The Effects of Extraversion and Attention on Short-Term Habituation of Auditory Evoked Potential Responses

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CURRICULUM STUDORIUM

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ABSTRACT

The Effects of Extraversion and Attention on Short-Term Habituation of Auditory Evoked Potential Responses.

The Auditory Evoked Responses to tonebursts of 80 dB, 500 hz and of .2 second duration were recorded from two groups of 24 subjects each, classified as introverts and extraverts. In the experimental condition, a train of four stimuli with ISI of 1 second was repeated 24 times with an intertrain interval (ITI) of 60 seconds, giving a total of 96 stimulations. Each of the four stimuli was averaged across the 24 trains. In the control condition, the 96 stimuli were given in a continuous series at the regular rate of 1/sec. All subjects underwent the two sessions which were given in a counterbalanced order. Half of the subjects of each group were requested to attend to the stimulus and the remaining half were instructed to ignore the stimulus. No differences between attend and ignore conditions were observed for the N1 - P2 component. When the amplitude of peaks N1 and P2 was analysed from a prestimulus baseline, an interaction between extraversion and attention was observed. Under the attend condition, introverts displayed larger P2 amplitude than extraverts. However, introverts had smaller N1 amplitude than the extraverts under the attend condition. Larger initial N1 - P2 amplitude was also observed for the introverts thus demonstrating consistency with previous results (Stelmack, Achorn, & Michaud, 1977). These findings suggest that the larger N1 - P2 amplitude for introverts found in the previous research was expressed in larger initial amplitude response, mostly contributed by P2 component. The findings support Eysenck's proposal that introverts are characterized by higher levels of cortical activity.

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INTRODUCTION

Many studies stemming from Eysenck's (1967) theory of extraversion, have discussed the personality dimension of introversion-extraversion and its various correlates. According to this theory, individuals who are introverted will possess a neurally more aroused and less inhibited cortico-reticular system than the extraverted.

Four years ago, Stelmack, Michaud, and Achorn (1977) showed greater N1 - P2 amplitude for introverts at 55 and 80 dB intensity with low (500 hz) frequency auditory stimulation. The subjects were required to count the number of alternating high and low frequency tones. The authors interpreted the increased amplitude for introverts as indicative of higher levels of cortical excitation and lower levels of inhibitory potential as proposed by Eysenck. Stelmack et al. suggested that the observed larger N1 - P2 amplitude in their study could be understood in terms of greater sensitivity for the introverts. This interpretation was consistent with reports of enhanced sensory sensitivity of introverts (Siddle, Morrish, White, & Mangan, 1969; Smith, 1968; Haslam, 1967; Stelmack & Campbell, 1974) and with results of the physiological responsiveness reflected in larger initial electrodermal responses for the introverts (Mangan & O'Gorman, 1969; Stelmack, Chian, Bourgeois, & Pickard, 1979). The paradigm used by the authors (Stelmack et al., 1977) could not determine whether this sensitivity was reflected by constant larger N1 - P2 responses through the entire experimental session or in larger initial responses with slower decaying in responses than extraverts.

The greater N1 - P2 amplitude for the introverts reported in the previous study could also be accounted for by the task requirement to count the stimuli . It is well established that introverts perform better than extraverts on vigilance tasks (cf: Harkins, Russel, & Geen, 1975). The attention to auditory stimulation is also recognized to have an enhancement effect on the late component of AER (Naatanen, 1975; Picton, & Hillyard, 1974). This possible attentional effect should then be reflected in larger N1 - P2 amplitude for the introverts when they attend but not when they ignore the stimulus. It is felt that due to lack of such a control, Stelmack et al.'s study could not adequately assess whether or not a relationship between attention and extraversion existed.

A primary aim of this study will be to replicate the effect of the previous study by using a short-term habituation paradigm to allow the examination of pattern of responses and at the same time to control for attention effects.

A second aspect of this study will be an attempt to investigate attention effects on response decrement. At the present time there is uncertainty regarding the influence of attention on evoked response decrement. Some investigators showed that a subject's state has an effect on the N1 - P2 component and its short-term habituation (Fruhstorfer, 1971; Fruhstorfer, & Bergstrom, 1969) while others (Ohman & Lader, 1972; Picton, Hillyard, Galambos, 1974) reported that the manipulation of attention had no effect on habituation rate. It is hoped that the results of the present study will provide some clarification in this debate.

To examine if habituation is accomplished by the first few stimuli, a stimulus-by-stimulus analysis versus blocks of stimulus sequence analysis will be performed on the same data. Some authors have succeeded in demonstrating that an asymptote level is reached at the third stimulus (Fruhstorfer, 1970, 1971; Ritter, Vaughan, & Costa, 1968) while others (Ohman & Lader, 1972) have argued that more stimuli and a longer period of time are required to obtain complete habituation. The two statistical analyses proposed in this study might bring information regarding short and long-term habituation.

To determine the occurrence of habituation, two conditions will be introduced in this study: an experimental condition consisting of trains of stimuli and a control condition in which a series of tones are given. The interaction between these two conditions will indicate the occurrence of habituation.

CHAPTER 1

Review of the Literature

This chapter presents a review of the theoretical and experimental work which provided the basis for the problem to be investigated in this paper. The chapter is divided into six sections. The first part gives a general overview of Eysenck's theory of extraversion and is followed by a review of experimental work in sensory sensitivity (section 2), attention (section 3), habituation (section 4) and cerebral evoked potentials (section 5). The last section discusses the evoked potential procedures used in the present study. The chapter concludes with the statement of hypotheses.

Eysenck's Theory of Extraversion

In everyday situations people show personality characteristics which differentiate them from one another even within the same family. Some are lively, outgoing, talkative, friendly, while others are quiet, careful, serious and have few friends. Even though people differ from each other, common interest, attitudes, values and behaviors lead to the formation of categories. For example some people are frequently seen in libraries while others like to gather in parties. It is these individual variations which became the subject of study for Eysenck. His goal was to offer a theory that ties individual differences in temperament to individual differences in physiological functioning.

Eysenck (1947) started his investigation by using objective tests and factor analysis methods. He extracted two major and independent second order factors which he identified as "introversion-extraversion" and "neuroticism-stability". The given traits were quantified in terms of a dimension ranging from low to high and the difference between extraverts and introverts was a matter of degree instead of a circumscript category.

After having isolated and identified these dimensions of personality, Eysenck moved toward an explanatory approach in which a theory of the basis for the dimensions would be tested with specific experiments. His first attempt was to explain behavioral differences between introverts and extraverts in terms of learning theory. Differences in conditionability were said to depend on differences in the excitation-inhibition balance (Eysenck, 1957). Introverts were proposed to be prone to develop excitation and the extraverts to develop reactive inhibition. Consequently introverts would be expected to display sensitivity and efficiency in processing of sensory stimulation, acquire conditioned responses more quickly and extinguish them more slowly than extraverts.

The excitation-inhibition balance was a hypothetical construct; the physiological basis of this notion was not specified. In 1967, Eysenck identified the extraversion dimension with differences in arousal level related to specific structures of the ascending reticular activating system and which he called cortico-reticular loop. This loop includes afferent sensory pathways to the cortex, afferent collaterals to the reticular formation and ascending pathways from the reticular formation to the cortex.

The reticular system, located caudally in the brain stem, extends from the caudal bulb to the diencephalon and is composed of a diffuse cellular network comprising cells of various shapes and sizes and with axon travelling in many different directions. The neural impulses generated in the sensory system travel through the RAS to the sensory receiving area of the cortex, while neural messages connected diffusely throughout the cortex reach the RAS by mean of collaterals. Communications travel in both directions: the cortex receives large numbers of fibres from the reticular system and in turn, sends messages directly back.

The extent to which cortical areas exert an effect upon the reticular formation and participate in the control of sensory input is relevant to Eysenck's hypothesized corticoreticular feedback loop. The cortical connections to the reticular formation provide a means whereby the cortex could control the activating mechanism of the brainstem and thus influence its own level of arousal. French, Verzeana and Magoun (1952) compared transmission latencies of the specific sensory pathways and those of the reticular formation. Impulse velocities were faster in the specific sensory pathways which suggests that there is time for a stimulus to reach the cortex via the specific path and then relay down to the reticular formation in time to affect its own arousal properties.

That the cortex is known to be the modifier of its own arousal by filtering out sensory stimulation, or by allowing more informatory sensation, had an impact on Eysenck's theory. He related differences in behavior with differential thresholds in various parts of the ascending reticular activating system, and postulated that introverts have lower thresholds of arousal than extraverts (Eysenck, 1967). Consequently, introverts would be more sensitive and responsive to external stimulation and in general they would condition better than extraverts.

Gray (1972) has offered suggestions for the modification of Eysenck's theory of introversion-extraversion. After reviewing the conditioned fear literature and re-reviewing some of the studies investigating the physiological basis of the extraversion dimension, Gray concludes that Eysenck's hypothesis of greater conditionability for the introvert should be replaced with the hypothesis that introverts are more susceptible to punishment and frustrative nonreward. Furthermore, the results of experimental work which demonstrated that both sodium amytal and lesions in the frontal cortex produce an increase in extraverted behavior are interpreted by Gray to suggest that a frontal cortex - medial septal - hippocampal system lies at the basis of the extraversion dimension. Gray, therefore, suggests that the physiological basis of extraversion dimensions lies not only in the ascending reticular activating system, but also in a negative feedback loop consisting of the orbital frontal cortex, the medial septal area, and the hippocampus.

The behavioral evidence which Gray (1973) derived compelled him to rotate the lines of causal influence at 45^{0} from Eysenck's dimension and to focus on the dimension of anxiety (diagonal from extravert to neurotic introvert) and impulsivity (diagonal from stable introvert to neurotic extravert). According to Gray, increasing level of anxiety reflects increasing levels of sensitivity to punishment while increasing level of impulsivity demonstrates increasing levels of reward. Later Gray (1977, 1978) suggested an underlying physiological system activity to explain the anxiety-impulsivity dimensions. The behavioral inhibition system (BIS) consisting of an interacting set of structure comprising the septo - hippocampal system (SHS) its monoamenergic afferents from the brainstem and its neocortical projection in the frontal lobe is according to Gray, responsible for the increasing level of anxiety. A separate and independent system is believed to control the level of impulsivity. However the structure of this system is not well known.

Present research is not a test to distinguish between Eysenck's and Gray's theory but both physiological bases account for predictive effects with personality differences.

One may argue that the arousal properties of the ARAS is presented in a rather simplistic manner by Eysenck and that different states of arousal resulting from the ARAS activity cannot be directly tested in human subjects. However, his theory linking the major aspects of the descriptive system to causal theories enables a large number of predictions which may be verified by experimental studies. Extraversion and Neuroticism measures continue today to enjoy investigative appeal for researchers interested in relating dimensions of personality to physiological measures. Although there is a good deal of evidence to support the hypothesis, the question is far from being resolved.

Eysenck concludes that his theoretical framework is an attempt to interpret the personality dimensions and that "different and as yet unknown structures might exist in the brain stem and the midbrain which served the function of mediating the personality features associated with neuroticism and extraversion" (Eysenck, 1967, p. 255). Research which has considered the validity of the hypothesis that introverts are characterized by increased level of cortical arousal, is reviewed in the present proposal and is drawn from a number of sources, specifically sensory sensitivity, attention and habituation. The present research problem has been drawn from evidence in those three areas.

Extraversion and Sensory Sensitivity

If introverts are characterized by lower thresholds of reticular activity, one predicts that introverts would have lower sensory thresholds since increased activity in the reticular system is associated with a lowering of sensory thresholds. Support for this hypothesis has been brought by a number of investigations in different modalities.

Smith (1968) was the first to report lower absolute sensory thresholds for introverts than for extraverts. Using a 500 hz pure tone as a stimulus and a test group consisting both of extreme introverts and extraverts, Smith detected a difference in absolute auditory thresholds. In this comparison, the confidence in his findings would have been enhanced if he had employed more than three subjects per group.

Siddle, Morrish, White, and Mangan (1969) utilizing a visual stimulus with a larger group of subjects (15), found a rank order correlation of -.52, demonstrating a negative relationship between extraversion and sensitivity of the excitatory process. Neuroticism was reported by the authors as a confounding variable in their results, since high N subjects were included.

Haslam (1966) attempted to relate personality to pain thresholds. She employed a radiant-heat type of apparatus and found that introverts had a lower mean pain threshold than extraverts. The author suggested that the difference in thresholds was attributable to a difference in level of arousal, supporting Eysenck's hypothesis that introverts are characterized by lower threshold of arousal.

Dunstone, Dzendolet and Hewckeroth (1964) used low frequency sinusoidal electrical stimulation of the human vestibular apparatus, which produces sway at and above threshold levels to investigate personality effects upon response level (RL). They found that introverts responded at significantly lower levels than was the case for extraverts thus demonstrating evidence of lower level of arousal for introverts.

In a more recent study Stelmack and Campbell, (1974) using a signal detection method which provided measures of sensitivity that were relatively independent of response bias, showed that under low frequency auditory stimulation, (500 hz) introverts were significantly more sensitive than extraverts. With high frequency stimulation (6000 hz) extraverts showed an increase in sensitivity, while the introverts showed a decrease. The authors discussed their results in relation to Eysenck's (1963) hypothesis of the relationship between hedonic tone and strength of sensory stimulation. Introverts manifest lower intensity levels of optimal or preferred stimulation while extraverts are seen to prefer stronger more intense levels of stimulation. Stelmack and Campbell suggest that introverts may have lower frequency levels of preferred stimulation as well as lower intensity levels.

Moreover, there is some support for the suggestion that equal amounts of stimulation will produce greater response in the introvert than in the extravert. Corcoran (1964) found remarkably high negative correlations, ranging to approximately 0.70, between degree of extraversion and amount of saliva secreted to a few drops of lemon juice. When citric acid or a diluted commercial product were employed, no significant correlations were found. Eysenck and Eysenck (1967) replicated Corcoran's study and they also found a high degree of correlation between personality and the amount of secreted saliva.

In general, the studies cited provide evidence of the introverts' greater sensory sensitivity and results are consistent with the proposed hypothesis of increased cortical excitation for the introverts.

Extraversion and Attention

Another area which is particularly suitable for investigating the arousal hypothesis with individual differences is the effect of sustained attention on performance. The sustained attention to a periodically presented stimulus is characterized by a progressive decline in detection performance. In terms of Eysenck's (1967) theory, introverts are expected to be superior to extraverts in vigilance tasks because the persistently heigthened arousal level of introverts facilitates vigilant attention and prevents performance decrements.

Over a dozen studies have demonstrated the superiority of introverts in connection with many different types of task. Bakan (1959) developed a vigilance task consisting of a tape recording of digits presented at the rate of one per second. The task for the subject was to detect any successive odd-even-odd sequence. Bakan found the performance of introverts to be significantly superior to extraverts. Four years later, Bakan, Belton and Toth (1963), using this same task, found that the proportion of the extraverts showing a performance decrement over time was significantly greater than the corresponding proportion of the introverts.

Some investigators suggested that impulsivity, one of the extraversion components, (Eysenck & Eysenck, 1968) was related to the vigilance decrement. Krupski, Raskin and Bakan (1971), hypothesized that impulsive persons will tend to generate commission errors (CE) on the vigilance task developped by Bakan (1959). The CEs expected to be positively correlated with extraversion were not significant in Krupski et al.'s findings. However, the results found in the expected direction were interpreted by the authors as evidence that the personality variable is related to the making of commission errors.

Using a serial-reaction task, Thackray, Jones and Touchston (1974) attempted also to relate impulsivity to performance decrement. They found that extraverted subjects were characterized by impulsivity and increased lapses of attention, while introverted subjects were less impulsive and failed to show any evidence of a decline in attention.

Brebner and Cooper (1974) noticed, in many studies, differences in performance between introverts and extraverts on the last part of the task. Using a reaction time (RT) task they found a slowing in the performance of the extraverted subjects in the second half of the experiment with no such tendency for the introverts. The absence of any difference between the two groups in the early stages of the performance was interpreted by the authors as evidence that arousal level was not the explanation for individual differences in performance. They hypothesized the existence of an imbalance between the effects of stimulation and response organization to explain differences in the performance of introverts and extraverts. The stimulation was believed to create an excitatory state (s-excitation) but response preparation to build up an inhibitory state (R-inhibition) in the introvert, while the extravert generates excitation from the emission of response (R-excitation) but inhibition from the stimulation effect (S-inhibition). In a subsequent study (Brebner & Cooper, 1978) the extraverts were found to take shorter time to inspect visual stimuli than did the introverts and they attempted to change the stimuli more often, thus supporting the "imbalance" hypothesis.

Harkins and Geen (1975) suggested that differential performance on a vigilance task associated with extraversion-introversion could be due to arousal (Eysenck, 1967). In a 42 minute visual signal detection task, divided into three 14 minute trials, the introverts were found to be superior to extraverts in their detection rates but the rate of decline was the same for each group. The authors hypothesized that the introverts, being characterized by greater cortical arousal, will perform better than extraverts at the beginning of a test, but as the task progresses, the arousal level decreases and performance declines at an equivalent rate for each personality type. In a similar investigation (Gange, Geen, & Harkins, 1979), the introverts were also found to detect more signals than did the extraverts during a vigilance task. The authors interpreted their findings as being consistent with the assumption that introverts are more arousable than extraverts across a range of situations varying in arousal potential and attentional demands.

