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A CONVERGING MEASURES TEST OF EYSENCK'S BIOLOGICALLY-BASED THEORY OF INTROVERSION - EXTRAVERSION

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A CONVERGING MEASURES TEST OF EYSENCK'S BIOLOGICALLY-BASED THEORY OF INTROVERSION-EXTRAVERSION

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WESLEY A. BULLOCK
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A CONVERGING MEASURES TEST OF

EYSENCK'S BIOLOGICALLY-BASED

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A DISSERTATION

APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

By

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Abstract

Eysenck's (1967) theory of introversion-extraversion postulates that brainstem reticular arousal differences are the source of behavioral and performance differences between introverts and extraverts. The present study tested Eysenck's theory utilizing the convergent measurement of electroencephalographic, performance, and psychometric indices of arousal. Twelve introverts and twelve extraverts, classified using the Eysenck Personality Inventory extraversion scale, had their brainstem auditory evoked responses (BAERs) monitored under three levels of caffeine administration (0.0 mg/kg, 1.5 mg/kg, and 3.0 mg/kg) and three levels of task demand (resting, simple reaction time, and complex reaction time). Results indicated main effects for the personality, caffeine and task manipulations upon wave components of the BAER and speed of responding on the reaction time tasks. Several interactions were also evident between the three factors for components of the BAER and the speed of responding on the reaction time tasks. The use of Thayer's (1967) Activation-Deactivation Checklist, and an independent measure of self-perceived boredom and arousal, confirmed the arousal inducing properties of the caffeine and task manipulations, but did not reveal any personality differences in subjectively felt arousal.

A Converging Measures Test of
Eysenck's Biologically-based
Theory of Introversion-Extraversion

In 1957, Hans Eysenck presented a biologically-based model of introversion-extraversion (IE) in which the behavioral differences between introverts and extraverts were hypothesized to be a function of inherent cortical arousal differences. According to Eysenck's (1957) theory, introverts are characterized by a tendency to develop greater neural excitation (resulting in a high level of cortical arousal), as compared to extraverts, who tend to manifest greater neural inhibition (and therefore are typified by a lower level of cortical arousal).

In 1967, Eysenck coalesced the functions of neural inhibition and excitation with the function of the ascending reticular activating system (ARAS), located in the brainstem. As Wilson (1978) has noted, "This structure is thought by neurophysiologists to be responsible for producing nonspecific arousal in the cerebral cortex in response to external stimulation" (p. 299). In its present state, Eysenck's (1967) theory postulates that behavioral differences between introverts and extraverts in a given social situation are a reflection of individual differences in the activity of the ARAS.

The foundation of Eysenck's (1967) theory is that introverts are hypothesized to have generally higher basal levels of activity in the ARAS, and thus are more highly aroused than extraverts given standard conditions of stimulation. Eysenck's theory also incorporates within it Hebb's (1955) concept of an optimal level of arousal for maximum performance. Thus, Eysenck postulates that introverts and extraverts differ in their inherent level of brainstem arousal such that introverts have a resting level of brainstem arousal that is "above optimum," while the resting level of ARAS arousal in extraverts is "below optimum."

According to Eysenck, the overaroused condition of introverts leads them to exhibit more restrained and inhibited behaviors and to seek social situations that are non-arousing in an effort to dampen external stimulation. Conversely, the lower internal arousal in extraverts leads them to exhibit more unrestrained and impulsive behaviors and to seek social situations that are more highly arousing in an effort to increase external stimulation. Again, the behavior of both extreme personality groups is merely the result of their attempts to maintain an "optimal" level of arousal.

Since its formulation, a virtual plethora of researchers has attempted to test Eysenck's theory of IE--with varying degrees of success. Among the numerous investigations of Eysenck's theory, several studies have employed psychophysiological measures, such as heartrate, electrodermal, and electroencephalographic (EEG) activity, in an attempt to more directly assess arousal level differences between introverts and extraverts. Unfortunately, while many of these studies do support Eysenck's propositions, the cumulative results are by no means conclusive. Some studies using these psychophysiological measures report no differences in arousal between introverts and extraverts, and some even report extraverts as being more aroused than introverts. (See Gale, 1973, 1981, 1983; Gilliland, 1981; Stelmack, 1981 for reviews.)

There are at least two reasons for the failure of these studies to reach a consensus concerning IE arousal differences. First, the dependent measures cited above do not offer a direct measure of the foundational hypothesis of Eysenck's (1967) theory; that is, they measure peripheral indices of arousal mechanisms, but not arousal at the level of the ARAS. A second reason for the massive body of amphibolic results lies in the fact that these psychophysiological measures are all profoundly influenced by factors which are external to the subject, i.e., the arousal inducing properties of the experimental situation. Recent reviews of the IE literature have in fact imposed some degree of order on the confusion of experimental outcomes simply by post hoc stratification of the studies according to the arousal inducing properties of the testing situation (see Gale, 1973, 1981, 1983; Gilliland, 1981; Stelmack, 1981).

The Brainstem Auditory Evoked Response

Recently, a new psychophysiological technique has been developed which may circumvent many of the problems associated with the measures of physiological arousal noted above. This new technique is the brainstem auditory evoked response (BAER) and it offers a potential solution to the problem of more directly measuring brainstem arousal differences in introverts and extraverts.

The BAER is an EEG technique that measures activity along the brainstem auditory pathway (Jewett, Romano, & Williston, 1970). The BAER is a remarkably distinct and reliable series of seven positive waves which occur in the first 10 msec of auditory neural processing following a brief auditory stimulus (a click or tone pip). The BAER is similar to the cortical evoked response in that it is computer averaged over many trials and is time-locked to the stimulus. Unlike the cortical evoked response, the BAER has been reported to be stable during fluctuations in subjective arousal and environmental conditions (Amadeo & Shagass, 1973; Jewett & Williston, 1971; Mendel & Goldstein, 1969, 1971; Picton & Hillyard, 1974), although some recent investigations have questioned the "immutability" of the BAER to situational attention manipulations (see Bullock, 1983; Lucas, 1982).

The BAER "far-field" potential reflects sequential electrical events at successively higher levels of the brainstem auditory pathway, a pathway which has collateral input into the reticular formation--along with other sensory systems (Brodal, 1957; Thompson, 1967, cited in Corcoran, 1981). Each of the seven wave peaks of the BAER is hypothesized to reflect activity at a specific brainstem structure. The postulated generators of wave I through VII are, respectively, the acoustic nerve, cochlear nuclei, superior olives, lateral lemniscus, inferior colliculus, medial geniculate, and thalamo-cortical radiations (Stockard & Rossiter, 1977).

The importance of being able to monitor brainstem activity is self-evident given Eysenck's (1967) hypothesis that arousal differences in introverts and extraverts are based on brainstem ARAS activation differences. By implication, if there really are differences in brainstem arousal between introverts and extraverts, these should be reflected in different transmission times (i.e., different latencies between peaks of the BAER waveform) and different amplitudes of the BAER wavepeaks, given particular stimulus parameters. Of particular interest are those neural structures along the auditory pathway which are central to the ARAS (i.e., the lateral lemniscus (wave IV) and the inferior colliculus (wave V), since exploration of EEG activity at this level of the BAER may provide a more direct test of Eysenck's fundamental postulate.

