date Signature

_____

Printed Full Name (print clearly)

TO RECEIVE PROPER COURSE CREDIT, PLEASE CLEARLY PRINT YOUR INSTRUCTOR(S) NAME AND YOUR COURSE NUMBER BELOW:

_____ _____

PSY 201 Instructor PSY 202 Instructor

APPENDIX H

Debriefing Sheet

Beyond Ability: Effects of caffeine, impulsivity, affect, action control, and rational-experiential thinking on academic and creative performance

As the long title above suggests, the purpose of my study is to investigate the effects of psychological arousal and personality on both academic and creative performance. Psychological arousal is essentially your level of energy or awakeness. If you are very aroused you are likely to feel hyper energized, or even jittery. If you are not aroused at all you are likely to be asleep (or dead). Caffeine, as you might guess, is a way to manipulate arousal. The purpose of the caffeine in this study was to enhance the arousal of those participants who had caffeine.

Manipulations of arousal have been shown to have a curvilinear effect on performance in much past research. This is the old Yerkes-Dodson Law, first proposed in 1908. The idea is that the more aroused (or anxious) you are, the better you will perform—but only to a certain point. At about the midpoint of your range of arousal, the theory goes, you perform your best. But if you get too excited or anxious (too aroused), your performance will start to decline. Because people vary individually in their baseline arousal, caffeine and other personality factors should differentially effect performance in different people. This kind of pattern was the theme around which my hypotheses were built.

One of the questionnaires I gave you assesses impulsivity and neuroticism. Both of those constructs are thought to be associated with arousal. Another questionnaire, called the Action Control Scale, assesses the extent to which you are either action or state oriented. Action oriented people tend to think less about things before they do them, whereas state oriented people will often ruminate about things or hesitate for quite a bit before taking action. It turns out that anxiety tends to be higher for state-oriented people. I hypothesized this might also affect the arousal—performance relationship. The other personality measure you did included number of emotion-related adjectives. This measure had to do with how you responded to the caffeine manipulation (or lack thereof) and what your arousal level was coming in to the experiment.

Finally, all of you who are here completed two questionnaires in mass testing. I selected equal numbers of people at each level of those questionnaires to participate in this study. One mass-testing measure was an emotion adjective checklist similar to the one you filled out today, except that it measures how you typically are, rather than how you felt after you had caffeine. The other measure you did in mass-testing was called the Rational Experiential Inventory. It measured the extent to which you tend to think in a very linear and rational manner, on one hand, or the extent to which you make decisions and think based more on your experience.

Because they involve so many interacting variables, my hypotheses are pretty complex. That is why I did not go into great detail about them here. If anyone is curious, feel free to e-mail or talk to me personally and I can tell you more about my study. My e-mail address is printed below. You may also leave a message on the psychology graduate phone and I will get back to you as soon as I can. My results should be available by the beginning of July. Send me an email if you want me to e-mail or mail you a general summary of the results.

Thanks for participating in my study!

Sara Chambers

Secham@maila.wm.edu (and/or) Chambers9@aol.com Psychology graduate phone: 221-3891

VITA

Sara Elaine Chambers

Born in Glendale, California on December 5, 1966, the author graduated from Santa Cruz High School in 1984. She earned a Bachelor of Arts in English in 1991 from the University of California at Santa Barbara. In 1997 she entered the Master of Arts program in General/Experimental Psychology at The College of William & Mary where she served as a teaching assistant in statistics, personality, and introductory psychology courses for two years while completing all course work but the thesis. Professional presentations while at The College of William & Mary included: *Plea Bargaining, Courtroom Justice, and Prospect Theory* (1997, with D. Galbis-Reig & K. G. Shaver); *Creativity, Health, and Successful Aging: Insight from a 44-Year Study* (1997, with G. J. Feist & F. Barron); and *Mood-Congruent Judgment in Personally-Relevant Choice Dilemmas* (1998). The present thesis is submitted in partial fulfillment of the requirements for the degree of Master of Arts in Psychology.