Results cited are sometimes contradictory or difficut to interpret. Although there are still anomalies in studies involving performance tasks it may be said that vigilance experiments give some support to an arousal theory of introversion-extraversion.

Extraversion and Habituation of the Orienting Reaction

A number of habituation studies have been reported which address the arousal hypothesis associated with differences in personality. These habituation studies have provided critical tests and support of Eysenck's theory.

The definition of habituation, although expressed in different terms by a large number of authors, is operationally defined in every study as a response decrement resulting from repeated stimulation (Harris, 1943). It is by no means certain that the processes underlying the observed decrement in response are the same in all cases. In fact a number of researchers do not agree with the theoretical mechanisms of behavior change (Graham, 1973; Groves & Thompson, 1970; Lynn, 1966). Of all the numerous theories formulated, only those relevant to the present study will be discussed.

The introversion-extraversion dimension explained in terms of a cortico-reticular loop has similarities with the sokolovian model of the Orienting Reflex (Sokolov, 1960), a biological activity for attending to pertinent information in the environment. Both Sokolov and Eysenck emphasized the importance of the cortico-reticular activity in sensory information processing, cortical arousal and inhibition.

The mechanism proposed by Sokolov is a stage of stimulus analysis followed by a second stage of excitation or inhibition of the orienting reaction. If the cortex analyses the stimulus as a familiar one it initiates an inhibitory blocking action on the OR by sending inhibitory impulses which prevent the OR from occurring. The blocking action takes place in the afferent collaterals. On the other hand, if the stimuli are new or significant to the organism, the cortex sends excitatory impulses to the reticular formation.

According to Eysenck's theory, introverts should habituate slowly, showing more persistent ORs because of their poor inhibitory properties, whereas extraverts, because of their excessive inhibition, habituate with greater ease. The conceptual similarity in these positions has thus prompted Eysenck to suggest that the links between his theory of introversion-extraversion and the neuronal model of Sokolov might be the association of sensitivity with high level of cortical arousal. Experimental evidence bearing on the predictive validity of Eysenck's theory has shown a complex picture and has mostly used electrodermal measures.

In an analysis of OR habituation and the role of individual differences, O'Gorman (1977) reviewed all the studies supporting or rejecting the hypothesis linking introversion with increased levels of corticoreticular activity. The discussion on possible sources of experimental error causing inconsistent results, leads O'Gorman to suggest that extraversion is related to electrodermal habituation to an auditory stimulus under conditions of non-threat, moderate stimulus intensity and short interstimulus interval. In the same line of thought, Stelmack (1981) suggested that the higher skin conductance levels and the greater frequency of nonspecific responses for the introverts is not only related to stimulus specificity but also to differences in basic arousal processes.

As noted in both O'Gorman's (1977) and Stelmack's (1981) reviews, the effect frequently observed in electrodermal studies seemed to be a greater initial response with a slower response decrement for the introverts when a low frequency and a stimulus intensity range of 75-90 dB were used (Crider & Lunn, 1971; Fowles, Roberts, & Nagel, 1977; Mangan & O'Gorman, 1969; Marton, 1972; Wigglesworth & Smith, 1976). Whether or not personality differences are expressed in different autonomic and cortical responses is still a question in debate today.

A few studies related extraversion with habituation of electroencephalographic responses. Marton and Urban (1966) were among the first investigators to study this relationship. They used a low frequency (400 hz) auditory stimulation and found that extraverts habituate faster than introverts. Marton and Urban concluded that inhibitory potential develops faster in persons with traits of extraversion. Since the authors neglected to report tables or figures illustrating the data, and since the techniques used to measure habituation are not described, it is difficult to judge the reliability of the findings.

Fenton and Scotton (1967) hypothesized that the extraverts habituate more rapidly than introverts to a photic stimulus because of their quicker build-up of cortical inhibition. To test this hypothesis they used a bright double flash stimulation which was delivered 60 times at irregular intervals after a prominent alpha rhythm was present in every subject. Habituation was defined as 50 percent decrease in voltage from the average of the 10 alpha waves which immediately preceded the onset of the paired flash. No difference in the rate or extent of habituation between introverts and extraverts was found. In Fenton and Scotton's study, since the delivery of the stimuli did not follow a prearranged schedule but was contingent on the presence of alpha activity, individual differences were confounded with differences in the duration of the experiment. Moreover the MPI administered after the experimental session resulted inevitably in unequal grouping of introverts and extraverts. The authors did not report the number of subjects per group.

Gale, Coles, Kline and Penfold (1971) attempted to control for numerous methodological errors by using a complex design in which both extraversion and neuroticism were considered. However no difference in response amplitude or in speed of habituation has been found between introverts and extraverts. Even if this study was considered rigorous (Gale, 1973) the stimulus delivered at two seconds intervals was longer than in studies reporting significant results. It is well established that the rate of stimulus delivery has an effect on the habituation outcomes (O'Gorman, 1977).

Another complicated project investigating neuroticism and extraversion in the assessment of conditioning, habituation and extinction was carried by Frigon (1976). Results showed greater mean duration of alpha blocking for the introverts during the presentation of a 1000 Hz, 70 dB tone. Frigon interpreted his findings as demonstrating higher cortical arousal for introverts.

Habituation of alpha-blocking studies in relation to the introversion-extraversion dimension are inconclusive. Some problems can be traced to choice of statistical technique and to the interpretation given the particular EEG measure used, as well as the limitations within the data collected (Gale, 1973).

Even though the average evoked potential method has been employed in several investigations of individual variations, nothing is known of its application to relate habituation with extraversion. In the present study, response decrement related to individual differences will be studied by using an evoked potential measuring technique which will be described after reviewing empirical findings attempting to associate personality dimension with variation of average potential components.

Extraversion and Cerebral Evoked Potentials

One promising source of information that has only recently become accessible to neurophysiologists is from the study of cerebral evoked potentials, first reported by Dawson (1954), and generally recognized as providing a reliable measure of cortical response to stimulation. The evoked potentials method measures the changes in the electrical activity of the nervous system elicited by a physical stimulus or psychological event. Since scalp-recorded evoked potentials are difficult to discern because of the background electroencephalographic (EEG) activity, techniques to improve the signal-to-noise such as time locked stimuli and signal averaging must be used.

Evoked potentials consist of different components identified as early (0-10 ms after stimulus onset), middle (10-50 ms), and late (50-250 ms) components (Picton, Hillyard, & Galambos, 1974). The late components are themselves broken down into P1, N1, P2 and N2 with "P" indicating positive electrical valence in relationship to baseline, and "N" negative.

Their respective average latencies following stimulus start are 50, 100, 170 and 250 ms respectively (Picton & Hink, 1974).

Evidence which addresses the arousal hypothesis has been provided by this cerebral evoked potential (CEP) measure even if a very limited number of studies relating evoked potentials with personality traits have been reported.

Some of the first studies exploring this relationship were done by Shagass and Schwartz (1963; 1965). Shagass and Schwartz's (1963) study showed that somatosensory EP amplitudes were lower for dysthymics (low E and high N) than for psychopaths and hysterics (high E, hign N) thus demonstrating opposite results as expected from Eysenck's theory. But the groups were formed in a rather complex manner. Dysthymics were grouped together with non-patients because no differences were observed between these two groups in their stimulus-intensity AER regressions. Similarly, psychopaths, hysterics, and behavior problem cases were grouped together with psychotic patients. The heterogeneous nature of the groups tested was possibly confounding the personality variable and consequently was contributing to the effects observed in Shagass and Schwartz's study.

Visual evoked responses, age and personality, were studied by Straumanis, Shagass and Schwartz (1965). Their findings supported their hypothesis that increased EP amplitude reflects reduced inhibition thought to be typical of introverts. A study confined to 17 to 19 year old college students failed to confirm this hypothesis (Haseth, Shagass & Strumanis, 1969). Nickerson (1975) found no relationship between extraversion and photic evoked potentials amplitude.

The lower recovery of the initial somatosensory component was associated with greater inhibitory activity. Greater amplitude was related to evidence of greater introversion (Shagass, 1972). This assumption did not find support in Burgess's (1974) study, which attempted to replicate Schwartz's findings (Shagass & Schwartz, 1965).

It is uncertain whether the difference in results mentioned in the above studies depends on the sample of subjects, on the techniques used or on the interpretation of results.

For the age group 15-19 years, Shagass and Schwartz (1965) found that mean amplitudes (mean amplitude of peaks 1, 4, 5, 6 summed without regard to sign) of extraverts were significantly higher than that of introverts. For subjects in the age group 40-59 years and 60 years and over, the introverted group had significantly higher amplitude than extraverts. For subjects in the age group 19-30 years the difference in amplitude was not significant. The samples of recent studies consist entirely of older adolescents, in whom the relationship might be more like that in the 20 to 30 year old group. Techniques used could account for differences in results. Correcting for individual differences in sensitivity by applying different levels of stimulus intensity according to subjects' absolute threshold to somatic stimulation may have precluded the observation of individual differences in the evoked responses. The great controversy found in studies to relate evoked potential measures with state of arousal, could also be due to interpretation of the EP measures. In his two previous studies on visual evoked response, Shagass (1972) explained the smaller evoked response amplitude found in the adult groups over 40 by the stronger need of others and by greater degree of inhibitory neural functioning at that age.

A related psychological dimension which belongs to the realm of 'cognitive style' is the concept of augmenting-reducing as a cognitive stimulus-control factor, originated by Petri (1967). Recently, studies relating EP characteristics to augmenting-reducing were reported by Soskis and Shagass (1974), Buchsbaum (1974), Spilker and Callaway (1969) and Bucksbaum and Silverman (1968). Subjects who show a decrease in amplitude of response at high levels of stimulus intensity are referred to as reducers. In the same way Eysenck proposed that the extraverts had a higher optimal level of stimulation than the introverts. The curve for introverts is shifted to the low end and the one for extraverts to the high end of the stimulation dimension. Introverts respond to low intensity level while the extraverts react to stimuli of high intensity. Introverts and reducers show similar patterns of response to stimulus intensity. Soskis and Shagass (1974) found a trend relating augmentation of the early visual EP slope to extraversion with correlations ranging from .41 to .66.

Studies pointed to a relationship between augmenting and a general outgoing, destructible, manic-like, stimulus-seeking temperament (Callaway, 1975). Farley and Farley (1967) found a correlation of +.47 between extraversion and stimulus seeking as measured by the sensation seeking (SSS) of Zuckerman (Kolin, Price, & Zoob, 1964). However more recent studies relating SSSII to Eysenck's questionnaires showed correlations ranging between 0.2 and 0.5 with a median correlation of 0.29 (Zuckerman, 1979). Only a weak relationship between the broad traits of extraversion and sensation seeking exist. SSS does have much in common with the broad construct of impulsivity but is particularly related to the aspect of impulsivity called risk taking. Impulsivity and risk-taking are subtraits of extraversion (Eysenck & Eysenck, 1963) and in this way show similarity with sensation seekers.

Since there is a positive correlation between sensation seeking and extraversion, and since reducers have been found to decrease visual evoked potential responses with increase of intensity (Barnes, 1976), one would expect that introverts would also show decreased auditory evoked potential amplitude with increase of intensity. However these comparisons are difficult to establish since two different modalities (visual and auditory) are involved.

Late components of average evoked responses have also been investigated and related to the extraversion dimension although the amount of relevant research is not extensive. Stelmack, Achorn, and Michaud (1977) have reported that introverts obtained greater N1 - P2 amplitude than extraverts with low frequency stimulation (500 hz) at high (80 dB) and moderate (55 dB) intensities. These differences were not apparent under high frequency (8000 hz) with high and moderate intensities or under low-intensity (40 dB) for both high and low frequencies. Subjects were required to count the series of alternating high and low frequency tones. Since the effectiveness of attention was not assessed it is not clear whether the observed effects are due to differences in attentional processes or to differences in sensitivity to stimulation. The authors concluded that the larger N1 - P2 amplitude observed in introverts denoted higher excitatory and lower inhibitory cortico-reticular activity compared to extraverts, supporting Eysenck's proposal that introverts tend to possess a high and less inhibited cortical arousal system.

Joseph (1978) argued that the effects in Stelmack et al's study could have originated at the brainstem level and could be projected as the cortical components. Thus the greater N1 - P2 amplitude of introverts might have resulted from greater activity at the level of brainstem rather than by greater arousal in the ascending reticular activating system. To test his hypothesis he employed auditory stimulation of a 4000 hz signal over three intensity conditions, 50 dB, 70 dB and 90 dB (SPL) and found out that introverts displayed significantly greater amplitudes for wave V, compared to extraverts, at low intensities (50 dB and 70 dB) of stimulation but not at 90 dB. Introverts also displayed greater amplitude for N1 at low intensity (50 dB) auditory signals whereas extraverts displayed significantly greater amplitude at 90 dB intensity. Joseph concluded that the sensory system as well as subcortical areas of the brain were involved in individual differences in cortical arousal.

However, Campbell, Baribeau-Braun, and Braun (1981) in a similar study, failed to support Joseph's findings (1978). Different rates of stimulus repetition as well as different intensities (20, 30, 50 and 70 dB, HL) were manipulated to investigate the role of sensory influences. Neither variation of the ISI nor stimulus intensity revealed significant differences amongst group varying in extraversion. Campbell et al. (1979) suggested that individual differences in the late components observed in previous studies could be due to the level of arousal or attention.

Meanwhile, Stelmack and Wilson (in press) reported two studies conducted to investigate the role of peripheral factors in individual differences. Three frequencies (500, 2000, and 4000 hz) were varied but the ISI and the intensity (80 dB) were kept constant. Results showed similar effects as in Campbell's (1978) study, with no significant difference between the two extraversion groups. However when the tone bursts were substituted by clicks delivered at a rate of 20 per sec with intensity levels ranging from 55 to 90 dB in steps of 5 dB, results were contrary to Campbell's findings. The mean Wave V latency was found longer for the extraverts than for the introverts under all levels except at 90 dB. Extraversion was also positively correlated with the latency of the wave I BER component at 75, 80 and 85 dB. The authors suggested that individual differences found in the late cortical components (Stelmack, et al., 1977) may be due to peripheral or brainstem influences.

Brainstem auditory evoked responses (BAER) of introverts and extraverts were examined for subcortical signs of stimulation augmentation and reduction (Andress & Church, 1981). Twenty subjects received click intensities of 20, 40, 60, and 80 dB (HL) in random order. Both groups showed patterns of decreasing conduction time and increasing amplitudes with increasing intensity except at 80 dB, where the introverts had significantly faster interpeak latencies and larger wave V and V1 amplitudes than the extraverts. Andress and Church proposed that a central inhibitory mechanism against intense auditory stimulation exists for all subjects but that extraverts have a lower threshold for this phenomenon. They also suggest that personality differences manifest themselves at the subcortical as well as cortical levels.

Whether the higher arousal for the introverts was expressed in higher sensitivity or in better performance with attention, the experimental design used by Stelmack et al (1977) did not distinguish between the expression of these two factors. If differences in sensitivity were the main source of variation in the N1 - P2 amplitude, then introverts would regularly display larger responses through different conditions. This sensitivity could also be manifested in larger initial response or in following a slower decaying over periods, resulting in larger average N1 - P2 amplitude than the extraverts who perhaps display an initially low response or manifest faster decrements in amplitude with stimulus repetition. On the other hand, if the effects were attributed to attention, the response amplitude would be larger for the introverts in the attend condition but not in an unattend condition. The experimental design used could not distinguish such patterns of responding.

Stelmack et al's (1977) study needs to be repeated in a paradigm allowing the expressions of sensitivity and attention separately. This investigation is the purpose of the present study. A short-term habituation paradigm with the manipulation of attention level will be employed to replicate findings and at the same time, control for the sensitivity and attention effects. Before presenting the problems more specifically, a brief review of the technique used is given.

Evoked Potential, Habituation and Attention

Habituation of EP has been demonstrated in a number of experimental paradigms. Bancaud, Bloch and Paillard (1953) noticed in the raw EEG of certain subjects, the presence of a V wave response which progressively decreased with repeated auditory stimulation. The course of this slow habituation was found to be independent of decreased response in alpha blocking electrodermal and muscular start responses. A series of studies on this slow habituation of human visual and auditory AER's (Bogacz, Vanzulli, & Garcia-Austt, 1960, 1962; Garcia-Austt, Bogacz, & Vanzulli, 1961; Perry & Copenhaven, 1965; Roeser & Price, 1969; Vanzuelli, Bogacz, & Garcia-Austt, 1960, 1961) described how responses follow a slow decaying course over periods of a half-hour or so. Late negative components were found to be most sensitive but decrements to some extent in most components between 100 and 300 msec were noted.

Long term habituation of the vertex potential has been found difficult to assess (Picton, Hillyard, Galambos, & LaJolla, 1976) since drowsiness (Weitzman & Kremer, 1965; Williams, Tepas, & Marlock, 1962) sleep (Firth, 1975) and any change in subject's level of alertness may affect the habituation process. Walter (1964) claimed that responses recorded from the frontal region suddenly diminish some time during the presentation of the first 20-100 stimuli, leading Ritter, Vaughan and Costa (1968) to develop a technique to study the short term decrements in AER. Short trains of stimuli with relatively long intervals between the trains but with short ISI within the train, were presented and then averaged across trains, stimulus by stimulus. This more reliable technique has since been applied in numerous investigations and is also used in the present study.