Research on IE and the BAER

The relationship of the BAER and IE has been explored in recent investigations by several authors. Andress (1981) has reported that at a click intensity of 80 dB (SL), but not at lower intensities, introverts evidence shorter latency and increased amplitude of wave V, as well as decreased conduction time (CT) between waves I-V, as compared to extraverts. Andress (1981) cautiously interpreted her findings as evidence that introverts manifest greater neural excitatory processes than extraverts, and therefore as supportive for Eysenck's arousal-based theory. However, it remains unclear why the effect obtained by Andress was not present at click levels lower than 80 dB (SL), particularly given that introverts are typically found to be more sensitive to low level auditory stimulation than extraverts (see Eysenck, 1967).

In a study very similar to that of Andress (1981), Campbell, Baribeau-Bräun, and Bräun (1981) did not find any BAER latency or amplitude differences between introverts and extraverts when intensity or rate of the clicks was manipulated. Notably, the study by Campbell et al. did not use click intensities above 70 dB, so their null findings cannot be taken as contradictory evidence.

In a recent study by Stelmack and Wilson (1983), introverts were again found to display shorter latency for wave V than extraverts to high frequency, 80 dB tone bursts and to click stimuli which ranged from 55-85 dB (SPL). This finding is very much in line with the report by Andress (1981) of decreased latency of wave V for introverts at higher intensity levels. However, Stelmack and Wilson did not replicate Andress' finding of decreased interpeak-latency between waves I and V for introverts at higher intensity levels. Stelmack and Wilson suggest that, "The absence of differences in interpeak latency, or central transmission time, centre the effects on wave I." Stelmack and Wilson (1983) further postulate that neurophysiological differences between introverts and extraverts may be "more fundamental than is presently supposed" such that "the development of the neurophysiological basis of individual differences in extraversion which presently focusses [sic] on differences in cortico-reticular arousal systems, [may need] to accommodate differences in axonal or synaptic transmission" (p. 14).

A study by Bullock, Gilliland, and Kujawski (1982) has also reported IE differences in the BAER. At a click intensity of 70 dB (SL) no IE differences were observed;

however, at a click intensity level of 90 dB (SL) extraverts showed significantly larger amplitudes for wave V--pointing toward possible transmarginal inhibition effects in the introverts at this very high intensity level. (Transmarginal inhibition is a term Eysenck borrows from Pavlovian conditioning theory which refers to the recruitment of protective neural inhibitory processes in situations of extreme arousal or overstimulation of sensory pathways.) Bullock et al. (1982) also confirmed the finding by both Andress (1981) and Stelmack and Wilson (1983) of longer wave V latency in extraverts, as well as the finding by Andress (1981) of decreased CT between waves I and V for introverts.

Finally, a recent study by Bullock (1983) examined the interactive relationship of age, IE, and situational arousal on the BAER. This study, which included middle-aged and elderly adults as well as the more typical young adult, called into question the reported stability of the BAER to variations in situational arousal. In this study, a main effect was found for a situational attention task such that the BAER recorded during a complex vigilance task was associated with increases in the latency of wave I and wave V across all age groups, as compared to a condition where the subjects were resting quietly with eyes closed. Although no main effects for IE were found, the results of this study also revealed complex interactions between the age, personality, and situational arousal factors.

To date, the most commonly reported finding concerning IE differences on the BAER has been decreased latency for wave V in introverts as compared to extraverts. As noted earlier, Stelmack and Wilson (1983) attribute this finding to sensitivity differences between introverts and extraverts at the level of the acoustic nerve, although they do not explain why this peripheral sensitivity difference is manifested only at relatively high levels of auditory stimulation. By contrast, the results of the Andress (1981) and Bullock et al. (1982) studies support central ARAS arousal differences, as they have reported decreased CT from wave I-V in introverts, as well as decreases in the absolute latency of wave V. The results of these last two studies suggest a continued focus on central brainstem arousal differences between introverts and extraverts (particularly at the level of wave V--the inferior colliculus), as well as more peripheral sensitivity differences.

In summary, the BAER holds as a very promising tool in the verification and explication of hypothesized brainstem arousal differences between introverts and extraverts. However, although it appears that a methodological threshold may have been breached in terms of a more direct access measure of brainstem ARAS activity, there remains the more tedious job of elucidating the meaning and <u>theoretical</u> implication of these results. As noted earlier, studies by

Bullock (1983) and Lucus (1982) have called into question the reported immutability of the BAER to situational attention factors. Given that introverts and extraverts show relatively consistent performance differences on such tasks as simple vigilance and reaction time, the demonstration of an interaction between IE and difficulty level on a performance task which parallels changes in the BAER would lend significant support to Eysenck's fundamental hypothesis of behavioral differences between introverts and extraverts being a function of brainstem arousal differences.

Research on IE and Reaction Time Tasks

In general, the relationship between IE and reaction time (RT) performance has been found to be highly dependent upon the exact parameters of the experimental paradigm. Nonetheless, those studies which have examined RT differences between introverts and extraverts evidence a remarkable consistency, when they are stratified according to the arousal inducing properties of the experimental milieu. For example, Buckalew (1973) has reported that in a simple RT task of relatively short duration (20 minutes), where the intertrial interval (ITI) was relatively short (5 sec), extraverts have faster RTs than introverts. Similarly, Thackray, Jones, and Touchstone (1974) have reported that over the course of a 40 minute choice RT task extraverts outperformed introverts during the first 20 minutes, but performed more poorly (i.e., slower RTs) during the last 20 minutes, leading to a significant interaction between IE and time-on-task for RT performance.

The finding that time-on-task is a crucial factor in producing IE differences on RT performance is given further support by Brebner and Cooper (1974). In this study, extraverts were found to have significantly longer RTs than introverts in the last half of a 45 minute time period, while no significant differences were found between the two personality groups in the first half of the 45 minute time period. Notably, the ITI for this study was 18 seconds, making it comparable to many studies which have demonstrated IE performance differences on simple vigilance tasks. In this regard, Brebner and Cooper (1974) reported that extraverts produced a significantly higher proportion of missed signals than introverts over the course of the 45 minute testing period. The finding concurs with the literature on IE and simple vigilance performance (see Bakan, Belton, & Toth, 1963; Claridge, 1960).

From the results of their own and earlier studies, Brebner and Cooper (1974) have developed a simplified model of IE in which extraverts are hypothesized to be "geared to respond" to environmental stimuli, while introverts are hypothesized to be "geared to inspect" environmental stimuli (see also Brebner & Cooper, 1978). Although this simplified model has recently been challenged as inadequate to explain the complex behavioral/biological differences between introverts and extraverts (Paisey & Mangan, 1983), it has nevertheless received further support by a study completed by Brebner and Flavel (1978). In this study, extraverts were found to make more errors of commission than introverts in a simple visual RT paradigm which included "catch trials" during which the subject had to refrain from making the RT response. This study also reported that when the proportion of catch trials was low (10%), the extraverted subjects manifested significantly decreased RTs as compared to the introverts. The time-on-task in this study was 7.5 minutes for each of 3 blocks of trials and the ITI was 2.3 seconds. Thus, the finding under these experimental parameters that extraverts had faster RTs than introverts corroborates the results reported by Buckalew (1973) and Thackray et al. (1974).

A study by Gilliland and Bracy (1979) has examined the differential performance of extraverts and introverts in a simple visual RT task before, during, and after aperiodic noise. Each of these three sessions lasted 7 minutes for a total time-on-task of 21 minutes. (ITI is not mentioned in this brief report.) The results of this study indicated that a "cafeteria type" noise delivered at 80 dB SPL had a disruptive effect on the RT performance of both personality groups, i.e., increased RT. Gilliland and Bracy also found that the detrimental effects of the noise continued for the extraverts even during the last 7 minute session when there was no noise, while the introverts' RT performance returned to a level comparable to a "no noise" introverted control group. Of particular interest was the finding that both the extravert "noise" group and the "no noise" extravert group had mean RTs which were longer than their introverted counterparts over the course of the 21 minute RT task and also during each of the 7 minute sessions. Gilliland and Bracy suggest that this last result was a function of the greater susceptibility of the extraverts to the boredom of the task.