Both the physical characteristics of the stimulus and certain related variables have been shown to affect the habituation response of the vertex potential.

The magnitude of the decrements has been found to be a direct function of the rate of stimulation, having larger decrements with more rapid rates of stimulation (Webster, 1970; Webster, Dunlop, Simons, & Aitkin, 1965). With stimulus delivery at one per second, larger decrement has been obtained over the first several stimuli, but no short habituation was observed when the interstimulus interval was increased to 10 seconds (Fruhstorfer & Bergstrom, 1969; Fruhstorfer, Soveri, & Jarvilehto, 1970; Ritter et al., 1968; Webster, 1970; Webster et al., 1965). To leave enough time for the complete recovery of the vertex response, it is also recognized that the stimulus trains must be delivered at a rate of one train per minute (Fruhstorfer, 1970; Picton, Hillyard, & Galambos, 1976). Considering the effect of the stimulus delivery on the amplitude reduction, a stimulus rate of 1/sec and a train delivery of 1/min is applied in the present study to provide maximum decrement.

Lengthening the duration of a repeated toneburst also enhances the decrement in the vertex potential (Weber, 1970). No reduction in AER amplitude was observed with a 50 msec stimulus duration but there was a definite amplitude reduction when a 500 msec toneburst was used. Weber's findings supported Sokolov's (1960) hypothesis that longer stimulus duration produces faster habituation rate. A 200 msec toneburst duration as used in the present study is a good compromise between the demands of time and the effects of habituation.

The dependence of habituation upon stimulus intensity has been demonstrated by Picton et al. (1976) in a study comparing a 30 dB with a 60 dB toneburst when all stimuli had the same frequency. Amount of decrease in amplitude has been found to increase with increase of intensity but the apparent change could be due to the initial larger amplitude with increase of intensity (Davis & Zerlin, 1966). However previous studies which failed to observe habituation rate used a low intensity stimulus (Rose & Ruhm, 1966), leading Picton to suggest that an increase in stimulus intensity also increases the amount of habituation of the vertex potential. Individual differences in habituation using the electrodermal method have also been observed in studies employing auditory stimulation in the 75-90 dB range as discussed earlier in this paper. In the present study an 80 dB toneburst is used thus ensuring maximum habituation.

When the frequency of the habituation stimulus was varied from low (250 hz) to high (4000 hz) frequency a tendency was noticed for the amplitude of the responses to get smaller with increased frequency but no effect on habituation rate was found (Picton et al., 1976). When a dishabituation test stimulus was used, the amplitude of responses to the test stimulus was observed to become larger as the deviation of the frequency between the test stimulus and the habituation stimulus increased (Butler, 1968; Picton et al., 1976). This frequency effect is consistent with earlier investigations reporting that N1 - P2 amplitude decreases with increasing frequency, particularly at higher intensity levels (Davis, Bowers, & Hirsh, 1968; Rothman, 1970).

If lower frequency produces higher amplitude, the habituation effect should be easier to observe with a low frequency stimulus especially in a paradigm using fewer stimulus presentations, as in the present study. Since the previous study showed significant result using a 500 hz (Stelmack et al., 1977), a low frequency tone is used in this study.

Subject's state has been found to affect the N1 - P2 components and its habituation rate. In general, increasing vigilance or directing attention to certain stimuli by counting them or otherwise making them relevant enhances ERP amplitude and particularly the N1 - P2 component, even if the subject cannot predict the occurrence of relevant stimuli (Hillyard, Hink, Schwent, & Picton, 1973; Picton & Hillyard, 1974). In the same way, larger initial amplitude response of a train of clicks was observed in the attentive state (Fruhstorfer, 1971) and a progressive reduction of amplitude was noticed only with decreasing vigilance (Fruhstorfer & Bergstrom, 1969). Using a reaction-time task, Ohman and Lader (1972) found that attending to a repeating auditory stimulus enhanced the evoked potential amplitude but unlike Fruhstorfer's findings, the decline in amplitude was steeper when the subjects attended to the stimulus than when they ignored it. The authors failed to replicate this result, but they found larger N1 - P2 amplitude to the attended stimulus under conditions of high activation with no effect on the rate of habituation (McLean, Ohman, & Lader, 1975). Meanwhile, Picton et al. (1976) also reported that the manipulated attention level had no effect on the habituation rate. The authors nevertheless found larger initial amplitude response and an accentuation of the positive wave at about 300 msec latency (P3) to the first click when the subjects were required to count the presented stimuli. These findings are compatible with previous results demonstrating larger N1 - P2 amplitude with selective attention (Davis, 1964; Naatanen, 1967; Picton, Hillyard, Galambos, & Schiff, 1971) and increased P3 peak with decision making (Hillyard, 1969). More recently Donald and Young (1980) demonstrated that the rate of habituation of N1 to an auditory stimulus was slower in the attended channel, suggesting the involvement of an input from selective attention.

Subjects not provided with specific instructions have also been found by Salamy and McKean (1977) to show no N1 - P2 amplitude change but a decrease in responses was seen when the subjects read. After reviewing the studies investigating the effect of attention on short-term habituation and considering their contrary outcomes, Ohman and Lader (1977) suggested that "attention has only a limited effect on habituation of the vertex EP" (p. 107).

The conflicting results found in the studies of the attention effects on the habituation rate suggest that the attentive task used could account for the differences found. In all previous studies the state of the subject's attention has been manipulated by introducing a second modality such as a motor response, a visual observation or a reading task. The effect of a new modality, besides directing the subject's attention away from the experimental stimulus, might also activate new neural units, thus producing maximum response amplitude (Butler, 1968) and less decrement than expected. The conditions of eyes closed, eyes opened and having the subject lying down or sitting upright, might also have different arousal effects (Stelmack, 1981) and slow down the rate of habituation.

An attempt is made in this study to manipulate the state of attention within the same modality and having the subjects with their eyes closed in both conditions. The use of a "mantra", a method borrowed from the Transcendental Meditation, seemed to be appropriate in the present paradigm. A "mantra" consists of a soft sound word that the subject is asked to repeat continuously and mentally, while concentrating on the sound of the word and ignoring all external stimulation. If during the attend condition the subject is asked to concentrate and count the stimuli, and during the ignore condition he is required to ignore the stimuli and concentrate on his mantra, a mental effort will be required in both conditions and a single modality (auditory) will be used with the condition of eyes closed kept constant. Therefore, by keeping a uniform state of arousal in both ignore and attend condition, the change in the habituation rate could be attributed to the attentional effect. It is for this purpose that the present study uses a "mantra" to direct the attention of the subject away from the experimental stimulus. More detail concerning the methodology used will be given in the next chapter after the formulation of hypotheses.

Statement of Hypotheses

Introverts have been reported by Stelmack et al. (1977) to obtain greater N1 - P2 amplitude of the auditory evoked responses than extraverts with low frequency stimulation (500 hz) at 80 dB, for a group of 30 subjects who were required to pay attention and count the number of stimuli. The authors suggested that the difference found between introversion and extraversion in AER was due to a greater increase in arousal for the introverts than for the extraverts, thus making the findings compatible with Eysenck's theory.

From these results, questions emerge concerning the pattern of the individual responses and the contribution of attention on the variation of these responses. Three main questions are formulated as follows:

If the larger N1 - P2 amplitude found for the introverts in Stelmack et al's study is due only to sensitivity, will the introverts produce consistently larger N1 - P2 amplitude than the extraverts when they ignore as well as when they attend to a stimulation?

Were the larger N1 - P2 response amplitudes for the introverts compared to the extraverts due to a consistently larger N1 - P2 amplitude or due to a larger initial response or a slower rate of response decrement for the introverts?

Could the results found be accounted for by the greater vigilance of the introverts caused by the counting task and reflected in a constant larger N1 - P2 amplitude response for the introverts?

These are the questions that the present study attempts to answer. As mentioned earlier in this study, limitations in Stelmack et al's design did not control for the effects of attention and habituation factors. As it has been demonstrated in some of the investigations reported earlier in this paper these two variables, attention and habituation, vary with individual differences.

Therefore, the purpose of this study is to replicate Stelmack et al's study using a paradigm allowing the manipulation of these two factors and the measurement of their effect on the N1 - P2 components to determine whether observed effects were due to attention or sensitivity expressed in habituation. The predicted results, based on the theory of the biological basis of extraversion (Eysenck, 1967) and the N1 - P2 evoked potential component changes associated with changes in arousal, are as follows:

Since introverts have lower thresholds of sensitivity than extraverts (Eysenck, 1967) the intensity is perceived higher by the introverts and because higher intensity produces greater amplitude (Davis & Zerlin, 1966), it is expected that introverts will produce greater N1 - P2 amplitude than extraverts under all conditions.

Since longer trials to reach criterion for electrodermal habituation has been noted for introverts (Crider & Lynn, 1970; Mangan & O'Gorman, 1969; Stelmack, Bourgeois, Chian, & Pickard, 1979), and because the human auditory vertex response is known to habituate (Bancaud et al., 1953), the introverts are expected to show less decrement in N1 - P2 amplitude responses than the extraverts to a repeated auditory stimulation, under both attend and ignore conditions.

Since introverts perform better than extraverts in tasks which require attention (Harkins et al., 1975), and since N1 - P2 amplitude increases with attention (Naatanen, 1975; Picton & Hillyard, 1974), it is expected that the introverts will produce larger N1 - P2 amplitude than the extraverts in the attend condition only.

Since, in a short term habituation paradigm using trains of stimuli and short ISI, the auditory evoked responses reached the asymptotic level after the second to fourth stimulus (Ritter et al, 1968), it is expected that the N1 - P2 amplitude decrement will be greater in the experimental (train) condition than in the control (no-train) condition.

Since the evidence of attentional factors on habituation rate is not conclusive (Ohman & Lader, 1977), and because previous research used a second modality to direct the attention away from the stimulus (thus engaging new neural units), and since engaging the same neural units maximized the habituation effect, (Butler, 1968) and since prognosive response decrement was noticed only with decreasing vigilance (Fruhstorfer & Bergstrom, 1969) it is expected that within the same modality the N1 - P2 response decrement will be larger in the ignore condition than in the attend condition.

Since previous results (Stelmack et al., 1977) showed larger N1 - P2 amplitude for introverts when they were required to count a continuous series of tones, it is expected that introverts will produce greater N1 - P2 amplitude than extraverts under attend and control (no-train) conditions thus replicating previous study.

CHAPTER II

Method

This chapter presents the methodology of the experiment. It describes the experimental paradigm used to measure the personality, attention and habituation effects, and the procedure followed for the classification of subjects into introvert and extravert groups.

The instrumentation and procedure used for obtaining the dependent measures of cortical evoked potentials are specified. This chapter concludes with the methods of analysis of the dependent variables under study and statistical procedures involved in the testing of hypotheses outlined in chapter I.

Experimental Paradigm

The experimental paradigm used to measure short term changes in the auditory evoked responses with stimulus repetition is derived from Ritter, Vaughan and Costa's (1968) study. Short term effects are examined by presenting short trains of stimuli with relatively long intervals between trains and then averaging evoked responses to their ordinal position in the train.

The stimulus used in this paradigm was a low frequency (500 hz) high intensity (80 dB) toneburst of 200 msec duration and 10 msec rise-fall time. During the experimental (train) condition, a train of four stimuli with ISI of 1 sec was presented at a rate of 1/min. (4 sec duration followed by 56 sec delay) and was repeated 24 times, giving a total of 96 stimulations. In the control (no train) condition the 96 tonebursts, having the same quality as in the experimental condition, were presented in a continuous series at the regular rate of 1/sec throughout the entire session.

Forty eight subjects classified along the extraversion dimension participated in two sessions (experimental and control) which were separated by a 20 minute rest period. Half of the two groups (introverts and extraverts) were instructed to pay attention and count the number of stimuli given in both experimental and control sessions, while the other half was asked to ignore the tone and concentrate on the sound of a mantra (mental word) given by the experimenter.

Experimental and control conditions were given in a predetermined order as follows: half of the subjects in each group (attend and ignore) received an experimental (train) condition first and control (no train) condition second while the other half of the subjects received control condition first. Double blind procedure was used to assign subjects to each condition. During the rest period, the subjects received classical music by the earphone and were required to read.

Subjects

Eighty male subjects, ranging in age 17 to 32 were selected from a sample of 500 students and young professionals, on the basis of their Eysenck Personality Questionnaire (EPQ) scores, (Eysenck, 1975). A sample of this test appears in Appendix 1.

Two groups of 24 subjects each were formed by a random selection of the 80 subjects scoring in the range of 1 to 9 for the introverts and between 16 to 24 for the extravert group ($\pm$ 1 SD from the mean). The means and SD's obtained by the introvert group for the Extraversion (E) scale were 6.12 and 2.17, for Neuroticism (N) 10.96 and 5.60 and for Psychoticism (P) 4.54 and 2.83. The means and SD's obtained for the extravert group were 19.83 and 0.59 for the (E) scale, 10.54 and 4.54 for (N) and 4.65 and 2.90 for (P). The mean extraversion score for the total 48 subjects was 13.54 with standard deviation of 6.77 while the mean neuroticism score was 10.35 and SD of 5.10. There were no significant differences between introvert and extravert groups in either Neuroticism nor Psychoticism.

The subjects were screened for normal auditory sensitivity at 500 hz. Subjects reporting experience in transcendental meditation, history of brain injury, or displaying eyeblink artifacts during the experimentation, were rejected and replaced.

All the subjects were unpaid students and professional volunteers. The undergraduate students from University of Ottawa participating in this study received bonus marks toward an introductory course.

Apparatus and Calibration Procedure

The auditory stimuli were given binaurally through a set of Koss LU-10 earphones. The frequency (500 hz sine wave), the intensity (80 dB), the duration (200 msec) and the rise/fall time (10 msec) of the stimulation, were controlled by a system consisting of Lafayette Model 1421 audio Amplifier, Hewlett-Packard Model 4437A Attenuator, Hewlett-Packard Model 3300A Function Generator and Electronic Switch (Achorn, 1977). The quality of the auditory stimulus was monitored throughout the experiment using a Tektronics Model RM 64 oscilloscope.

The stimulus was initiated by a pulse coming from a PDP-8E computer previously programmed to give the proper number of stimulus presentations, interstimulus interval and intertrain interval depending on the conditions (experimental or control) selected by the experimenter. The current stimulus number was displayed to the experimenter on a TMC Model 150 Scaler.

The Belltone audiometer screening device and the auditory stimulus system were calibrated using a Bruel and Kjaer audiometric calibration system and Hewlett-Packard Model 3734A Electronic Counter. The stimulus frequency was first adjusted to 500 hz using the Electronic Counter. Then, the sound intensity was calibrated at 80 dB (SPL) with a Bruel and Kjaer type 2204 impulse precision sound level meter, type 4152 artificial ear and type 1613 octave filter set at A weighting.

The ON time (0.2 sec and 4 sec) OFF time (0.8 sec and 56 sec) and rise-fall time (.01 sec) of the stimulus, were verified by monitoring the output of the earphones, the computer sweep voltage, and the stimulus synchronization pulse, with a Tektronix, type RM 64 storage oscilloscope triggered by the computer. The timebase of the scope was previously calibrated by a Fairchild Type 781 A Time-Mark Generator. The PDP-8E computer timebases were calibrated using a Dawe type 901, Digital Frequency Meter.

The apparatus used for electrophysiological recording was a Nihon-Kohden RM-85 8-channel polygraph. One channel of monopolar EEG activity, Cz with mastoid reference, and one channel of eyeblink monitor were recorded using Beckman silver-silver chloride electrodes connected to Nihon-Kohden RR-5 Biophysical Amplifier. The EEG amplifier was set for a bandpass of 20 sec to 100 hz with a gain of 48 dB and the eyeblink amplifier was set for a bandpass of 0.3 sec to 100 hz with a gain of 30 dB.

On-line averaging was done by PDP-8E lab 8 computer system. The resulting average evoked potential was displayed on a Tektronix oscilloscope for visual inspection and plotted by a Moseley 7004 XY plotter using a model 17171A DC preamplifier system.

The computer system was programmed (Achorn, 1979) to perform the following procedure:

1) to digitize the input EEG and EOG data at a rate of one sample per msec,
2) to calculate a .1 sec prestimulus baseline for each channel,
3) to deliver the stimulus at the predetermined rate,
4) to sort and sum the data into the proper display buffer depending on data channel, stimulus number, stimulus order in trains and stimulus block,
5) to plot various combinations of the thirteen display buffers.

The buffers gave 500 msec averaging for EEG and EOG after each stimulus with 0.1 sec prestimulus baseline. Meanwhile, the EEG data was summed into four block averages: block 1 was the first 24 stimuli, block

2 the second 24 stimuli, block 3 the third 24 stimuli and block 4 the last 24 stimuli. Thus the EEG was summated into two buffers depending on its position in a stimulus train of four stimuli and on its position in the stimulus block (see Figure 1). The above procedure was used for both experimental (train) and control (no-train) conditions. After the 96 stimuli were presented, the thirteen buffers were used as accumulators to sum the results of any buffer to give the total average of the 96 stimuli. The display buffers were plotted on the XY plotter to give 12 graphs per condition, a total of 24 graphs per subject. Samples of graphs are shown in Figure 2.