Finally, a study by Keuss & Orlebeke (1977) examined the relationship between IE neuroticism and transmarginal inhibition in an auditory choice RT task. To induce transmarginal inhibition, the intensity of the stimulus tones (either 500 or 3000 Hz), were varied from 50 to 105 dB. The ISI in this study was 8.5 seconds and time-on-task was under 20 minutes. There were three significant findings in this study. First, it was found that subjects who were high on both extraversion and neuroticism had significantly faster RTs than any other combination of the extraversion and neuroticism factors. However, the high extraversion/high neuroticism subjects also produced more errors of commission reminiscent of the Brebner and Flavel (1978) study. Secondly, transmarginal inhibition, which was operationally defined as increased RT responding at higher stimulus intensities, was found only for the 3000 Hz tone. Keuss and Orlebeke attribute this result to the difference in the subjective loudness of the 1000 and 3000 Hz tones. Finally, with regard to personality differences in the recruitment of transmission inhibition, Keuss and Orlebeke reported that for the 3000 Hz tone, introverts had an earlier turning point in their RT/intensity curve than extraverts--pointing to the recruitment of protective neural inhibition at lower levels of environmental stimulation for the introverts.

To summarize the available research on IE and RT performance, three general conclusions may be drawn:

1) On a moderately arousing RT task (i.e., relatively short ITIs) extraverts perform as well, and often better, than introverts--at least in the short run (i.e., time-on-task is no more than 20 minutes).

2) On either a relatively slow-paced,non-arousing RT task (i.e., relatively long ITIs), <u>or</u> on RT tasks in which time-on-task extends to approximately 40 minutes, extraverts evidence slower RTs than introverts.

3) As RT complexity increases (as in a choice RT task), or as the intensity of the RT stimulus increases, extraverts have faster RTs than introverts, but they also tend to produce more errors of commission.

Oddly enough, the first of these conclusions actually goes against the logic of Eysenck's (1967) arousal model of IE. That is, if introverts have higher levels of ARAS arousal, and hence are more activated and sensitive to environmental stimuli, why do the <u>extraverts</u> tend to have faster RTs under conditions of moderate arousal? At the present time, this anomalous (yet persistent) result is best accounted for by the Brebner-Cooper model which postulates that extraverts are "geared to respond" while introverts are "geared to inspect" under moderately arousing environmental conditions.

The second of these conclusions may be accounted for by either of two possible explanations. First, Eysenck's (1957) early model of IE postulated that with repeated responding to a stimulus the neural excitatory processes of extraverts are eventually overcome by "reactive inhibition" (not to be confused with transmarginal inhibition). Put more simply, in a long, boring task the extravert eventually shows lapses in attention as a result of the build-up of neural inhibition. By contrast, the introvert remains activated and aroused because they do not build up reactive inhibition even during boring tasks, but rather, continue to have a preponderance of neural excitation. An alternative explanation, which relies on Eysenck's newer (1967) arousal model, has been offered by Gale (1973, 1981). According to Gale, extraverts, when faced with performing a very low arousing task (as in a slow-paced RT task or an RT task lasting over a long period of time), are placed in an environmental/behavioral conflict; that is, the situation is conducive to boredom and inattention, yet they have been asked to remain attentive and alert. Gale argues that this conflict situation results in a paradoxical increase in arousal in extraverts through self-induced arousal mechanisms. In the case of RT performance, these paradoxical increases in arousal may reach a point where transmarginal inhibition occurs in extraverts, leading to the decrements in RT performance described earlier. By contrast, introverts are able to continue performing at optimum under low arousal conditions because of their naturally high level of ARAS arousal. Several studies have in fact demonstrated that in situations of very low arousal, extraverts may exhibit greater electrophysiological arousal than introverts. (See Gale, 1973, 1981; Gilliland, 1981; Stelmack, 1981 for reviews.)

The third general conclusion may again be accounted for by the arousal inducing properties of the experimental situation. However, in this case the increase in task complexity or stimulus intensity causes the introvert to become over-aroused and recruit transmarginal inhibition processes which act to produce decrements in their RT performance, while the extraverts perform well in the face of this challenging/stimulating situation.

In conclusion, some consistency may be seen in these IE-RT studies once they are stratified by their major source of variation--the arousal inducing properties of the experimental environment. Unfortunately, only one of these studies used a psychophysiological measure of arousal concurrent with RT performance in order to obtain converging evidence of an IE-RT arousal relationship. This one study, by Thackray et al.(1974), reported that extraverts had greater increases in heart-rate variability over the course of 40 minutes of continuous RT responding. This finding may in fact be evidence of the "paradoxical arousal" which seems to develop in extraverts over the course of long, boring tasks. However, the fact that heart-rate measures are notoriously difficult to interpret, due to their dependence upon numerous environmental factors, leaves the theoretical significance of this finding unclear.

Research on Caffeine Administration, IE, RT, and the BAER

Caffeine is a potent central nervous system stimulant that has been used successfully in a number of studies to demonstrate the hypothesized arousal differences between introverts and extraverts (see Eysenck, 1967; Gilliland, 1980; Revelle, Amaral, & Turriff, 1976). Most of these studies have used caffeine to artificially increase internal arousal in an effort to reveal the inverted-U function which relates arousal level to performance.

Gilliland's (1980) study is particularly illustrative of work in this area. In this study, introverts and extraverts were pre- and post-tested on practice Graduate Record Examination verbal performance items while administered caffeine at either 0, 2, or 4 mg/kg of body weight. The results of this study revealed that introverts dramatically increased in performance between the 0 and 2 mg/kg conditions and then decreased in performance even more dramatically between the 2 and 4 mg/kg conditions. By contrast, extraverts were lower than introverts in baseline performance at the 0 mg/kg level, improved slightly at the 2 mg/kg level, and showed marked improvement at the 4 mg/kg level. Thus, increases in arousal induced by larger and larger doses of caffeine served to improve extraverts' performance in a linear fashion, while introverts' performance was only improved to a point and then significantly declined under the highest level of caffeine administration. In Pavlovian parlance, it may be said that transmarginal inhibition was induced in the introverts at the 4 mg/kg level of caffeine administration. (It may be noted in passing that similar kinds of performance decrements have also been reported for extraverts, but only when large doses of amphetamine were used as the central nervous system arousing agent--see Gupta, 1976.)

Studies which have examined the effect of central nervous system stimulants and depressants (e.g., caffeine and alcohol) on simple RT evidence numerous contradictory results. However, as Teichner (1954) has cautioned, attempts at broad interpretation of these drug studies is confounded by the considerable variation of experimental procedures used. Inadequate control of factors such as individual sensitivity, comparable dosage levels, habituation, and prior drug use may also serve to confound results.

Research on the effect of caffeine on simple RT illustrates the complexity of the problem. One might assume that caffeine administration would lead to increased arousal and, hence, decreased RT. While some studies have found this to be true (Hollingsworth, 1912; Schilling, 1921), other researchers report just the opposite, i.e., increased RT with caffeine administration (Cheney, 1935, 1936; Gilliland & Nelson, 1939). In general, it appears that at low doses (approximately 150 mg) the effects of caffeine on RT are not easily predicted. At higher doses (approximately 225-300 mg) RT has been reported to first be reduced, but then lengthened when subjects were tested 24 hours later (Horst & Jenkins, 1935). It seems reasonable to assume that some of the variability in the results of these studies may be accounted for by the uncontrolled factor of personality, as well as by the lack of experimental sophistication evidenced in many of these early studies.

Only one study has explored the relationship of caffeine administration and IE using the BAER as a psychophysiological measure of arousal. In this study, Bullock, Gilliland, and Dannels (1984) argued that for Eysenck's (1967) hypothesis of brainstem ARAS arousal differences to be upheld, the overall effect of caffeine on the BAER should mimic the differences already described concerning IE differences in the BAER; that is, increases in central nervous system arousal via caffeine administration should lead to decreases in latency and increases in amplitude of the BAER wave components. The results of this study indicated that the effect of 2 mg/kg of caffeine upon the BAER (compared to the BAER under a placebo condition) was indeed very similar to the average BAER pattern for introverts as compared to extraverts. Specifically, both introverts and individuals administered 2 mg/kg of caffeine evidenced decreased latency of wave V, as well as decreased interpeak latency between waves I and V. The caffeine did, however, appear to have a more potent effect on the latency of the BAER wave components than the IE factor alone, as caffeine administration was also associated with decreases in the latencies of waves III and VI.

Rationale and Predictions of the Present Study

In his recent review of EEG studies examining the IE dimension, Gale (1981) raised a criticism which is central to the development of the present study. It is Gale's contention that psychophysiological researchers exploring the IE dimension are too reductionistic in their approach; that is, "they emphasize the physiological domain at the expense of the behavioral and experiential domain." Keeping in mind Gale's admonition, the present study attempted to broaden the methodological approach used to explore the BAER and IE by including manipulations of both situational and physiological arousal during BAER recording.

Gale (1981) has also noted that, "Little attempt has been made so far to obtain from subjects themselves corroboratory evidence concerning the strategies they employ for adapting to environmental or experimental situations, nor indeed have state variables been tapped sufficiently to enable a partialling of trait and state effects within the laboratory" (p. 181). In an attempt to correct this deficiency, the present study employed a well-known psychometric measure of subjective arousal, the Activation-Deactivation Checklist (ADACL--Thayer, 1967), prior to and immediately following each experimental session. In addition, brief reports of subjective arousal and boredom were recorded during the course of each experimental session. One of the advantages of the present paradigm is that it makes it possible to reveal the relative influence of the various manipulations upon both the BAER and RT performance of introverts and extraverts, while simultaneously deriving self-report measures of the arousal inducing properties of the pharmacological and environmental arousal manipulations.

In his critical review of electroencephalographic studies of the extraversion dimension, Gale (1981) stated that, "The essence of psychophysiology is the integration of experiential, behavioral, and physiological domains." Gale went on to add that, "What the psychophysiologist demands of the *personality theorist* is a sensitivity to this need for integration" (p. 181, italics added). The primary purpose of the present study was to offer a test of Hans Eysenck's (1957, 1967) biological theory of extraversion which yielded to the "demands of the psychophysiologist" by incorporating within its experimental design an integration of psychophysiological, experiential, and performance measures. To this end, the present study examines the BAERs of introverts and extraverts across three levels of pharmacologically manipulated arousal (0.0, 1.5, and 3.0 mg/kg of caffeine), and across three levels of situationally manipulated arousal (resting, simple RT, and complex RT).

With regard to the BAER, it was predicted that introverts would have shorter wave latencies and larger amplitudes of the BAER wave components than extraverts during the lowest arousal situation (resting X 0.0 mg/kg of caffeine), consistent with previous studies. This relationship was expected to continue to some (undetermined) point at which the situational and pharmacological arousal would combine to induce transmarginal inhibition in the introverts. In terms of the BAER, transmarginal inhibition was operationally defined as significant increases in latency and decreases in amplitude of the BAER wave components, i.e., reduced neural efficiency due to overarousal/overstimulation.

With regard to RT, it is difficult to predict performance differences between introverts and extraverts at the lowest level of experimental arousal. Eysenck's (1967) theory predicts that introverts would have faster RTs than extraverts at this level of arousal. However, most of the past research, and the simplified model proposed by Brebner and Cooper (1974), predicts that the extraverts will show better performance. As with the BAER, it was predicted that the introverts would begin to show decrements in RT performance at the higher levels of pharmacologically and situationally manipulated arousal (complex RT X 3.0 mg/kg of caffeine), while the extraverts would continue to perform at optimum.

Method

Subjects

Subjects were 24 male undergraduate psychology students 18-21 years of age, drawn from a larger population of students (N=584), who had completed the Eysenck Personality Inventory (EPI), Form A (Eysenck & Eysenck, 1964). Twelve of the subjects were randomly selected from those students who fell in the upper 27% of the distribution of scores on the extraversion (E) dimension of the EPI, and twelve subjects were selected who fell in the lower 27% of the distribution (Cox, 1957). (Mean E score for the original sample = 13.6, s.d. = 3.8.) These two groups comprised the extravert and introvert groups, respectively. One subject's data had to be discarded due to equipment failure. This subject was subsequently replaced by random assignment of another person in the same personality group.

The final experimental group consisted of 12 introverts (mean E score = 5.5, s.d. = 2.3) and 12 extraverts (mean E score = 19.0, s.d. = 0.9). All subjects were within one standard deviation of the mean neuroticism score for the original sample (mean = 10.0, s.d. = 4.3). Other stipulations required that the subjects not be heavy caffeine consumers and not consume any caffeine the morning prior to testing time.

Apparatus

Subjects were instrumented for ipsilateral BAER recording with Grass silver-silver chloride electrodes placed at vertex (Cz) and mastoid, with the contralateral mastoid serving as ground. A Grass (model 7p511) EEG amplifier was used to amplify the subjects' EEG, using a low bandpass of 100 Hz, a high bandpass of 300 Hz, and a 60 Hz filter to reduce electrical artifact. A Nicolet CA-1000 clinical averager with low bandpass of 150 Hz and high bandpass of 3000 Hz was used to average the subjects' responses to auditory condensation clicks 0.1 msec in duration, which were delivered at a rate of 11.1/sec via Telephonics TDH-39P shielded headphones.

The averaging of the EEG was initiated at auditory click stimulus onset, with each BAER consisting of at least 2000 click trials. The analysis time was 10 msec comprising 250 sample points. To control for muscle tension and eye movement artifact, EEG potentials exceeding 10 uV triggered an automatic rejection system eliminating that trial from the evoked potential average. A permanent copy of the BAER was recorded via a Hewlett-Packard (model 7010B) X-Y plotter linked to the CA-1000 system.

The RT stimuli were delivered and RT responses recorded using an Apple II Plus microprocessor. Timing of RT events was accomplished using a Mountain Hardware "Apple Clock" (model MHP-X003) in conjunction with the microprocessor.

Procedure

All subjects attended a half hour orientation session prior to actual testing during which they were made familiar with the apparatus and procedures for BAER recording. Subjects were also given thorough instructions and 20 practice trials on both the complex and simple RT tasks during the orientation session.

On the first day of BAER testing, monaural click thresholds were determined for both ears of each subject at a click rate of 11.1/sec using the method of ascending and descending limits. During subsequent BAER testing, clicks were delivered to the subject's lower threshold ear at an intensity 80 dB above the individual's threshold (80 dB SL).

BAER testing occurred in one hour sessions on three separate days. In each session, the subject's BAER was recorded while they were resting quietly in a comfortable chair with their eyes closed, and while they were engaged in the simple and complex RT tasks.