The biophysical amplifiers, the averaging computer and the plotter were calibrated with a 10 uv, 10 hz input signal having the same temporal definition as the stimulus presentation procedure. One hundred calibration signals were averaged and plotted prior to every subject.

Instructions were delivered to the subject by earphones using a CTR 34 Radio Shack tape recorder. A mini scan intercom and TV camera allowed the experimenter to communicate and observe the subject during the experiment. A block diagram of experiment interconnections is shown in Figure 3.

Procedure

When the subjects came to the laboratory the purpose of the study was briefly explained. The electrodes were then placed on the following locations: the EEG electrode was placed at Cz, which is the midpoint between nasion and inion, a midline location (Jasper, 1958), the reference

Figure 1. Experimental schema illustrating the EP and EOG responses averaged stimulus by stimulus, and by blocks of stimulus.

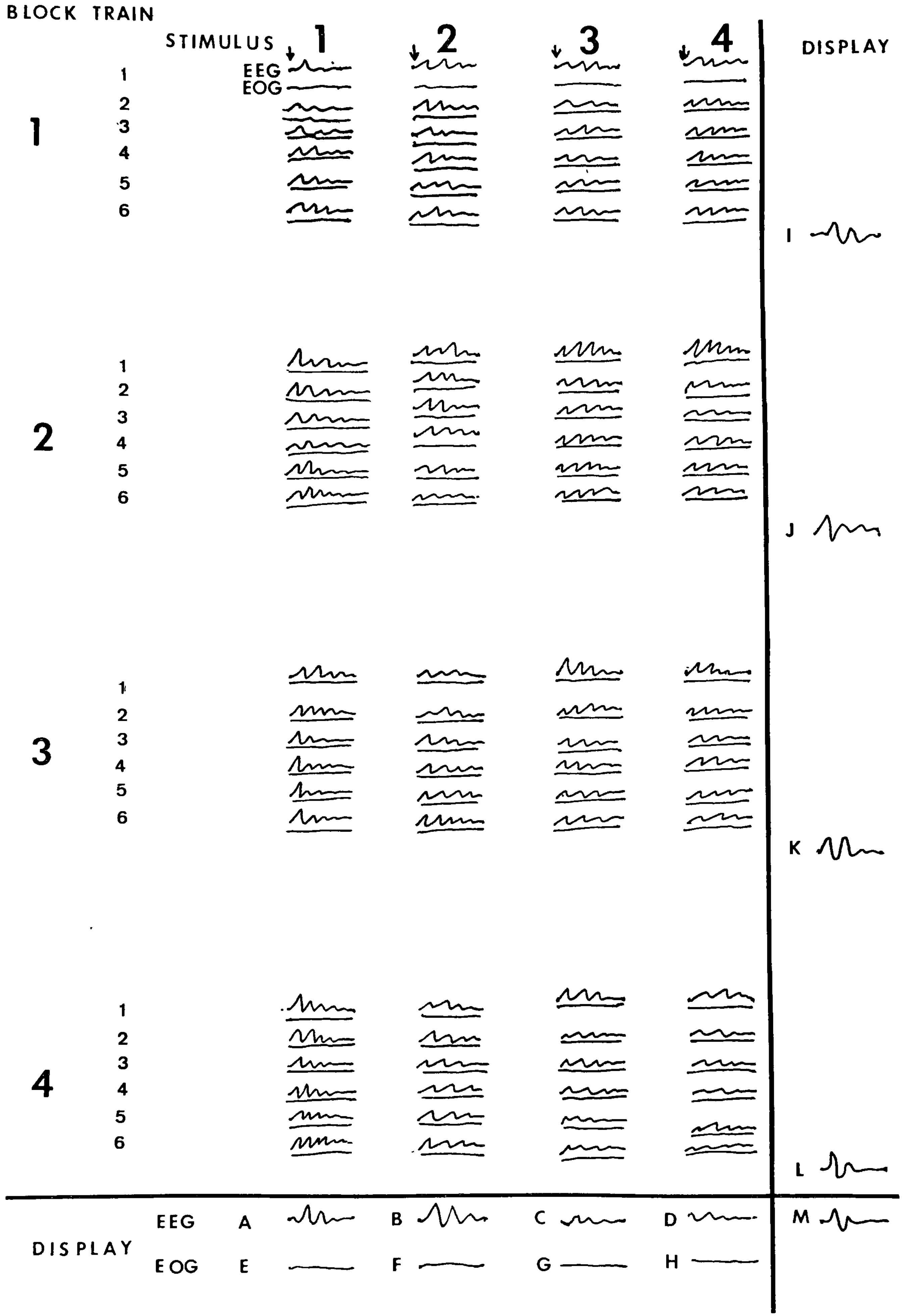
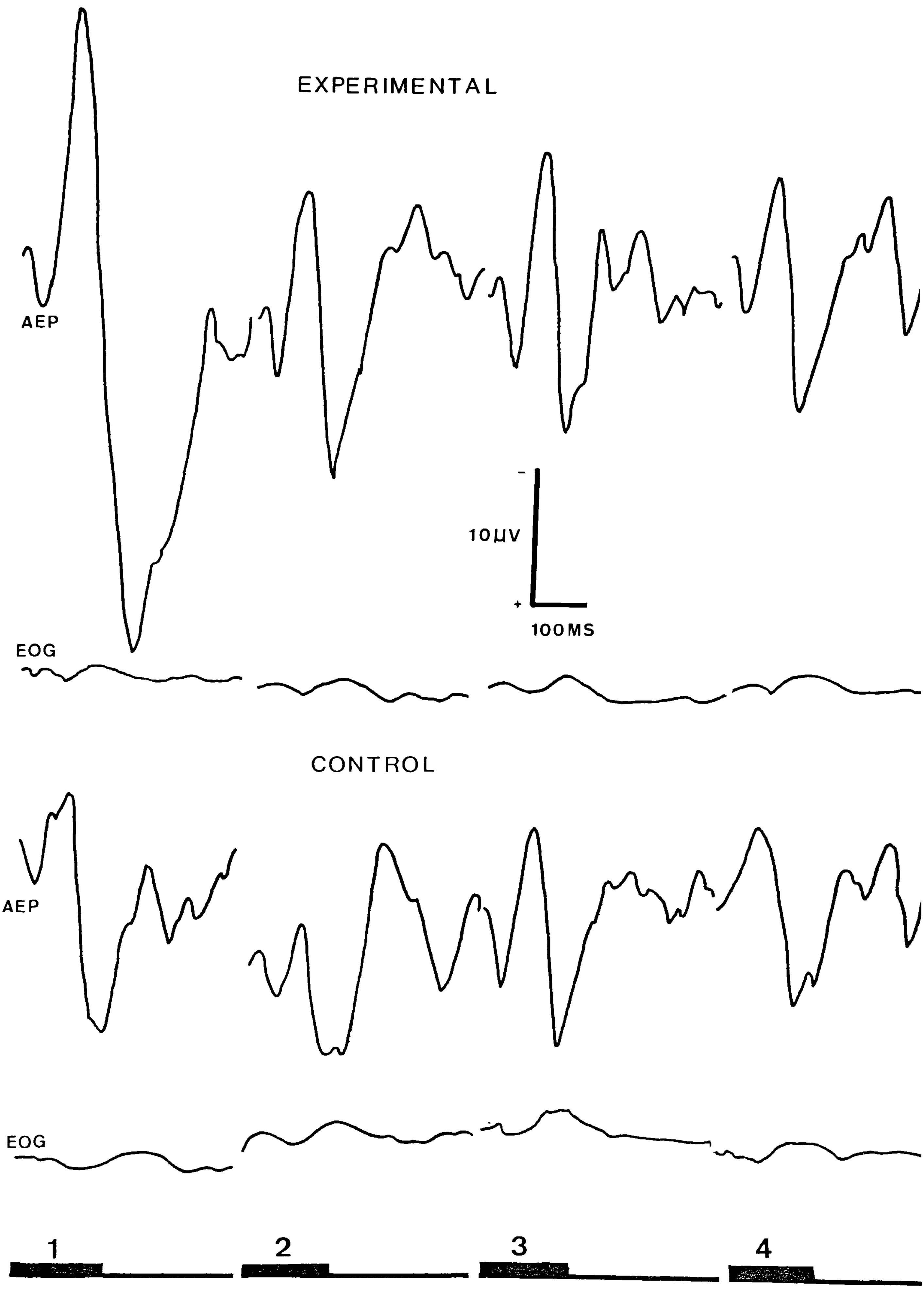
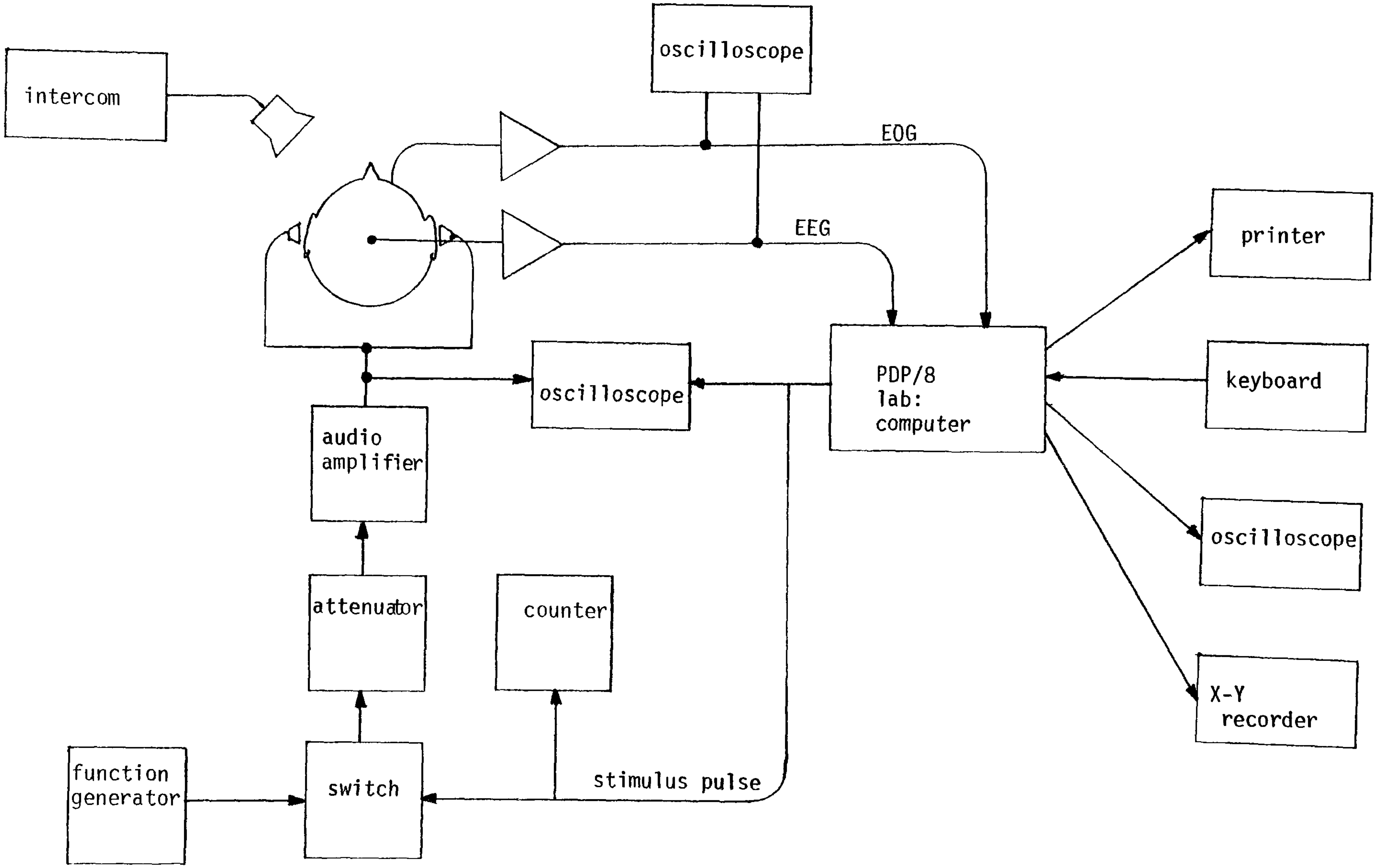

BLOCK TRAIN
STIMULUS
1
2
3
4
EEG
EOG
DISPLAY
1
2
3
4
5
6
I
J
K
L
M
DISPLAY
EEG
EOG
A
B
C
D
E
F
G
H

Figure 2. AER and EOG of experimental and control conditions for one subject.



EXPERIMENTAL
AEP
10µV
100MS
EOG
CONTROL
AEP
EOG
1
2
3
4

Figure 3. Block Diagram of Equipment Interconnection.


intercom
oscilloscope
EOG
EEG
printer
PDP/8
lab:
computer
keyboard
oscilloscope
audio
amplifier
oscilloscope
attenuator
counter
X-Y
recorder
function
generator
switch
stimulus pulse

electrodes were placed on the right and left mastoid. The EOG electrodes were then placed at the superior and inferior orbital ridges on the left side. The ground electrode position was the left wrist. Skin surface was prepared for electrode placement by cleaning the skin with cotton soaked in Isopropyl (99%) alcohol, and then abrading the skin with a sterilized applicator stick to prevent skin potential artifacts (Picton & Hillyard, 1974). The electrodes were then attached using Beckman electrode paste and adhesive collars. The impedence level was less than 5 Kohm. The subjects were then taken to the sound attenuated room adjacent to the equipment room of the laboratory and the electrodes were connected to the input of the polygraph. A brief explanation on the purpose of the camera and a short practice to communicate with the experimenter by intercom was given to the subject. The earphones were then placed over his ears, the light was dimmed and the door was closed. The prerecorded tape instructions were delivered to the subject by the earphones. If the subject was assigned to the attend condition, the instructions were as follows:

> We start now the first part of the experiment. Here is what you have to do. Sit comfortably and avoid large body movements, tongue movements or eyeblinks until the experiment is over. Close your eyes and relax, especially the muscles of the neck and the jaws. While you relax with your eyes closed you will receive a series of tones by the earphones. Your task is to listen to these tones and to count them mentally without articulation. You will be asked after the session to give the exact number of tones that you received. In summary, you have to sit comfortably and relax with your eyes closed making as little movement as possible while listening and mentally counting the tones. If you have some questions, use the intercom. If you have heard these instructions please press the button.

If on the contrary the subject was assigned to the ignore condition, he was instructed as follows:

> We start now the first part of the experiment. Here is what you have to do. Sit comfortably and avoid large body movements, tongue movement, or eyeblinks until the experiment is over. Close your eyes and relax especially the muscles of the neck and the jaws. While you relax with your eyes closed you will receive a series of tones by the earphones. Your task is to ignore these tones and instead concentrate on the sound of the word "SHENUM". Repeat mentally but without articulation this word through all the session like this: "Shenum, Shenum, Shenum" .. Repeat with me, but mentally, without articualtion: "Shenum..Shenum..Shenum.." Did you get it? Now I summarize. You are to sit comfortably and relax with your eyes closed making as little movement as possible while concentrating and repeating mentally without articulating the word "SHENUM". Ignore the tones that you will receive by the earphones. If you have some questions use the intercom. If you have heard these instructions press on the button.

If there were no questions, the first session started.

The command to initiate the presentation of the stimuli and the simultaneous analysis of the AER was manually controlled by the PDP-8 keyboard. The conditions were selected by typing an E (experimental) or C (control). Immediately, the computer initiated the stimulus delivery and started to sort and sum the data into the appropriate display buffers. The subject then received 96 stimulations in trains of four stimuli or in a continuous series depending on the condition assigned to the subject and selected by the experimenter. During the data gathering, the experimenter observed the display of the subject's response and the current stimulus number. The subject was also monitored by video for gross motor movement.

At the end of the first session, the door was opened and the light was turned on. To minimize the carry over effects, the subject was asked to read while listening to the classical guitar (Jeux Interdits by

Narcisso Yepes) delivered by the earphones. During that time the experimenter plotted the twelve graphs. When the rest period was over, the light was again dimmed, the door shut and the instructions were delivered by the earphones. For the attend condition the instructions were as follows:

> We start now the second part of the experiment. The instructions are the same as those given in the first part. I summarize. Sit comfortably and relax with your eyes closed making as little movement as possible while listening and counting mentally the tones. If you have questions, use the intercom. If you have heard these instructions, press the button.

For the ignore condition, the subject was instructed as follows:

> We are starting the second part of the experiment. The instructions are the same as those given in the first part. I summarize. You have to sit comfortably and relax with your eyes closed making as little movement as possible. Ignore the series of tones and concentrate on the word "Shenum". If you have questions, use the intercom. If you have heard these instructions press the button.

The second session was repeated with the same protocol as the first session. To prevent any contamination of the experiment, the binaural audiogram was administered at the end of the second session instead of prior to the experiment. The subject received a set of ascending and descending trials from 0 dB to 80 dB at 500 hz. If the subject had an auditory threshold above 25 dB his EEG and EOG records were disregarded (No subject was rejected). The electrodes were then removed, the subject was shown his results with some explanations, and he was asked to fill out a questionnaire (as shown in Appendix 2) before leaving the room. The EOG records were then examined. If the EEG has been contaminated by eyeblink artifacts greater than 30 uv and timelock to the stimulus, the subject was rejected. Three subjects were rejected and replaced.