At the beginning of each session, the subject drank 4 ounces of a sugar-free, non-caffeinated cola beverage. Caffeine dosage was adjusted for the subject's body weight. Thus, the cola beverage contained either 1.5 mg/kg of caffeine, 3.0 mg/kg of caffeine, or a small amount of quinine water (placebo condition). The caffeine conditions were administered via a double-blind procedure such that neither the experimenter nor the subject knew how much caffeine (if any) was administered on each of the three test days. Placebo or caffeine administration occurred 30 minutes prior to BAER testing. Administration of the caffeine conditions was counterbalanced within each personality group.

During the RT tasks, the subject remained seated in an upright position, but was instructed to watch the CRT of the microprocessor. During both the simple and the complex RT tasks, a rectangular box (4 cm wide X 14 cm long) was presented in the center of the CRT. This box was divided at its midpoint by a 4 cm line, creating two smaller rectangles (4 cm wide X 7 cm long) with a common side.

Subjects were required to focus their attention on the center of the left box for the simple RT task. During the simple RT task, subjects were instructed to press the "L" key of the microprocessor with the middle finger of their right hand as quickly as possible whenever a dot (5 mm X 3 mm) appeared in the center of the left box. The dot appeared in the box at random intervals between 4 and 6 seconds (mean interval = 5 sec). Although subjects were asked to "avoid" making errors by either: 1) pressing the key before the dot appeared ("anticipation" error), or by 2) pressing the wrong key ("choice" error)--speed of responding was emphasized as being most important.

BAER recording was initiated at the onset of the first RT trial. At no time during the simple RT trials did a dot appear in the box on the right. If the subject made either an anticipation or choice error, a message was printed on the screen indicating the type of error, and the subject was then required to hit the "Return" key of the microprocessor to reinitiate that trial. Subjects continued simple RT responding for a total of 80 "errorless" dot trials. During the approximately 7 minutes of RT responding two BAERs were recorded, each comprising at least 2000 click trials during the first and second half of the RT session.

During the complex RT task, a dot continued to appear every 4-6 seconds in the left hand box. However, in addition, a cross (10 mm X 13 mm) appeared at random intervals in the box on the right. Presentation of the cross stimulus occurred randomly between 1 and 3 seconds (mean interval = 2 seconds) following 40 randomly chosen dot trials. Subjects were instructed to press the "A" key of the microprocessor with the middle finger of their left hand as quickly as they could whenever the cross appeared in the box on the right of the CRT. The net result of the complex RT task was that subjects were required to divide their attention between the two rectangular boxes, and to differentially respond according to the stimulus which was presented. Also, because the crosses were presented randomly after 40 of the dot trials, the subject was required to make <u>some</u> kind of response about every 3.5 sec. As with the simple RT task, speed (rather than accuracy) was emphasized, although both anticipation and choice errors continued to be monitored. During the complex RT task, two BAERs were again recorded, beginning with the onset of the first RT time.

To avoid practice effects on the RT task across the 3 days of testing, subjects were given approximately 7 minutes of "warm up" trials each day during the 30 minutes following caffeine or placebo administration. Also, to assess the effectiveness of the caffeine arousal manipulation, subjects were given Thayer's (1967) ADACL prior to caffeine administration and at the end of each experimental session. Finally, in order to assess arousal changes throughout the course of the experimental session, questions concerning the subjects' perceived level of arousal and boredom were written into both the simple and complex RT programs. These questions took the form of two 10-point Likert scales, which appeared just prior to, and immediately following, the RT tasks. Question 1 asked: "On a scale of 1 to 10 please rate how 'aroused' you feel right now," where 1 corresponded to "not at all aroused" and 10 corresponded to "very aroused." Likewise, Question 2 asked: "On a scale from 1 to 10 please rate how 'bored' you feel right now," where 1 corresponded to "not at all bored" and 10 corresponded to "extremely bored."

Results

Analyses of peak amplitude, latency, and conduction time (CT) data from the BAER were restricted to waves I, III, V, and VI. As is common in BAER studies, responses at waves II, IV, and VII were not reliably reproduced across conditions, with wave II occasionally missing altogether and wave IV frequently merging with wave V. The statistical design was a 2(IE) X 3(CAFFEINE) X 3(TASK) ANOVA with IE (introverts versus extraverts) treated as a between factor and with repeated measures on CAFFEINE (0.0, 1.5, and 3.0 mg/kg) and TASK (resting, simple RT, and complex RT).

Concerning the amplitude of the wave components of the BAER, individual variability between subjects tended to be large. Thus, no amplitude differences were found for any of the wave components as a function of either the IE, CAFFEINE, or TASK variables.

The most prominent personality differences centered around waves III and V. Main effects for IE were observed such that the CTs of both waves I-III and waves I-V were significantly faster in introverts as compared to extraverts across all levels of CAFFEINE and TASK, $F(1, 83) = 8.92, p < .01$ and $F(1, 84) = 8.43$, $p < .01$, respectively.

There was also a main effect of IE for the absolute latency of wave V, $F(1, 84) = 8.80$, $p < .01$, such that the introvert group showed significantly decreased wave V latency as compared to the extravert group. (See Figure 1 and Table 1.)

Insert Figure 1 and Table 1 About Here

A marginally significant main effect of the CAFFEINE factor on the BAER occurred for the latency of wave V, $F(2, 84) = 2.87$, $p = .067$. Examination of this effect utilizing Ryan-Einot-Gabriel-Welch (REGW) protected t-tests (see SAS, 1982) revealed that the latency of wave V was significantly decreased across all subjects when they were administered either 1.5 mg/kg or 3.0 mg/kg of caffeine, as compared to the latency of wave V under the placebo condition, $t(84) = 4.90$, $p < .05$ and $t(84) = 3.85$, $p < .05$, respectively.

The TASK factor had a main effect on the latency of wave VI, $F(2, 84) = 4.42$, $p < .05$. Individual comparisons revealed that the complex RT task was associated with significantly longer wave VI latency as compared to the latency of wave VI during the simple RT task, $t(84) = 4.55$, $p < .05$. (See Table 2.)

Insert Table 2 About Here

Finally, a marginally significant (but theoretically provocative) three-way interaction occurred between IE, CAFFEINE, and TASK for the CT of wave I-V, $F(4, 84) = 2.25$, $p = .07$. Individual comparisons of this interaction revealed that the mean CT of wave I-V was significantly longer for the extraverted subjects during the simple RT task under the placebo condition than the mean CT of wave I-V for the introverted subjects under any combination of CAFFEINE and TASK. (See Figure 1.)

A 2(IE) X 3(CAFFEINE) X 2(TASK) repeated measures ANOVA was used to analyze the RT data. As expected, simple RT was faster than complex RT, $F(1, 10) = 85.39$, $p < .01$. In addition, a marginally significant three-way interaction was found between IE, CAFFEINE and TASK, $F(2, 10) = 3.65$, $p = .065$. Individual comparisons revealed that this three-way interaction was due to the introverts performing significantly faster on the simple RT task under both the 1.5 mg/kg and 3.0 mg/kg caffeine conditions than the extraverts on the complex RT task under any of the three caffeine conditions, $p < .05$ for all comparisons. (See Figure 2.)

Insert Figure 2 About Here

In general, it may be noted that performance on the simple RT task was virtually indistinguishable between the two personality groups, while the introverts tended to have faster RTs than extraverts for the complex RT task across all levels of caffeine administration. No significant differences were found between the personality groups for the number of anticipation or choice errors made on either RT task, nor were there any significant differences found in the number of anticipation or choice errors as a function of either the CAFFEINE or TASK variables.