Analysis of AER Records

Five components of AER were measured: N1 - P2 amplitude, N1 amplitude, P2 amplitude, N1 latency and P2 latency.

Hand scoring of a large number of records is tedious, and may increase the probability of measurement errors. It would seem that more confidence could be placed in the computer scoring using a manual digitizer (graphic digital converter). This method has the advantage of using the entire graph by establishing a mean curve. The hand scoring technique, which would require more rigorous steps to average the two curves, tends to focus on a small segment as the deflection site. Based on the assumption that the digitizer method provides more accurate measures, and considering the large number of graphs (1152) to be scored, this technique has been applied.

Evoked potential responses were then digitized by using a manually operated free cursor Instronics Digitizer and Graphic table. Data was transferred at a rate which provided 15 coordinates per msec of polygraph record through a telephone line to an IBM computer into a Wylbur programme. Data was transferred to a disk and was further smoothed to one coordinate per 5 msec by averaging the digitized samples occurring in that time interval. The disk file records of all subjects' data was analysed using a Fortran programme to determine all positive and negative peaks with a printout of peak amplitudes in microvolts and of latencies in msec. To control for procedure errors, the disk file records were plotted on a Calcomp plotter for comparisons against the original graphs for each subject.

A frequency distribution of all peaks detected was independently found for positive and negative peaks. Significant event clusters were found by using a chi (X) square test. From the clusters, four event windows were determined: two narrow windows starting at the time point where the frequency distribution just became significant (100 and 180 msec) and ending where the distribution ceased to be significant (125 and 200 msec) at .05 level and two wide windows determined by increasing the narrow windows in both directions to the point where the frequency was equal to or smaller than the mean(95-140 msec, 155-225 msec). The window corresponded very closely to the classical ranges of latencies for N1 and P2 (Picton et al., 1974).

A second Fortran Programme was prepared to use the window values to report N1 - P2, N1, P2 amplitude from the prestimulus baseline, with latencies.

Statistical Analysis

A Split Plot factorial design with two factors between and two within, has been analysed using a four factor analysis of variance, calculated with a BMD P2V (Dixon & Brown, 1977) programme for repeated measures. Two levels of personality, introverts and extraverts, and two levels of state of attention, attend and ignore, were the between variables, while two levels of habituation train, experimental (train) and control (no train) conditions, and four levels of stimulus repetition (or block repetition) constituted the within variables.

Three independent analyses of variance have been performed on the same data. Stimulus sequence analysis consisting of stimulus by stimulus analysed across train, Block sequence analysis consisting of stimulus sequence blocked in group of 24 stimuli each, and Total stimuli analysis which is the averaged 96 stimulations.

The post hoc testing of the differences between means for significant main effects after the initial analyses of variance were performed using Newman-Keuls procedure. The .05 level of confidence was adopted for all statistical tests.

To test the simple main effects of significant interaction, the numerator, sums of squares, degrees of freedom and mean squares for each level of one factor at another were derived following conventional techniques. A pooled mean square error for each denominator was calculated following Kirk (1968, p. 245-312).

It is likely that the added assumption of symmetry and equality of the variance-covariance matrix be violated to some unknown degree with repeated measures. To correct for the presence of heterogeneity of the measurements, the conservative _F_ test (Geisser & Greenhouse, 1958) has been computed by multiplying the degrees of freedom of the conventional _F_ test by 1/(T - 1) where T is the number of levels of a factor, in this case the stimulus repetition. _F_ ratios were considered significant if both the conventional and conservative test significance level exceeded .05 level. Very few conventional _F_ ratios have been rejected.

To test the homogeneity of partitioned error terms, an _F_ max ratio has also been calculated following conventional procedure (Kirk, 1968,

p. 302). One basic problem in the statistical analysis of the results involved the interaction between the experimental (train) and control (no train) condition, using the same subject in both conditions. The two sessions could differ because of greater habituation, subject fatigue, or differential arousal effects. However, the counterbalance of these two conditions and the 20 minute rest period between the two sessions, introducing auditory (music) and visual (reading) stimuli, should have controlled for these effects.

CHAPTER III

Presentation of Results

This chapter presents the results of the statistical analysis of AER component. In each of the three divisions of this chapter, stimulus sequence analysis, block sequence analysis and total stimuli analysis, results of N1 - P2 amplitude, N1 and P2 peaks with reference to a prestimulus baseline and the N1 and P2 latencies are reported. Anova and summary tables are shown in the appendix 3 and 4.

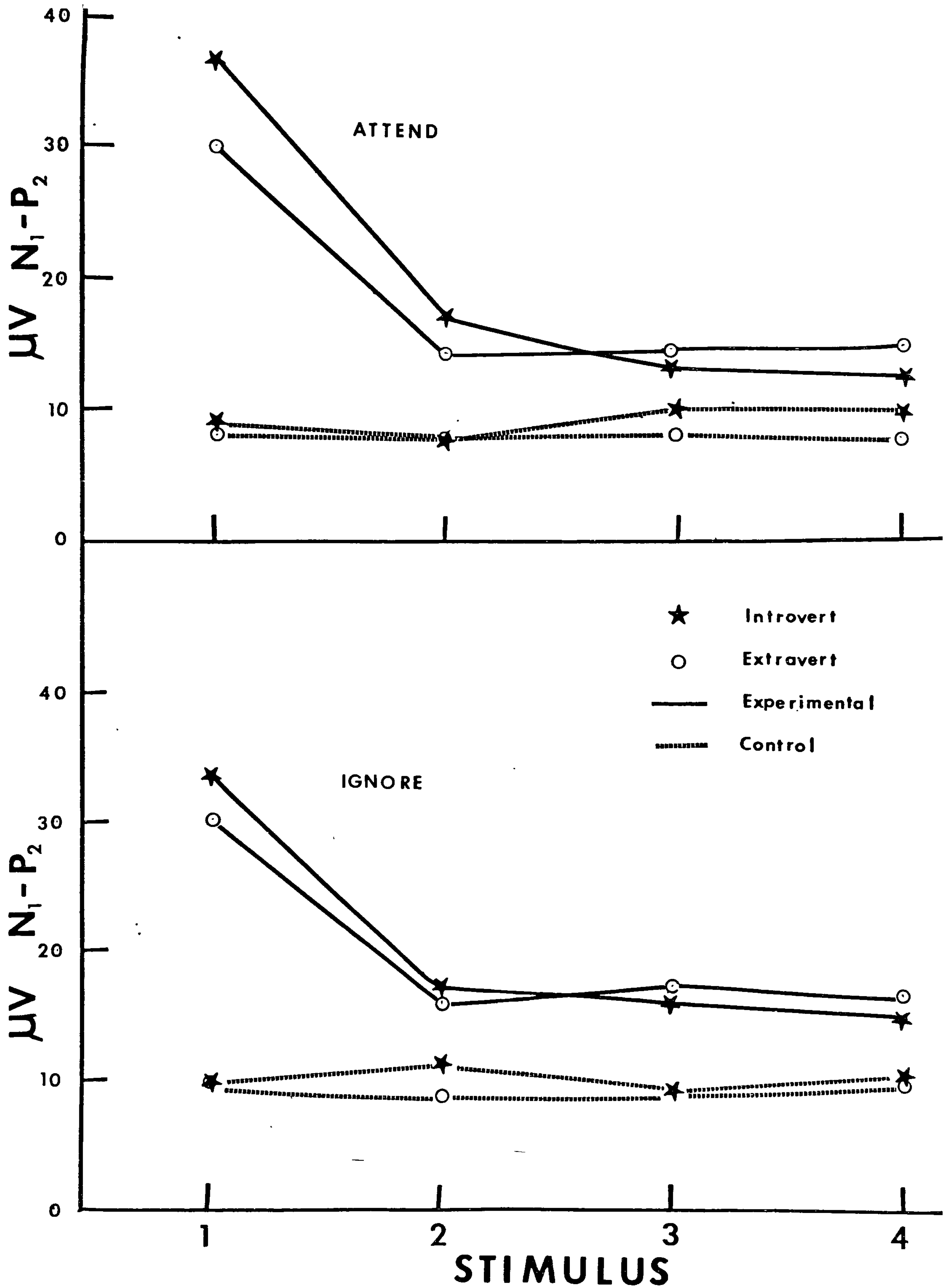
Stimulus Sequence Analysis

Amplitude

N1 - P2 amplitude. The four factor analyses of variance (ANOVA) of the N1 - P2 μV amplitude showed two significant main effects: the habituation-train effect $\underline{F}$ = (1/44) = 161.33, MSe = 63.32, and the repetition variable, $\underline{F}$ = (3/132) = 54.27, MSe = 32.96. No main effects were observed with peak to peak measures for personality dimension nor for the attention variable. Results of N1 - P2 amplitude are illustrated in Figure 4 and summarized in Table 1.

In the habituation-train main effect, the mean N1 - P2 amplitude was generally greater for experimental (train) condition, 19.83, than for the control (no train) condition, 9.50, while in the repetition main effect, comparison among individual means indicated that the mean N1 - P2 amplitude was significantly greater for the first stimulus, 21.05, than

Figure 4. Means of N1 - P2 amplitude for introvert and extravert groups under attend and ignore conditions at the experimental and control conditions for four levels of stimulus repetition.



ATTEND
IGNORE
μV $N_1 - P_2$
40
30
20
10
0
Introvert
Extravert
Experimental
Control
1
2
3
4
STIMULUS

Table 1

Means and SD of N1 - P2 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Levels of Stimulus Repetition

Repetition			1	2	3	4
Introverts	Attend	Experimental	36.45 (11.76)	16.72 (4.20)	13.26 (4.72)	13.21 (4.82)
		Control	8.97 (3.71)	8.24 (3.14)	10.46 (5.75)	10.06 (5.45)
	Ignore	Experimental	33.82 (16.25)	17.02 (6.36)	16.51 (4.93)	14.74 (6.30)
		Control	10.23 (5.61)	11.62 (5.35)	9.39 (4.00)	10.52 (5.51)
Extraverts	Attend	Experimental	30.02 (15.21)	14.35 (4.68)	14.77 (5.80)	15.48 (8.35)
		Control	8.77 (4.20)	8.76 (3.50)	8.97 (4.77)	8.11 (3.86)
	Ignore	Experimental	30.05 (16.17)	16.12 (8.07)	17.97 (6.07)	16.82 (8.02)
		Control	10.14 (4.31)	8.94 (4.46)	9.43 (4.60)	9.65 (4.42)

NOTE: SDs are given in parentheses.

for the second, third and fourth stimuli (12.70, 12.60, 12.32). These last three stimuli did not differ between their means.

In the N1 - P2 analysis, two-way and three-way interactions were found significant and are described below.

The habituation-train X repetition interaction $\underline{F}$ = (3/132) = 57.66, MSe = 30.12 showed that under the experimental (train) condition, stimulus one was significantly greater, 32.58, than stimulus two, 16.05, three, 15.63 and four, 15.06, but under the control condition, there was no difference between the four means, (9.53, 9.34, 9.56, 9.58). At each repetition level, the mean N1 - P2 amplitude under the experimental condition was significantly higher than under the control condition. Therefore, in general there was a significant habituation effect in the experimental condition but not in the control condition.

The personality, habituation-train and repetition interaction $\underline{F}$ = (3/132) = 2.83, MSe = 30.13, indicated that both introversion and extraversion has significantly greater N1 - P2 amplitude in the experimental condition than under the control condition. However, at the first level of repetition, under the experimental condition, the mean N1 - P2 amplitude for the introverts, 35.13, was significantly greater than for the extraverts, 30.03, while there was no significant difference under the control condition between the two groups (9.60, 9.46). When means between stimulus repetition were compared, both introverts and extraverts had higher N1 - P2 mean amplitude at the first stimulus than at the other following three levels, but no difference between means was found under the control conditions.

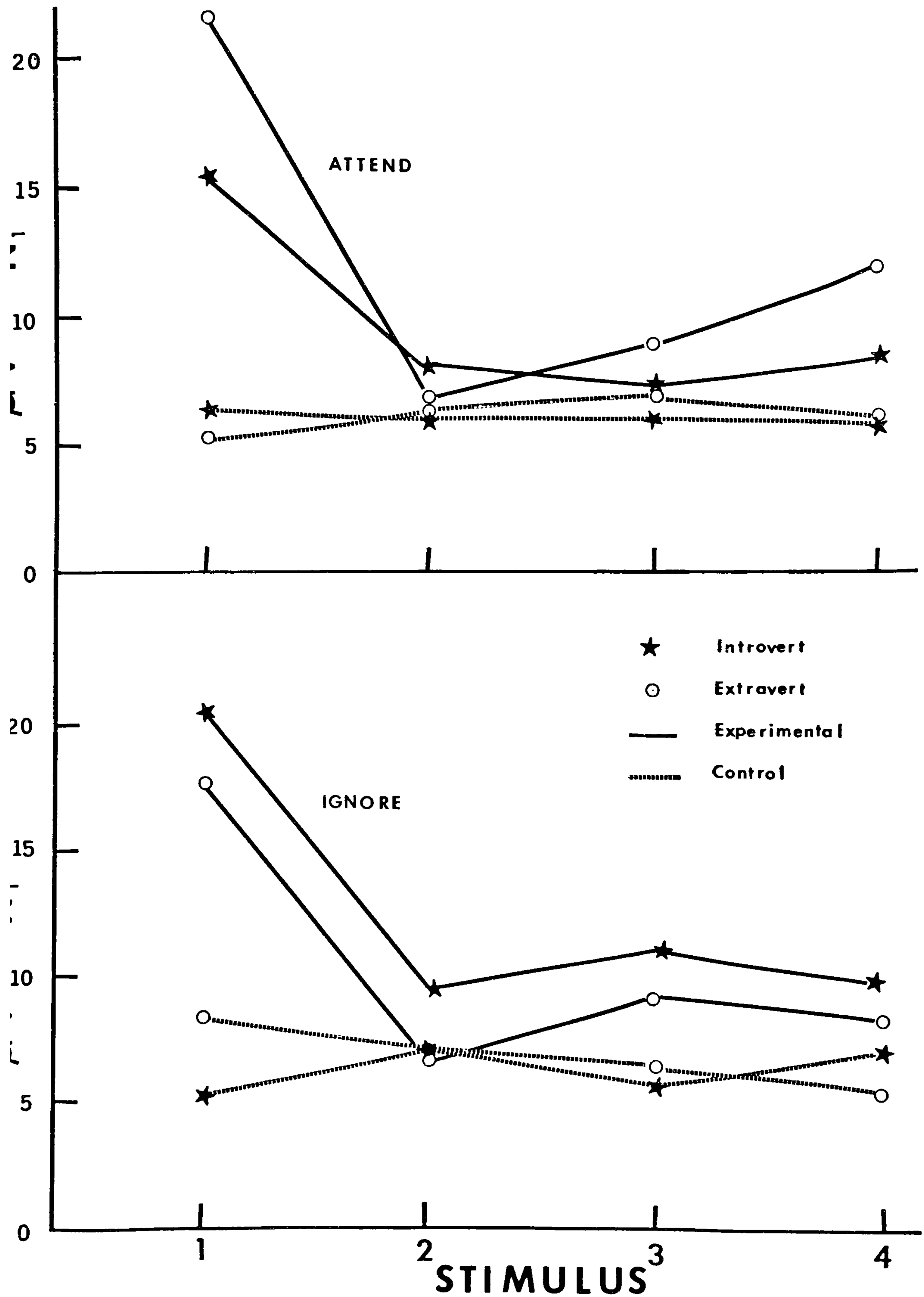
N1 amplitude. Baseline to negative peak amplitude analysis revealed two main effects as being significant: the habituation-train F = (1/44) = 102.84, MSe = 22.99, and the repetition, F = (3/132) = 39.70, MSe = 17.40. The habituation-train main effect had greater mean N1 amplitude under the experimental condition, 14.48, than under the control condition, 6.41. In the repetition main effect, comparisons among individual means indicated that the mean N1 amplitude was greater at the first stimulus, 12.99, than at the three-following stimuli, (7.23, 7.75, 8.00). The second, third, and fourth stimuli, did not differ between their means. Personality and attention main effects were not found significant.

An habituation-train repetition interaction was observed to be significant in the N1 amplitude, F = (3/132) = 33.99, MSe = 18.74. In this two-way interaction, the mean amplitude of N1 under the experimental condition of the habituation-train variable was significantly greater at stimulus one, 19.25, than at the other three levels of repetition (7.76, 9.09, 9.80). The N1 amplitude of the second was significantly smaller when compared to the fourth stimulus but not different when compared to the third stimulus. However under the control condition, there was no difference between the means of N1 amplitude at the four levels of repetition (6.72, 6.70, 6.41, 6.20). The means were all found significantly greater under the experimental condition compared to the control condition except for the second level of repetition where the two means did not differ.