A multivariate analysis of variance procedure (Wilk's criterion) conducted on the pre and post scores of the four subscales of the ADACL revealed only a marginally significant overall effect for the IE factor, $F(8, 37) = 1.93$, $p = .084$. Further analysis using univariate ANOVAs did not reveal any significant main effects for IE for any of the four subscales. The univariate ANOVAs did, however, find significant main effects for the caffeine factor on the posttest subscales of Deactivation-Sleep (DS) and High Activation (HA), $F(2, 27) = 4.27$, $p < .05$ and $F(2, 27) = 3.90$, $p < .05$, respectively.

Individual comparisons of the main effect of CAFFEINE on DS posttest score revealed that all of the subjects reported feeling significantly less deactivated and sleepy at the end of the sessions in which they had received either 1.5 or 3.0 mg/kg of caffeine, as compared to the end of the session in which they had received the placebo, $t(44) = 4.89$, $p < .05$ and $t(44) = 3.58$, $p < .05$, respectively.

Individual comparisons of the main effect of CAFFEINE on HA posttest score revealed that all of the subjects reported feeling significantly more highly activated at the end of the session in which they had received 3.0 mg/kg of caffeine as compared to the sessions in which they had received either 1.5 mg/kg of caffeine or the placebo, $t(44) = 3.98$, $p < .05$ and $t(44) = 4.36$, $p < .05$, respectively.

Finally, with regard to the subjective measures of arousal and boredom obtained via the Likert scale questions given prior to and immediately following each RT task, a 2(IE) X 3(CAFFEINE) X 2(TASK) repeated measures ANOVA revealed main effects for both the TASK and CAFFEINE factors. TASK was found to have main effects on the post measures of arousal and boredom such that all subjects were significantly less aroused and more bored following the simple RT task as compared to the complex RT task, $F(1, 44) = 21.94$, $p < .01$ and $F(1, 44) = 8.10$, $p < .01$, respectively.

Likewise, changes between the pre and post measures of arousal and boredom were significantly different across the two tasks, $F(1, 44) = 9.89$, $p < .01$ and $F(1, 44) = 4.09$, $p < .05$, respectively. All subjects finished the simple RT task feeling significantly less aroused and more bored than before they began the task, whereas they finished the complex task feeling <u>more</u> aroused (although not any more bored) than when they began the complex task.

CAFFEINE was found to have main effects on both the pre and post measures of arousal, $F(2, 44) = 4.07$, $p < .05$ and $F(2, 44) = 4.80$, $p < .05$, respectively, such that all subjects reported feeling significantly more aroused both prior to and following both of the RT tasks when they had been administered either 1.5 mg/kg or 3.0 mg/kg of caffeine. The caffeine manipulation had <u>no</u> effect on the subjective measure of boredom.

Discussion

The present results concur with earlier research in suggesting that personality differences on the IE dimension may indeed be manifested at subcortical levels as Eysenck (1967) has hypothesized. Further, differences between introverts and extraverts on the BAER continue to be centered around wave V (inferior colliculus). The decreased CT between waves I-III and waves I-V found for the introverted subjects in the present study, as well as the decreased latency of wave V for introverts, supports earlier work by Andress (1981) and Bullock et al. (1982) in which similar interpeak and absolute latency measures suggested that introverts evidence faster neural transmission along the auditory pathway between the acoustic nerve and the inferior colliculus (at least at relatively high levels of auditory stimulation).

In the present study, introverts manifested this greater neural efficiency across all levels of pharmacologically and environmentally manipulated arousal. It is particularly notable that the present study confirmed CT decreases between wave I-V in introverts, as well as an absolute latency decrease in wave V. This finding, coupled with the fact that no latency differences due to personality were found at the level of wave I, suggests that central ARAS arousal mechanisms are responsible for these latency differences between introverts and extraverts--and not just peripheral sensitivity differences, as Stelmack and Plouffe (1983) have suggested. It should be noted that the differing explanations offered for the observed differences in the BAERs of introverts and extraverts may to some degree be a function of the different BAER methodologies used by the different laboratories, such as the choice of condensation versus rarefaction or alternating polarity click stimuli, or the practice of equating introverts and extraverts using individual auditory thresholds (dB SL) versus not equating the subjects for initial threshold differences (dB SL).

Concerning the CAFFEINE and TASK manipulations, the present results concur with earlier work from this laboratory (Bullock et al., 1984) in suggesting that situational arousal which is either pharmacologically or environmentally induced does have an effect on the BAER. This replication is important since prior researchers have generally reported that the BAER is totally unaffected by situational arousal. It now appears that the widely held belief in the "immutability" of the BAER to situational arousal manipulations may be true only for the lower brainstem components, but not for components at the level of waves V and VI.

Of particular interest in the present study was the finding that the general effect of the caffeine administration upon the BAERs of both introverts and extraverts, compared to the BAER under the placebo condition, was isomorphic to the average BAER pattern for introverts compared to extraverts. Specifically, both introverts and individuals administered either 1.5 mg/kg or 3.0 mg/kg of caffeine evidenced decreased latency of wave V. This result appears to confirm the present study's hypothesis that decreased latency between waves I-V in the BAERs of introverts is a function of their higher level of CNS arousal.

The TASK factor was also associated with changes in wave peak latency for both introverts and extraverts--this time at the level of wave VI. The effects of the RT tasks were particularly interesting in that the simple RT task was associated with <u>decreased</u> latency of wave VI across both personality groups, while the complex RT task was associated with significantly <u>increased</u> wave VI latency across both groups. This finding suggests that a RT task which required only motoric and reflexive processing was associated with increased neural efficiency, while a RT task that required additional decision making processes was associated with decreased neural efficiency. This last finding also provides support for previous work (Bullock, 1983) in which the performance of a complex vigilance task was associated with increased latency of wave V across a group of young, middle aged, and elderly women.

The lack of any interactions between IE and the experimental manipulations of arousal for the BAER measure suggests that the introverts in this study were never pushed beyond their optimal level of arousal in terms of brainstem auditory pathway activation. Likewise, the RT data suggest that introverts in this study were not stressed by either the drug or task manipulations to a point where their performance degraded below that of extraverts. Thus, it does not appear that transmarginal inhibition was induced in the introverts even at the highest levels of caffeine administration and task demand. In fact, with regard to the RT tasks, it was found that under the low and high caffeine dosages the introverts performed significantly faster on the simple RT task than the extraverts did under any level of caffeine administration. Also, as noted earlier, the introverts consistently outperformed the extraverts on the complex RT task across all levels of caffeine administration, although this difference was not statistically significant.

One theoretically provocative (although statistically nonsignificant) result did emerge as a function of an interaction between IE and the CAFFEINE and TASK manipulations. In Figure 1, it may be noted that the CT of wave I-V for extraverts during the placebo condition varies greatly as a function of the type of RT task they were performing--simple or complex. This difference is noteworthy since it is exactly the opposite of the main effect of TASK at the level of wave VI. Specifically, extraverts showed shorter CT of wave I-V during the complex RT task and longer CT of wave I-V during the simple RT task. By contrast, introverts under the placebo condition exhibited the more usual pattern of longer CT during the complex RT task. Of even greater interest, however, is the change in the wave I-V CT of extraverts which occurs after ingestion of 3.0 mg/kg of caffeine. Under this condition, the effect of the simple and complex RT tasks upon the CT of wave I-V for extraverts dramatically shifts to the more usual result that CT is lengthened during a complex RT task.

Researchers have noted that consumption of alcohol by introverts has the effect of making them "look" like extraverts on measures of performance, since the alcohol is a CNS depressant that has the effect of lowering their level of arousal. In a similar vein, this latest finding suggests that the ingestion of 3.0 mg/kg of caffeine by extraverts has the effect of making them "look" like introverts in terms of their BAER under different TASK conditions.

In the present study, no personality differences due to subjective perceptions of arousal were evident using either the ADACL or the Likert scale questions concerning feelings of arousal and boredom. Nevertheless, these subjective measures do provide a validation check of the hypothesized effects of the CAFFEINE and TASK manipulations. Concerning the ADACL, the administration of either 1.5 mg/kg or 3.0 mg/kg of caffeine was associated with reported decreases in Deactivation-Sleep. The effect of caffeine on the subscale High Activation is particularly interpretable, since HA is defined by adjectives such as "jittery" and "stirred up," and the effect of 3.0 mg/kg of caffeine was to significantly increase those feelings in all subjects. Thus, both the low and high levels of caffeine administration led to decreases in "sleepiness," but only the highest dosage level led to increases in "jitteryness."

Caffeine administration at either the low or high dosage levels also was associated with increases in reported arousal using the Likert scale questions prior to and following each RT task. Caffeine administration did not, however, lead to any changes in perceived boredom throughout the tasks. Thus, it appears that an individual can be pharmacologically "aroused," yet still be bored. Finally, with regard to the subjective measures, there was no evidence for "paradoxical arousal" occurring in the extraverts across the course of the experimental tasks.

In conclusion, the data obtained in the present study regarding differences in RT performance and the BAER between introverts and extraverts lend themselves best to an interpretation derived from Eysenck's theory, i.e., extraverts are lower in ARAS arousal and evidence greater neural inhibition than introverts. In the case of the BAER this lower arousal/greater inhibition appears to result in increased CT along the brainstem auditory pathway. In the case of performance on a complex RT task, the lower arousal/greater neural inhibition of extraverts results in generally poorer performance. The RT differences found in the present study do not support the Brebner-Cooper model of IE--where introverts are hypothesized to be "geared to inspect" environmental stimuli while extraverts are "geared to respond" to environmental stimuli. In the complex RT task, greater inspection time was necessary to make the correct response, yet it was the introverts who performed fastest. Furthermore, contrary to the Brebner-Cooper model, extraverts did not commit more errors of commission than the introverts, even though speed of responding was stressed over accuracy of responding.

It is likely that the relatively atypical RT results of the present study are a function of the extensive practice and multiple trials subjects were given on the RT tasks. In particular, the lack of variability in the simple RT results suggests that a "ceiling effect" was in operation. Finally, in contrast to the present study's prediction, the addition of extra CNS arousal via administration of 3.0 mg/kg of caffeine and increased task demand apparently served only to keep the RT performance of introverts at a higher asymptotic level than that of the extraverts.

The failure of the present study to demonstrate transmarginal inhibition effects in the introverted subjects at the highest levels of caffeine administration and task demand for either BAER functioning or RT performance was unexpected. Nevertheless, this null finding is supported by the psychometric measures of activation and arousal, since they also found no differences between the introverts and extraverts in terms of subjectively felt arousal. Apparently, the cognitive demand of the complex RT task provided only a moderate level of arousal, even in conjunction with the administration of 3.0 mg/kg of caffeine. Given that even the relatively simplistic arousal manipulations of TASK and CAFFEINE did have main effects on the BAER and RT, further studies would profit by examining the differential effect of other stimulant and depressant drugs on the BAERs of introverts and extraverts while they are engaged in a variety of cognitive tasks ranging from relatively simple to very complex.

In a short critique of the psychophysiology of individual differences, Gale and Edwards (1983) urged researchers to abandon simplistic, single-factor, correlational studies and made an appeal for more "process-related" investigations which focused on the interactive nature of cognitive, behavioral, and physiological aspects of behavior, as well as social and interpersonal aspects. Having attempted an initial foray into the biological bases of IE utilizing this approach, the present author is compelled to add a cautionary postscript to the idealistic advice offered by Gale and Edwards. Namely, the gains accrued by implementation of complex, interactive designs are not without their costs, both in terms of increased logistical difficulty and in terms of increased difficulty of theoretical analysis. Nevertheless, given that the present study was able to take on this challenge and achieve a moderate degree of success, the present author retains an optimistic outlook for future studies which utilize multi-model approaches to understand the biological bases of individual differences.

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TABLE 1

Means and standard deviations
for the conduction time (measured in milliseconds)
between waves I-III and I-V
for each IE X CAFFEINE X TASK group

INTERVAL	IE	CAFFEINE (mg/kg)	TASK Resting	Simple RT	Complex RT
I-III	I	0.0	2.03 (.17)	2.01 (.17)	2.10 (.14)
	I	1.5	2.10 (.15)	2.07 (.12)	2.11 (.13)
	I	3.0	2.05 (.13)	2.08 (.18)	2.09 (.12)
	E	0.0	2.16 (.23)	2.27 (.51)	2.08 (.30)
	E	1.5	2.23 (.14)	2.31 (.16)	2.20 (.10)
	E	3.0	2.18 (.13)	2.16 (.24)	2.23 (.14)
I-V	I	0.0	3.94 (.21)	3.89 (.25)	3.96 (.21)
	I	1.5	3.92 (.22)	3.98 (.24)	3.98 (.22)
	I	3.0	3.95 (.18)	3.95 (.21)	3.95 (.19)
	E	0.0	4.22 (.22)	4.35 (.52)	4.07 (.33)
	E	1.5	4.16 (.27)	4.21 (.25)	4.12 (.25)
	E	3.0	4.19 (.14)	4.12 (.20)	4.16 (.23)

TABLE 2

Means and standard deviations
for the reaction time (measured in milliseconds)
of introverts and extraverts to the dot and cross stimuli
for each IE X CAFFEINE X TASK group

STIMULUS	IE	CAFFEINE (mg/kg)	TASK Simple RT	Complex RT
Dot	I	0.0	290 (19)	325 (26)
	I	1.5	283 (24)	326 (28)
	I	3.0	283 (17)	328 (20)
	E	0.0	290 (31)	350 (50)
	E	1.5	288 (30)	338 (46)
	E	3.0	285 (25)	344 (36)
Cross	I	0.0	.	353 (34)
	I	1.5	.	360 (35)
	I	3.0	.	346 (27)
	E	0.0	.	378 (51)
	E	1.5	.	368 (43)
	E	3.0	.	369 (38)

Figure Captions

<u>Figure 1.</u> Mean Conduction Time (msec) of Wave I-V for introverts and extraverts as a function of CAFFEINE and TASK.

<u>Figure 2.</u> Mean Reaction Time (msec) of introverts and extraverts as a function of CAFFEINE and TASK.