A significant three-way interaction effect was noted between the habituation-train, personality and attentional variables, for N1 amplitude, F = (1/44) = 6.89, MSe = 22.99. In this interaction, the means in the experimental condition were all significantly greater than the means in the control condition. When attentional levels were compared, there was no difference between means under the control condition but under the experimental condition, the introverts who ignored a tone had a significantly higher mean N1 responses, 12.66, than the other introvert group who attended to a tone, 9.98. The two extraverted groups did not differ significantly between their attentional means N1 amplitude under either experimental, 12.64, 10.59, or control condition, 6.24, 6.95. When introverts and extraverts were compared in the attentional condition, there was no significant difference between means in the control condition, but under the experimental condition, the extraverts showed significantly larger N1 mean amplitude 12.64, than the introverts, 9.98 when they both attended to a tone, but they did not differ under the ignore condition, 12.66, 12.59. The means of the N1 amplitude are summarized in Figure 5 and Table 2.

P2 amplitude. The analysis of baseline to second positive peak measures revealed a significant F ratio = (1/44) = 58.96, MSe = 46.64, for

Figure 5. Means of N1 amplitude for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four levels of stimulus repetition.



ATTEND
IGNORE
Introvert
Extravert
Experimental
Control
20
15
10
5
0
1
2
3
4
STIMULUS

Table 2

Means and SD of N1 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Levels of Stimulus Repetition

Repetition			1	2	3	4
Introverts	Attend	Experimental	15.67 (5.46)	7.82 (4.74)	7.52 (3.22)	8.91 (3.48)
		Control	6.77 (3.26)	6.16 (4.04)	6.15 (3.83)	5.99 (3.67)
	Ignore	Experimental	21.61 (10.18)	9.00 (6.31)	10.40 (3.45)	9.63 (6.45)
		Control	6.38 (4.94)	7.04 (4.43)	5.78 (4.74)	7.07 (4.10)
Extraverts	Attend	Experimental	21.76 (6.29)	7.48 (4.55)	9.19 (3.48)	12.17 (6.41)
		Control	5.17 (3.98)	6.46 (4.39)	7.09 (5.34)	6.27 (3.32)
	Ignore	Experimental	17.96 (9.87)	6.72 (5.84)	9.25 (4.80)	8.43 (4.96)
		Control	8.55 (5.06)	7.14 (3.13)	6.62 (3.70)	5.48 (3.67)

NOTE: SDs are given in parentheses.

habituation-train main effect as well as for repetition main effect, F = (3/132) = 14.36, MSe = 18.41. In general, the P2 mean amplitude in the habituation-train main effect was larger for the train condition, 9.66, than for the no-train condition, 3.01. In the repetition main effect, comparison among means indicated that the first stimulus was significantly greater, 10.67, than the second, third and fourth stimuli (5.50, 4.85, 4.38), but the last three stimuli did not significantly differ between their means. The personality and attention main effects were not found significant in the analysis of P2 amplitude.

A significant interaction between habituation-train and repetition was noticed in the analysis of the second positive peak, F = (3/132) = 12.77, MSe = 26.73. The mean of the first level of repetition, 18.53, under the experimental condition, was significantly larger than the mean at the other three levels of repetition (8.30, 6.54, 5.28). The mean at the second stimulus, 8.30, was not significantly larger than the mean at the first stimulus, 6.54, but was larger than the fourth mean, 5.28. The means for repetition from one to four, showed a monotonic decrease in the experimental condition. Under the control condition the means did not differ significantly. When compared to the control condition, the means of P2 amplitude under the experimental condition were all significantly greater except for the last stimulus, 5.28, 3.38.

Another two-way interaction was found significant in the P2 analysis, between repetition and personality dimension, F = (3/130) = 14.36, MSe =

18.41. The introverts had a significantly higher mean P2 amplitude at the first level of repetition, 9.77, compared to the three following levels, 5.40, 4.94, 4.23, while the extraverts did not significantly differ between their four repetition means, 6.38, 5.09, 4.75, 4.43. When personality groups were compared, the introverts showed a significantly larger P2 mean amplitude, 9.77, than the extravert group, 6.38, at the first stimulus, but not at the other three levels of repetition.

The analysis of variance also showed significant three-way interactions. An habituation-train X personality X attention interaction, $\underline{F}$ = (1/44) = 4.98, MSe = 46.64, showed that both introverts and extraverts had a greater mean P2 amplitude, 6.01, 9.65, 9.93, 7.86, under the experimental condition than under the control condition, 2.40, 2.60, 3.16, 3.87, but under the experimental condition, the extraverts had a significantly greater P2 mean amplitude, 9.65, than the introverts, 7.86, when they both ignored a tone. However, an opposite result was noticed when both introverts and extraverts attended to the same tone during the experimental condition. The introvert group had a significantly higher mean P2 amplitude, 9.93, than the extraverts, 6.01. Under the control condition, the two groups did not differ between their attention means.

A second three-way interaction was noticed in the P2 amplitude analysis between habituation-train, personality, and repetition, $\underline{F}$ = (3/132) = 3.54, MSe = 26.73. In this interaction, the extraverts had a significantly greater P2 mean amplitude under the experimental condition than under the control condition except for the last stimulus where the difference (2.85) between the means did not reach the .05 confidence level. The introvert group had significant larger P2 amplitude for the first two stimuli under the experimental condition, 16.49, 8.46, than under the control condition, 3.02, 3.33. When means for stimuli were compared, under the experimental condition, the extraverts had a higher P2 mean amplitude at the first stimulus, 10.17, than the following three stimuli, 8.13, 7.15, 5.85, but the means between the last three stimuli did not differ. The introverts showed also a significantly greater P2 mean amplitude 16.49, at stimulus one than at stimuli two, three and four, but the second stimulus 8.46, was also significantly greater than the last two stimuli, 5.92, 4.71. Both introverts and extraverts did not differ between their means at the four levels of repetition under the control condition. When extraverts and introverts were compared, the mean P2 amplitude for the introverts was significantly greater, 16.49, than for the extraverts, 10.17, under the experimental condition for the first stimulus only.

Analysis of baseline to second positive peak showed a significant four-way interaction between personality, habituation-train, attention level and repetition, $\underline{F}$ = (3/130) = 2.75, MSe = 26.73. When experimental and control conditions were compared, the extraverts under attend condition had higher P2 mean amplitude at the first two stimuli (8,26, 6.87) for the experimental condition when compared to the control condition (3.59, 2.30). The means of the last two stimuli did not differ between experimental and control conditions. Under the ignore condition, they showed higher P2 mean amplitudes under the experimental than under the control condition, for the first three levels of repetition, but not for the last level.

On the other hand, the introverts under attend condition had greater P2 mean amplitudes for the experimental condition compared to the control condition, for the first two stimuli but not for the last two. Under the ignore condition, they had a higher P2 mean amplitude for the experimental condition than for the control condition, for the first level of repetition only.

When individual means were compared in levels of stimulus repetition, there was no significant difference between means under the control condition, but under the experimental conditions, introverts who ignored a tone had a significantly higher P2 mean amplitude at the first stimulus, 12.21, compared to the following three levels, 8.02, 6.11, 5.11. When they attended to the tone, the first mean, 20.78, was also greater than the following three others, but the second mean, 8.89, was also greater than means 5.73 and 4.30 of the last two stimuli. In other words the slope was steeper for introverts under the ignore than under the attend condition for the experimental condition.

No significant difference was found for the extraverts when levels of stimulus repetition were compared under attend and ignore and under experimental and control conditions.

When attentional levels were compared, the two groups of introverts differed under neither levels of experimental condition nor at the four levels of the control condition. The extraverts showed a significant difference between their attention levels but on the last stimulus only, with a higher mean P2 amplitude for the extraverts who ignored a tone, 8.39, compared to the extraverts who attended to a tone, 3.31, during the experimental condition. They did not differ under the control condition.

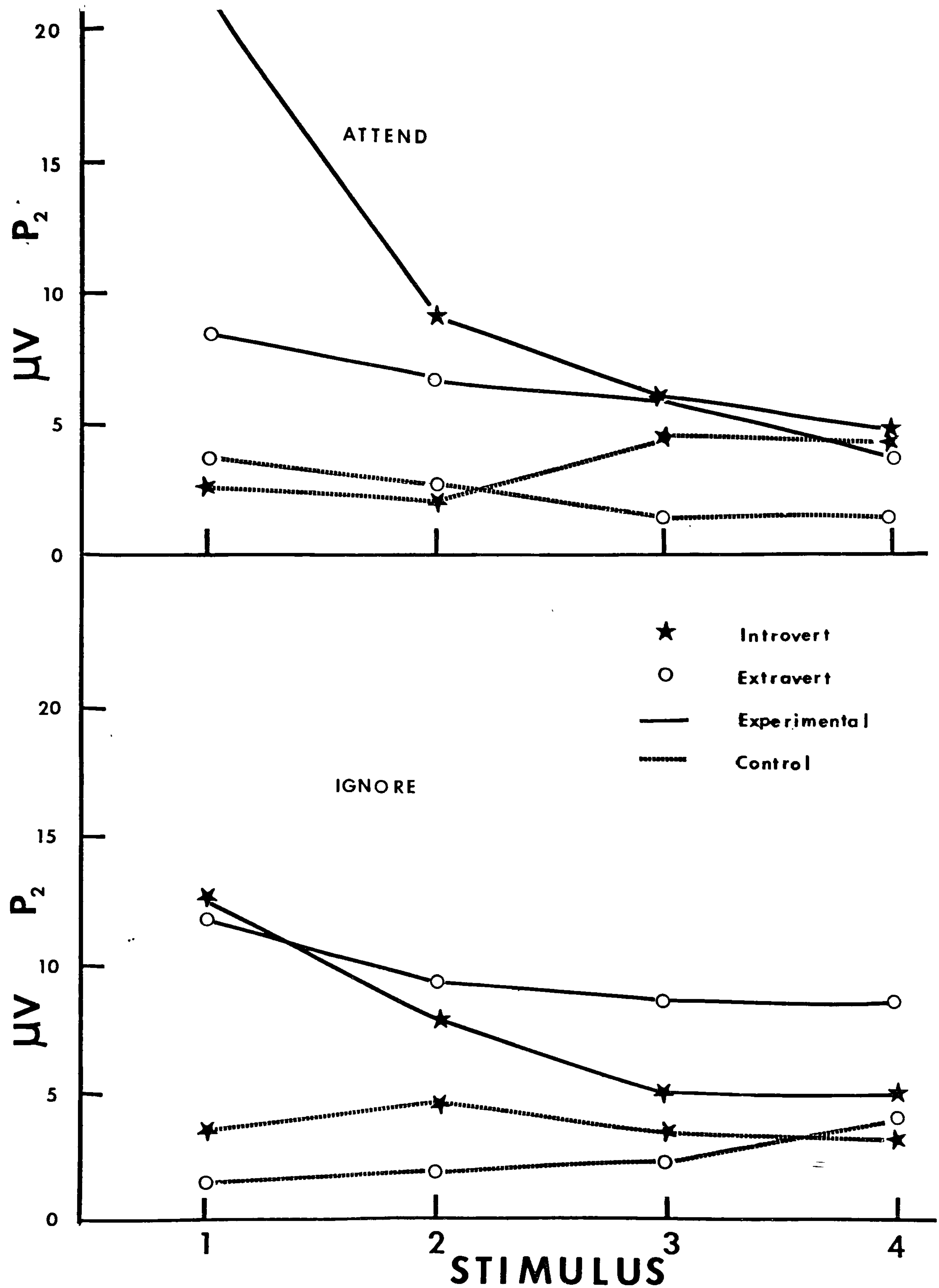
When introverts and extraverts were compared, they differed under the experimental condition when they both attended to a tone, with the introverts having a greater mean P2 amplitude, 20.78, than the extravert group, 8.26, but at the first level of repetition only. The two groups did not differ under the ignore condition nor under the control condition. Means for the four-way interaction are demonstrated in Figure 6 and summarized in Table 3.

Latencies

N1 latency. In the analysis of N1 latency, two main effects and a two-way interaction were found significant at .05 level. Their means are summarized in Figure 7 and Table 4.

The habituation-train main effect, *F* = (1/44) = 3.98, MSe = 96.92 showed a significantly longer mean N1 latency under the experimental condition, 116.12, than under the control condition 112.50. The repetition main effect, *F* = (3/132) = 20.48, MSe = 132.48, indicated that under the experimental condition, the first stimulus was significantly longer, 130.83, than the following three stimuli, 109.64, 111.98, 112.55 while these last three means did not differ.

Figure 6. Means of P2 amplitude for introvert and extravert groups under attend and ignore conditions at the experimental and control conditions for four levels of stimulus repetition.



ATTEND
20
15
10
5
0
μV P2
IGNORE
Introvert
Extravert
Experimental
Control
1
2
3
4
STIMULUS

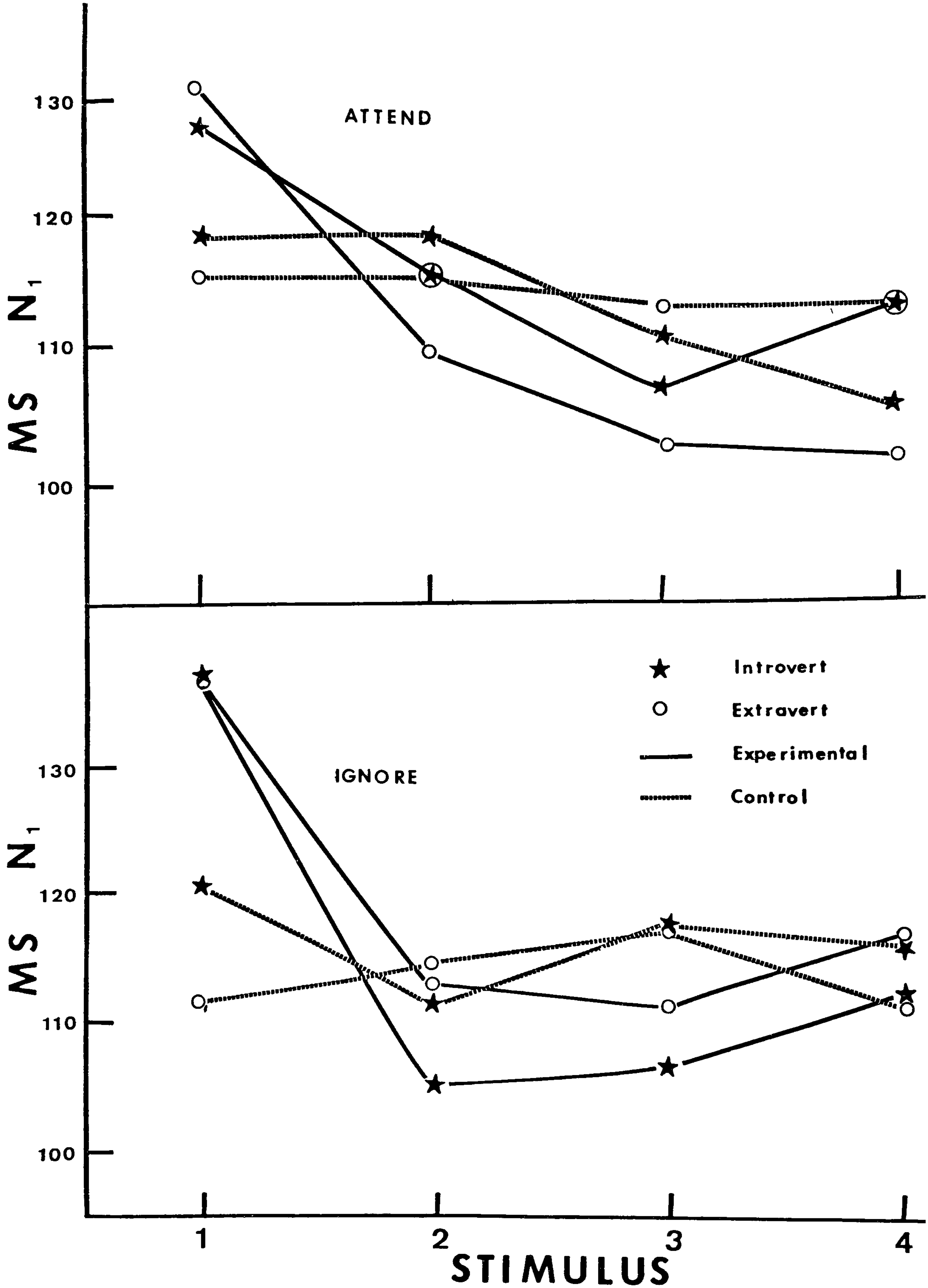
Table 3

Means and SD of P2 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Levels of Stimulus Repetition

Repetition			1	2	3	4
Introverts	Attend	Experimental	20.78 (11.03)	8.90 (2.62)	5.74 (4.99)	4.30 (4.14)
		Control	2.19 (3.59)	2.08 (3.34)	4.31 (3.04)	4.07 (3.01)
	Ignore	Experimental	12.21 (12.82)	8.02 (3.94)	6.11 (4.98)	5.11 (5.88)
		Control	3.85 (3.57)	4.59 (5.96)	3.61 (4.46)	3.45 (4.76)
Extraverts	Attend	Experimental	8.26 (12.78)	6.87 (5.99)	5.58 (5.31)	3.31 (6.37)
		Control	3.60 (4.18)	2.30 (4.28)	1.87 (3.56)	1.84 (3.31)
	Ignore	Experimental	12.09 (11.83)	9.39 (7.47)	8.76 (5.25)	8.39 (5.25)
		Control	1.59 (3.15)	1.81 (3.65)	2.81 (3.27)	4.18 (4.66)

<u>NOTE:</u> SDs are given in parentheses.