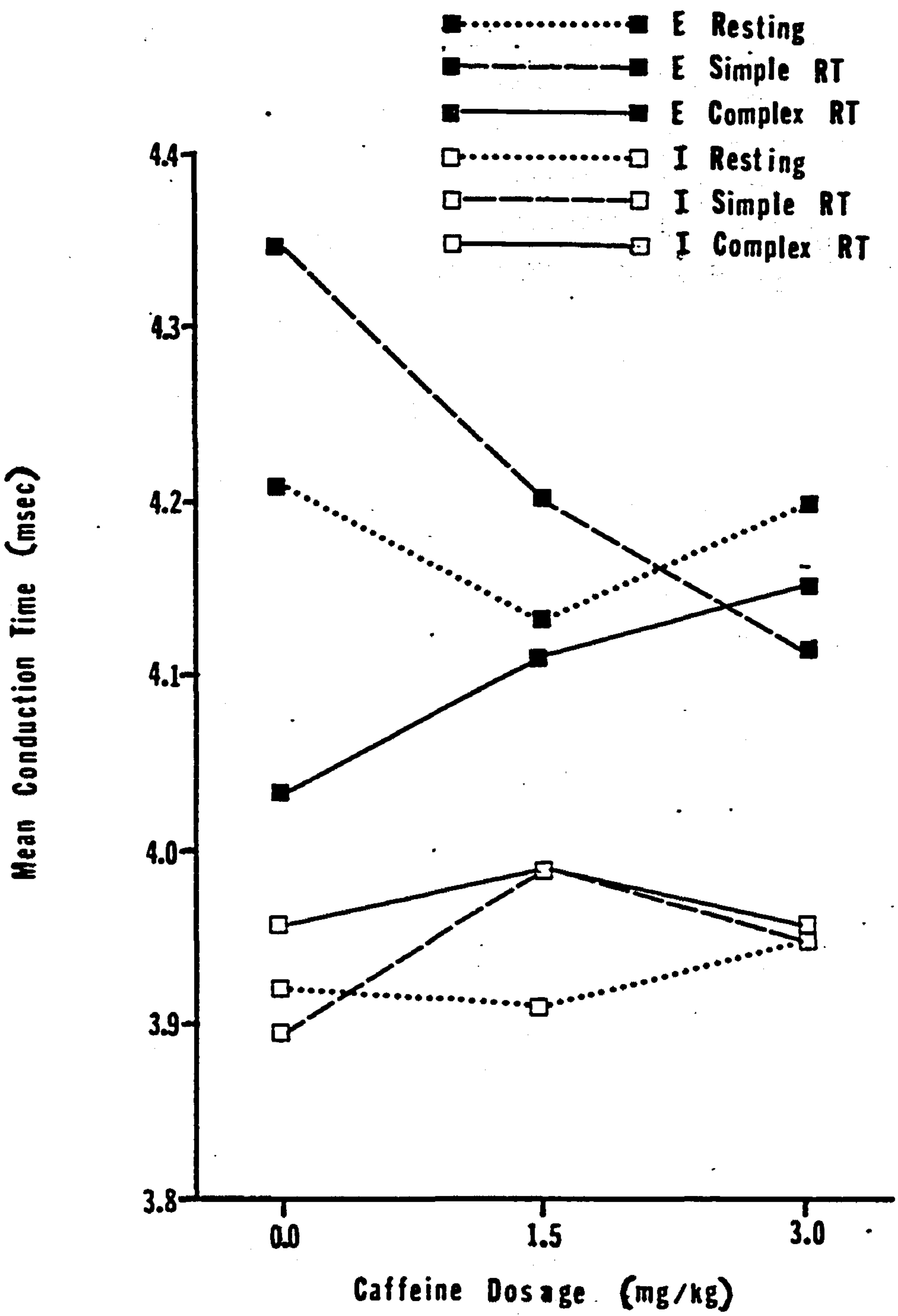
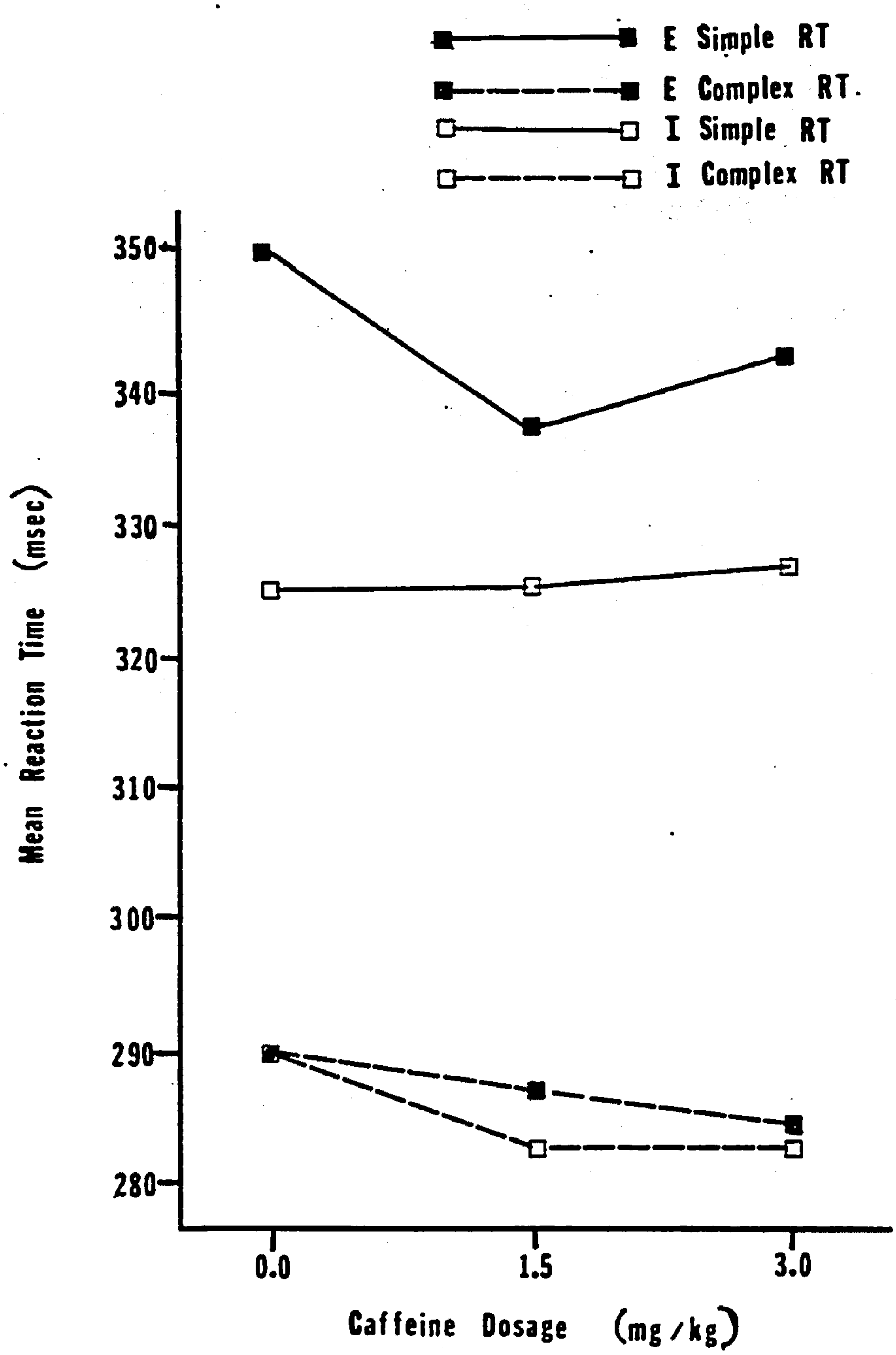

E Resting
E Simple RT
E Complex RT
I Resting
I Simple RT
I Complex RT
4.4
4.3
4.2
4.1
4.0
3.9
3.8
Mean Conduction Time (msec)
0.0
1.5
3.0
Caffeine Dosage (mg/kg)

Figure 1


E Simple RT
E Complex RT
I Simple RT
I Complex RT
350
340
330
320
310
300
290
280
Mean Reaction Time (msec)
0.0
1.5
3.0
Caffeine Dosage (mg / kg)
Figure 2