Figure 7. Means of N1 latency for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four levels of stimulus repetition.



ATTEND
IGNORE
MS N1
130
120
110
100
Introvert
Extravert
Experimental
Control
1
2
3
4
STIMULUS

Table 4

Means and SD of N1 Latency for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Levels of Stimulus Repetition

Repetition			1	2	3	4
Introverts	Attend	Experimental	128.33 (8.62)	115.83 (10.19)	106.67 (11.35)	112.50 (9.89)
		Control	117.92 (9.88)	117.50 (19.25)	110.42 (15.14)	105.83 (13.29)
	Ignore	Experimental	132.08 (18.52)	105.00 (12.79)	106.67 (16.70)	112.50 (13.40)
		Control	116.25 (14.64)	111.25 (12.45)	117.50 (12.34)	116.67 (9.37)
Extraverts	Attend	Experimental	131.25 (10.90)	109.58 (8.91)	112.92 (10.10)	111.25 (11.70)
		Control	115.83 (9.25)	115.83 (12.40)	113.33 (17.49)	112.92 (13.05)
	Ignore	Experimental	131.67 (14.51)	113.33 (13.71)	111.25 (12.08)	117.08 (12.33)
		Control	111.25 (14.00)	114.58 (14.53)	117.08 (12.33)	111.67 (12.31)

NOTE: SDs are given in parentheses.

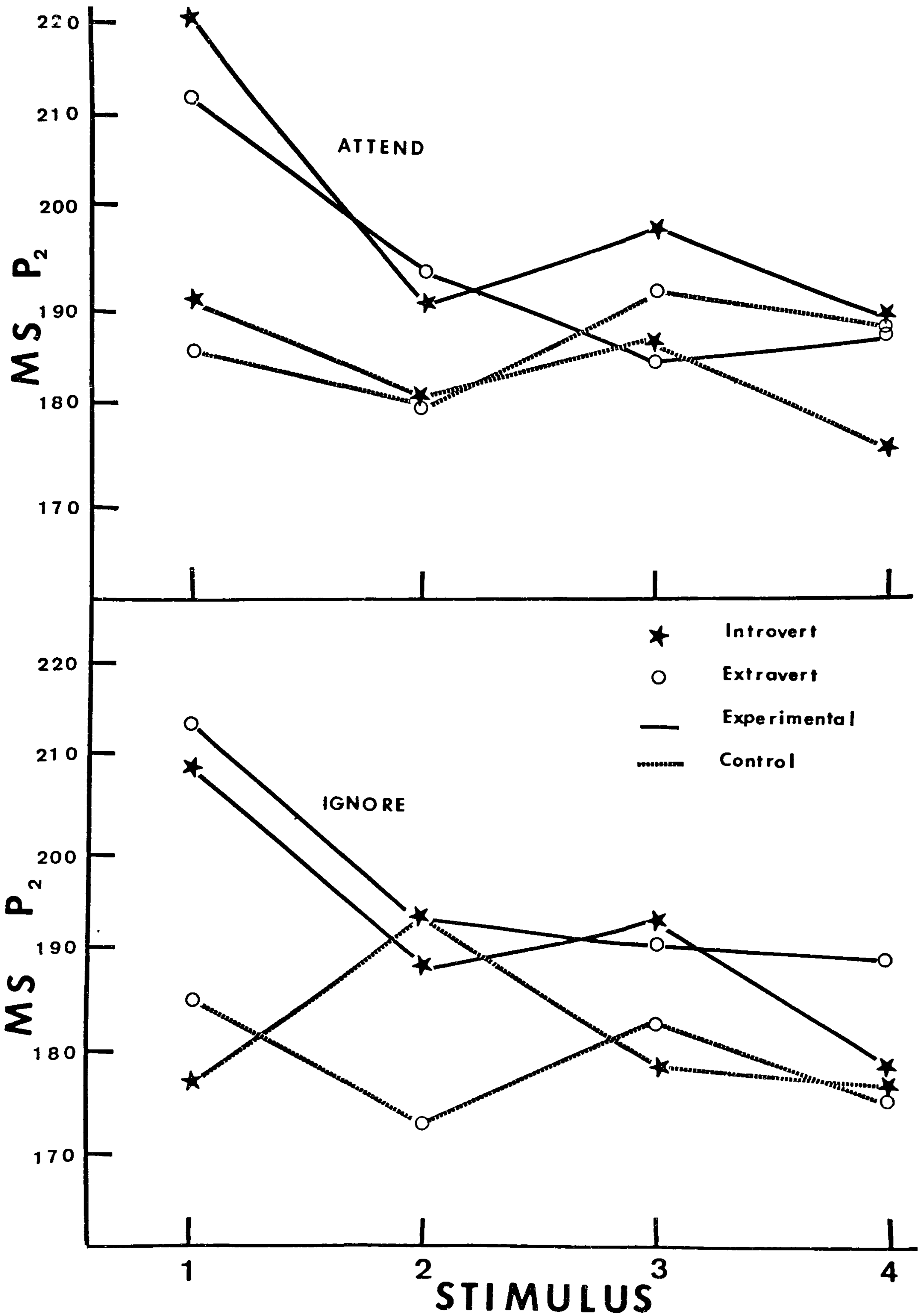
The habituation-train X repetition interaction, $F = (3/132) = 20.36$, MSe = 105.78, brought clarity in the above main effects, by indicating that under the experimental condition the mean N1 latency for the first level was significantly longer, 130.85, than the other three levels of repetition 110.94, 109.38, 113.33, while under the control condition the means at the four levels did not differ. At the first level, the mean N1 latency was also significantly longer under the experimental condition, 130.85, when compared to the control condition, 115.31. Difference between means at other levels of repetition was not significant.

P2 latency. The analysis of variance of the second positive peak latencies showed two main effects, one two-way interaction and a three-way interaction as being significant. Their means are illustrated in Figure 8 and summarized in Table 5.

The habituation-train main effect, $F = (1/44) = 34.02$, MSe = 439.05, had, in general, a significantly longer mean P2 latency 195.50 under the experimental condition, than under the control condition, 183.02. In the repetition main effect, $F = (3/132) = 13.64$, MSe = 355.27, individual comparison revealed significantly longer mean P2 latency at the first stimulus 199.33 than at the second, 186.30, the third, 188.55 and the fourth stimuli 182.87. The second and third means did not differ but the third mean was significantly longer than the fourth mean.

Habituation-train X repetition interaction, $F = (3/132) = 9.51$, MSe = 284.76 showed that under the experimental condition the mean at the first

Figure 8. Means of P2 latency for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four levels of stimulus repetition.



MS P2
220
210
200
190
180
170
ATTEND
IGNORE
Introvert
Extravert
Experimental
Control
1
2
3
4
STIMULUS

Table 5

Means and SD of P2 Latency for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Levels of Stimulus Repetition

Repetition			1	2	3	4
Introverts	Attend	Experimental	220.00 (17.71)	190.83 (14.59)	197.92 (22.10)	189.17 (16.21)
		Control	191.25 (21.86)	180.83 (17.56)	186.67 (16.97)	176.67 (18.13)
	Ignore	Experimental	209.58 (35.32)	187.08 (23.88)	193.75 (19.90)	179.58 (15.44)
		Control	178.33 (25.26)	192.92 (23.40)	179.17 (15.50)	177.50 (14.22)
Extraverts	Attend	Experimental	211.67 (17.36)	193.33 (21.67)	184.58 (21.69)	187.08 (19.36)
		Control	185.42 (19.00)	180.00 (19.54)	192.92 (22.91)	188.33 (20.82)
	Ignore	Experimental	212.50 (15.15)	192.92 (20.17)	190.42 (18.15)	187.50 (16.58)
		Control	185.83 (19.64)	172.50 (13.23)	182.92 (12.52)	177.08 (22.41)

NOTE: SDs are given in parentheses.

level of repetition was significantly longer, 213.44, than at the last three levels, 191.04, 191.67, 185,83, but these last stimuli did differ between their means. Under the control condition, the differences between the means at the four levels of repetition were not significant, 185.21, 181.56, 185.42, 179.90. When experimental and control conditions were compared, the mean at the first stimulus was significantly longer under the experimental condition, 213.44, than under the control condition, 185.21, but means at other levels of repetition did not differ significantly.

A three-way interaction between habituation-train, repetition and personality with F ratio = (3/132) = 2.88, MSe = 284.76, indicated that the extraverts under the experimental condition had a significantly longer mean P2 latency at the first level of repetition 212.08, than at the third, 187.50, and fourth levels, 187.29, but not longer than the second level, 193.13. Stimuli two, three and four, did not differ between their means. No difference was found between the means at the four levels of repetition under the control condition.

Introverts also showed a significantly longer P2 latency under the experimental condition for the first level, 214.64, compared to the second, 188.96, and fourth, 184.38, levels but did not differ from the third mean, 193.83. Under the control condition, there was no significant difference between the means of the four levels of repetition.

When experimental and control conditions were compared, extraverts showed longer P2 latencies under the experimental condition than under the control condition, at the first two levels of repetition. The introverts also showed longer mean P2 latency under the experimental condition than under the control condition but only at the first level of repetition with means of 214.64 and 184.79. No significant difference was found between means of P2 latency for personality groups in the interaction.

Block Sequence Analysis

Amplitude

N1 - P2 amplitude. When the data were analysed by blocks of 24 stimuli each, no significant interaction was found for the peak to peak amplitude. However two main effects were noticed as being significant: habituation-train main effect, F = (1/44) = 123.25, MSe = 53.29, and block main effect, F = (3/132) = 4.73, MSe = 16.51.

In the habituation-train main effect the N1 - P2 amplitude was generally greater under the experimental condition, 17.75, than under the control condition, 9.48. In the block main effect, individual comparison indicated that the mean N1 - P2 amplitude at the first block was significantly larger, 14.91, than the fourth level, 12.87, but not larger than the second, 13.53, and the third, 13.15, blocks. Means N1 - P2 amplitude are shown in Figure 9 and Table 6.

N1 amplitude. The negative peak analysis revealed two main effects and an interaction as being significant at .05 level.

Figure 9. Means of N1 - P2 amplitude for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four blocks of stimuli.

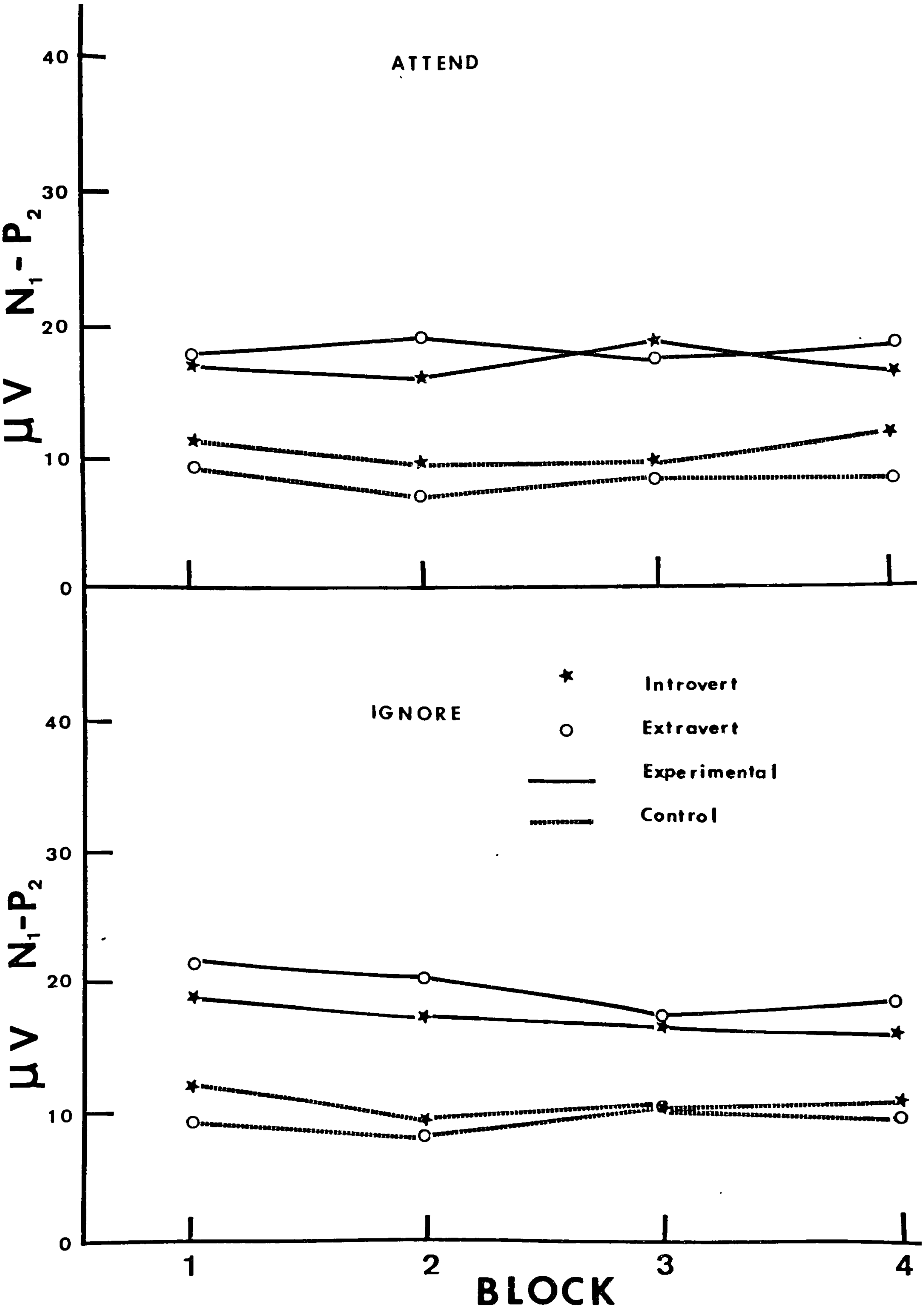

ATTEND
IGNORE
Introvert
Extravert
Experimental
Control
$\mu V \quad N_1 - P_2$
0
10
20
30
40
1
2
3
4
BLOCK

Table 6

Means and SD of N1 - P2 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Blocks of Stimuli

Repetition			1	2	3	4
Introverts	Attend	Experimental	17.27 (7.41)	16.80 (6.22)	18.39 (5.08)	16.41 (5.20)
		Control	11.43 (5.53)	9.48 (4.47)	9.10 (4.90)	6.79 (3.21)
	Ignore	Experimental	19.39 (7.27)	17.38 (3.85)	16.11 (6.66)	15.88 (6.82)
		Control	12.22 (5.45)	9.71 (5.33)	9.98 (5.58)	10.86 (3.41)
Extraverts	Attend	Experimental	17.70 (7.35)	18.33 (7.46)	16.11 (7.58)	17.01 (7.50)
		Control	9.66 (6.96)	7.15 (4.83)	8.44 (4.17)	8.41 (5.26)
	Ignore	Experimental	21.71 (8.93)	20.39 (7.96)	16.98 (8.47)	18.14 (0.25)
		Control	9.86 (3.84)	9.00 (4.34)	10.11 (5.33)	9.47 (4.39)

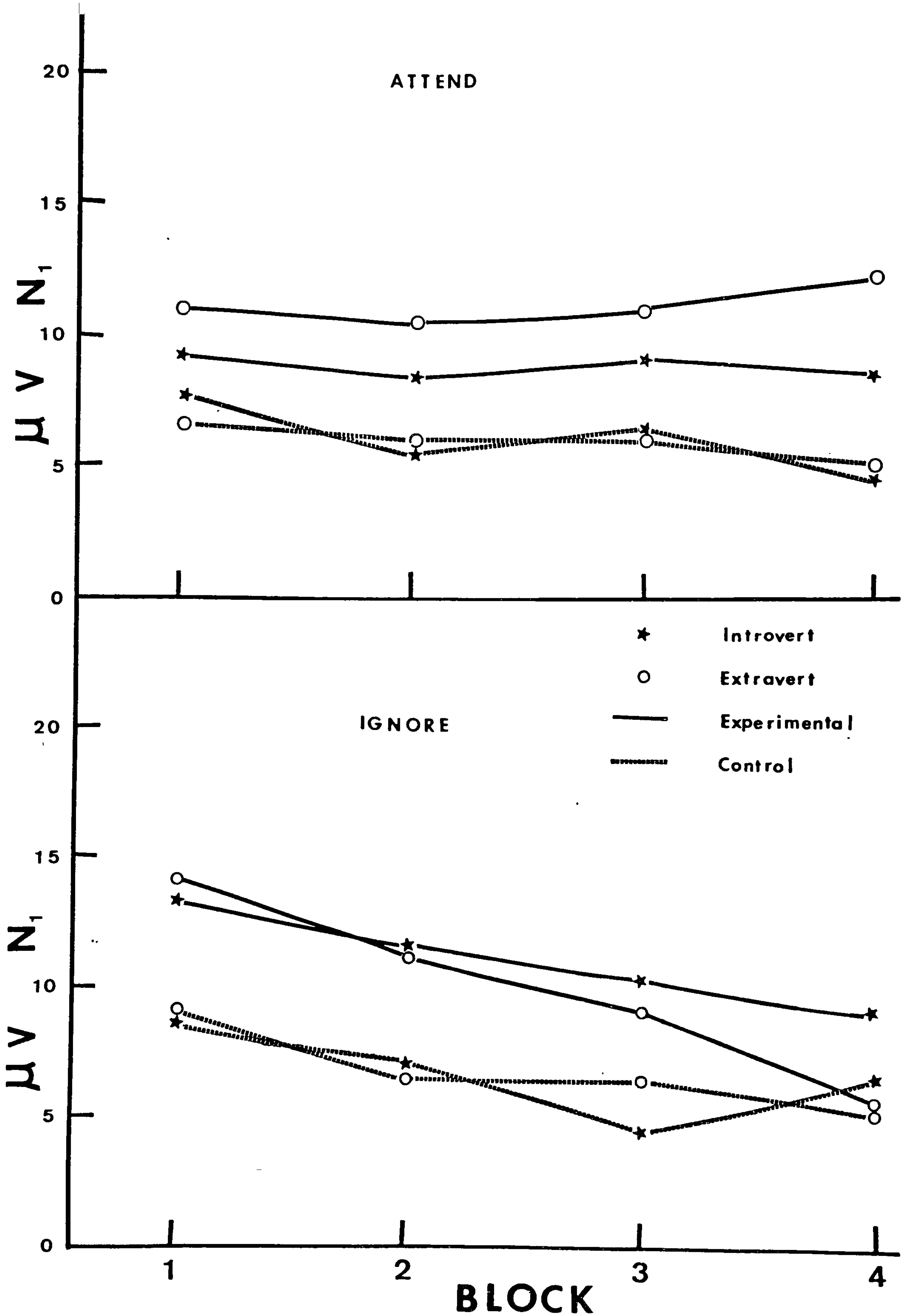
NOTE: SDs are given in parentheses.

The habituation-train main effect $\underline{F}$ = (1/44) = 65.88, MSe = 22.40, showed a higher mean N1 amplitude under the experimental condition, 10.36, than under the control condition 6.66. The block main effect, $\underline{F}$ = (3/132) = 9.91, MSe = 13.71, indicated that the mean N1 amplitude at the first level of blocks, was significantly greater, 10.02, than the mean at the fourth level, 7.20, but not greater than blocks two, 8.50, and three, 8.33.

A two-way interaction between blocks and attention level, $\underline{F}$ = (3./13) = 5.55, MSe = 13.71, revealed that under the ignore condition, the mean N1 amplitude was larger at the first block, 11.45, than at the last block, 6.61, but did not differ from blocks two, 9.40, and three, 7.78. The difference between these two means was not significant either. Under the attend condition there was no significant difference between the four block means, (8.67, 7.82, 8.21, 7.79). When ignore and attend conditions were compared, the first block had a significantly larger mean, 11.45, under the ignore condition than under the attend condition, 8.67. The means at other levels of blocks did not differ significantly between attend and ignore conditions. Means of N1 amplitude are illustrated in Figure 10 and summarized in Table 7.

P2 amplitude. The analysis of second positive peak measures showed a significant main effect and two significant interactions: the habituation-train main effect, $\underline{F}$ = (1/44) = 46.97, MSe = 38.68, the block X attentional level, $\underline{F}$ = (1/44) = 4.97, MSe = (3/132) = 3.43, MSe = 16.96, and the habituation-train X personality X attention level, $\underline{F}$ = (3/132) = 3.43, MSe = 16.96. Results of P2 amplitude are shown in Figure 11 and Table 8.

Figure 10. Means of N1 amplitude for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four blocks of stimuli.



ATTEND
IGNORE
μV N1
20
15
10
5
0
Introvert
Extravert
Experimental
Control
1
2
3
4
BLOCK

Table 7

Means and SD of N1 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Blocks of Stimuli

Repetition			1	2	3	4
Introverts	Attend	Experimental	9.23 (4.55)	8.74 (2.54)	9.16 (4.21)	8.85 (3.15)
		Control	7.48 (3.77)	5.57 (5.28)	6.42 (4.01)	4.60 (1.64)
	Ignore	Experimental	13.29 (6.14)	11.96 (4.04)	10.68 (6.25)	9.00 (7.78)
		Control	8.86 (4.81)	7.37 (3.03)	4.77 (3.62)	6.68 (4.97)
Extraverts	Attend	Experimental	11.07 (5.21)	10.67 (3.02)	11.29 (4.02)	12.35 (3.64)
		Control	6.94 (6.33)	6.32 (3.53)	6.02 (3.39)	5.36 (5.49)
	Ignore	Experimental	14.04 (3.85)	11.48 (8.03)	9.15 (6.94)	5.77 (8.19)
		Control	9.25 (3.46)	6.82 (2.67)	6.54 (3.51)	5.00 (3.38)

NOTE: SDs are given in parentheses.

Figure 11. Means of P2 amplitude for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four blocks of stimuli.

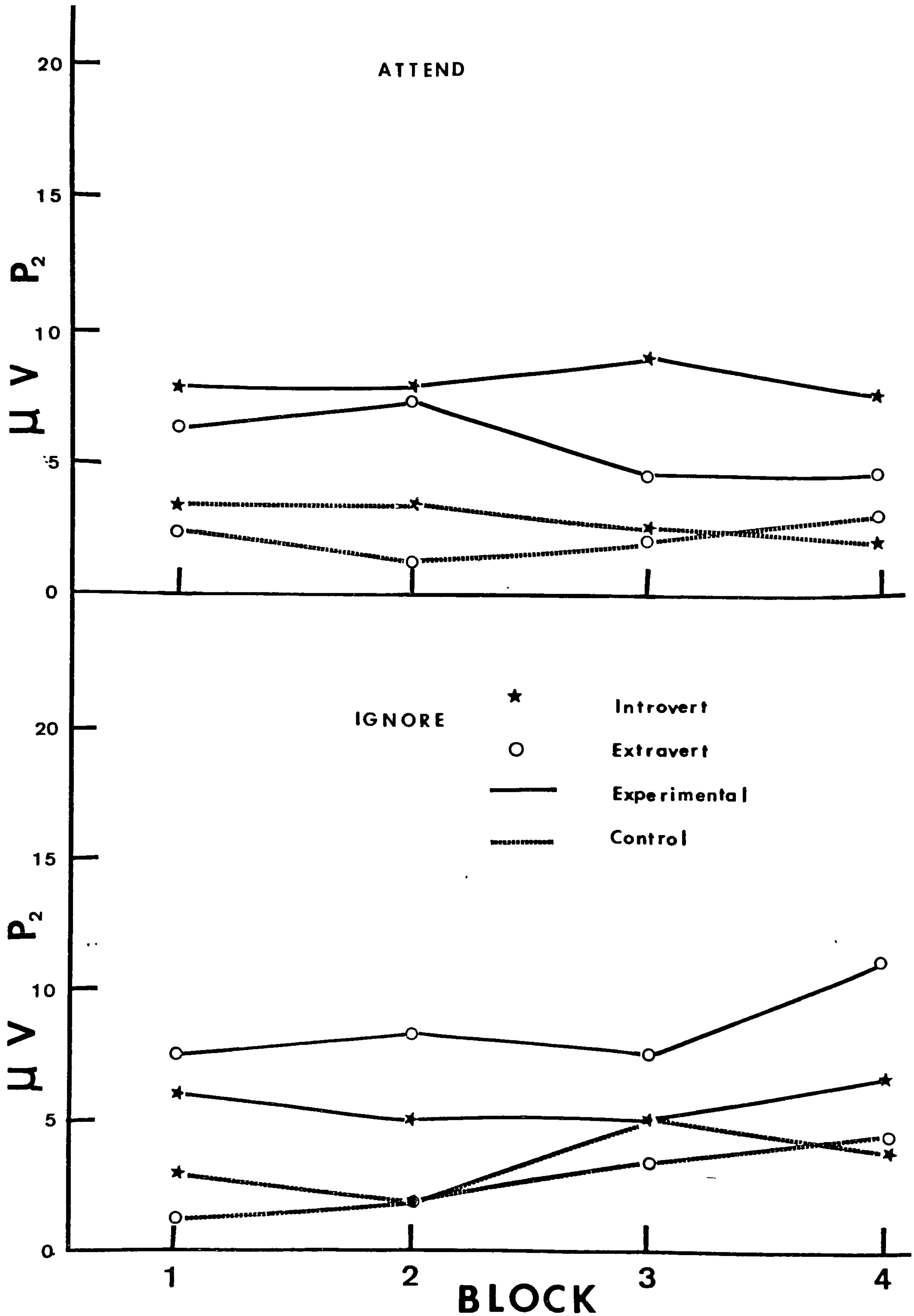

ATTEND
IGNORE
Introvert
Extravert
Experimental
Control
μV P2
BLOCK
0
5
10
15
20
1
2
3
4

Table 8

Means and SD of P2 Amplitude for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Blocks of Stimuli

Repetition			1	2	3	4
Introverts	Attend	Experimental	8.04 (5.07)	8.07 (7.07)	9.24 (4.01)	7.55 (4.35)
		Control	3.95 (4.42)	3.91 (4.29)	2.69 (3.75)	2.19 (2.99)
	Ignore	Experimental	6.10 (5.16)	5.42 (3.94)	5.42 (5.85)	6.88 (6.60)
		Control	3.36 (6.61)	2.34 (4.70)	5.21 (5.41)	4.17 (3.10)
Extraverts	Attend	Experimental	6.63 (6.66)	7.66 (6.55)	4.82 (7.28)	4.66 (6.38)
		Control	2.72 (5.36)	0.83 (4.73)	2.43 (3.19)	3.05 (4.27)
	Ignore	Experimental	7.68 (7.99)	8.19 (4.69)	7.84 (5.56)	12.37 (9.20)
		Control	0.61 (4.18)	2.18 (3.31)	3.56 (2.71)	4.47 (3.95)

NOTE: SDs are given in parentheses.

In the habituation-train main effect, the mean P2 amplitude was larger under the experimental condition, 5.44, than under the control condition, 2.98.

The two-way interaction between blocks and attentional levels, revealed that under the ignore condition, the mean P2 amplitudes at the first two blocks, 4.44, 4.71, were both significantly smaller than the mean at the last block, 6.97, but did not differ from the third level, 5.51. Under the attend condition the means did not differ between the four levels of blocks. When ignore and attend conditions were compared the difference between the means was found significant at the last block only with the ignore condition, 6.97, being larger than the attend condition, 4.37.

In the three-way interaction between habituation-train, personality and attention level, the extraverts had a higher mean P2 amplitude under the experimental condition than under the control condition for both ignore and attend conditions, while the introverts differed under attend condition only. When personality groups and attention levels were compared no significant difference was found.

N1 latency. The analysis of N1 latency showed that the habituation-train main effect, $F = (1/44) = 6.77$, MSe = 140.78, and the habituation-train X personality X attention level, $F = (1/44) = 4.17$, MSe = 140.78, were significant at .05 level.

In the habituation-train main effect, the mean N1 latency under the experimental condition was significantly greater, 117.22, than under the control condition, 114.17.

The three way interaction between habituation-train, personality and attentional level, showed that the extraverts had significantly greater mean N1 latency under the experimental condition, 120.63, than under the control condition, 113.33, when they ignored a tone but not when they attended to the same tone, with means of 116.88 and 113.44. Introverts, on the other hand, did not differ between experimental and control conditions under both ignore and attend conditions. When personality groups and attention levels were compared, no significant difference was found. The N1 latency means are summarized in Figure 12 and Table 9.

P2 latency. Two main effects and two interactions were found significant in the P2 latency analysis. Means are summarized in Figure 13 and Table 10.

The habituation-train main effect, $F = (1/44) = 72.76$, MSe = 405.26, showed that the mean P2 latency was significantly longer under the experimental condition, 200.65, than under the control condition, 183.13. In the block main effect, $F = (3/132) = 15.10$, MSe = 224.54, the Newman-Keuls' test indicated that the mean P2 latency at the first level of blocks, 200.11, was significantly larger than at the fourth block, 186.04, but not larger than the second, 189.85, and the third blocks, 191.57.

A two-way interaction, $F = (3/132) = 3.66$, MSe = 224.54, between blocks and attention level, indicated that under the ignore condition the mean P2 latency at the first block 200.94, was significantly larger than

Figure 12. Means of N1 latency for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four blocks of stimuli.

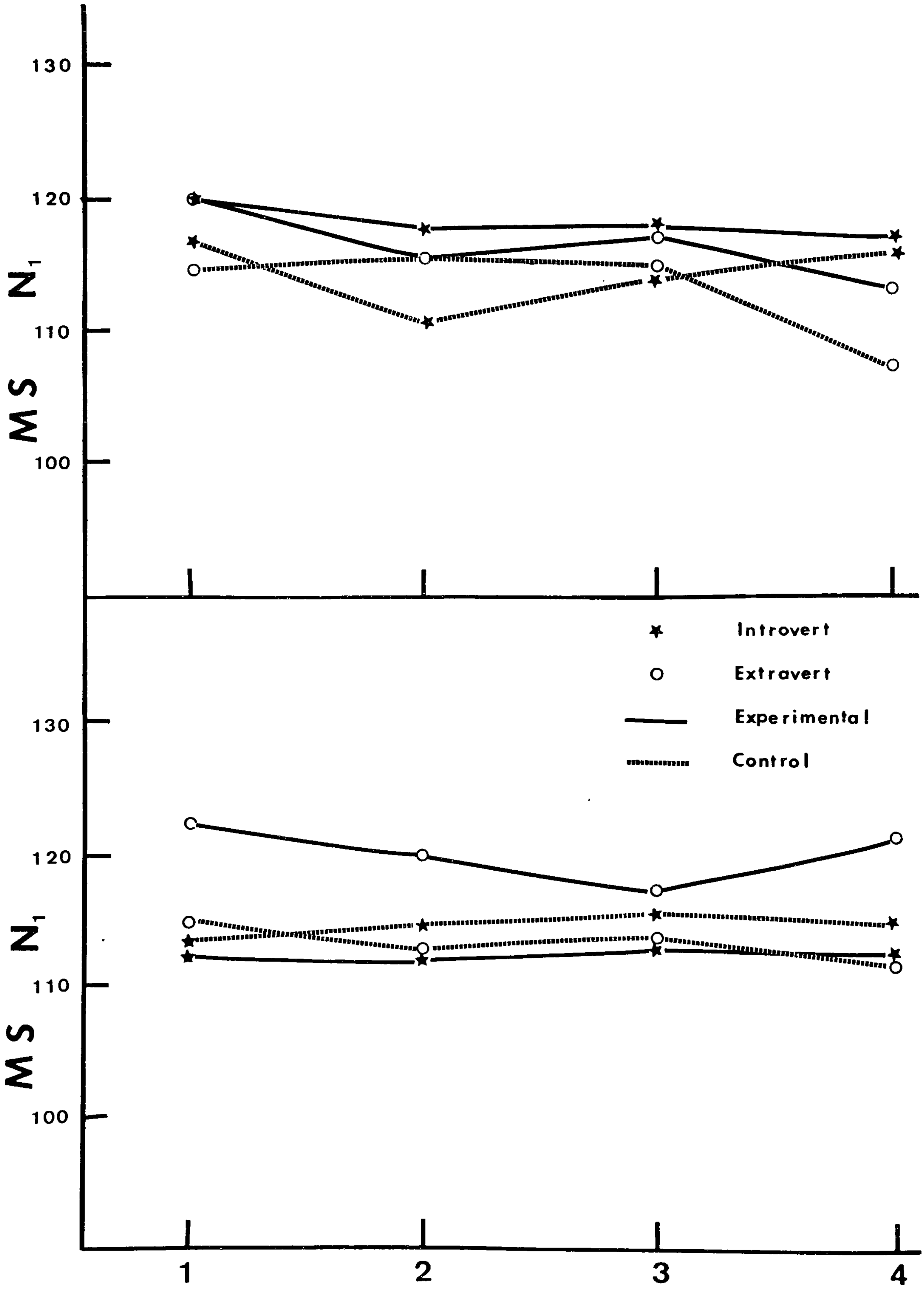

130
120
110
100
MS N_1
Introvert
Extravert
Experimental
Control
1
2
3
4

Table 9

Means and SD of N1 Latency for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Blocks of Stimuli

Repetition			1	2	3	4
Introverts	Attend	Experimental	120.42 (10.54)	118.75 (11.51)	118.33 (6.85)	117.92 (11.37)
		Control	117.08 (16.43)	111.25 (16.67)	114.58 (13.73)	116.67 (13.03)
	Ignore	Experimental	112.50 (14.38)	112.91 (15.44)	113.33 (10.29)	112.92 (12.15)
		Control	113.75 (16.53)	115.42 (10.97)	115.83 (15.50)	115.00 (15.37)
Extraverts	Attend	Experimental	120.00 (11.48)	116.25 (9.32)	117.50 (12.52)	113.75 (11.70)
		Control	114.58 (11.17)	116.25 (18.72)	115.42 (12.52)	107.50 (13.90)
	Ignore	Experimental	122.50 (17.25)	120.42 (10.10)	117.92 (12.87)	121.67 (14.82)
		Control	115.42 (12.33)	112.08 (12.15)	113.75 (16.25)	112.08 (10.54)

NOTE: SDs are given in parentheses.

Figure 13. Means of P2 latency for introverts and extraverts under attend and ignore conditions at the experimental and control conditions for four blocks of stimuli.

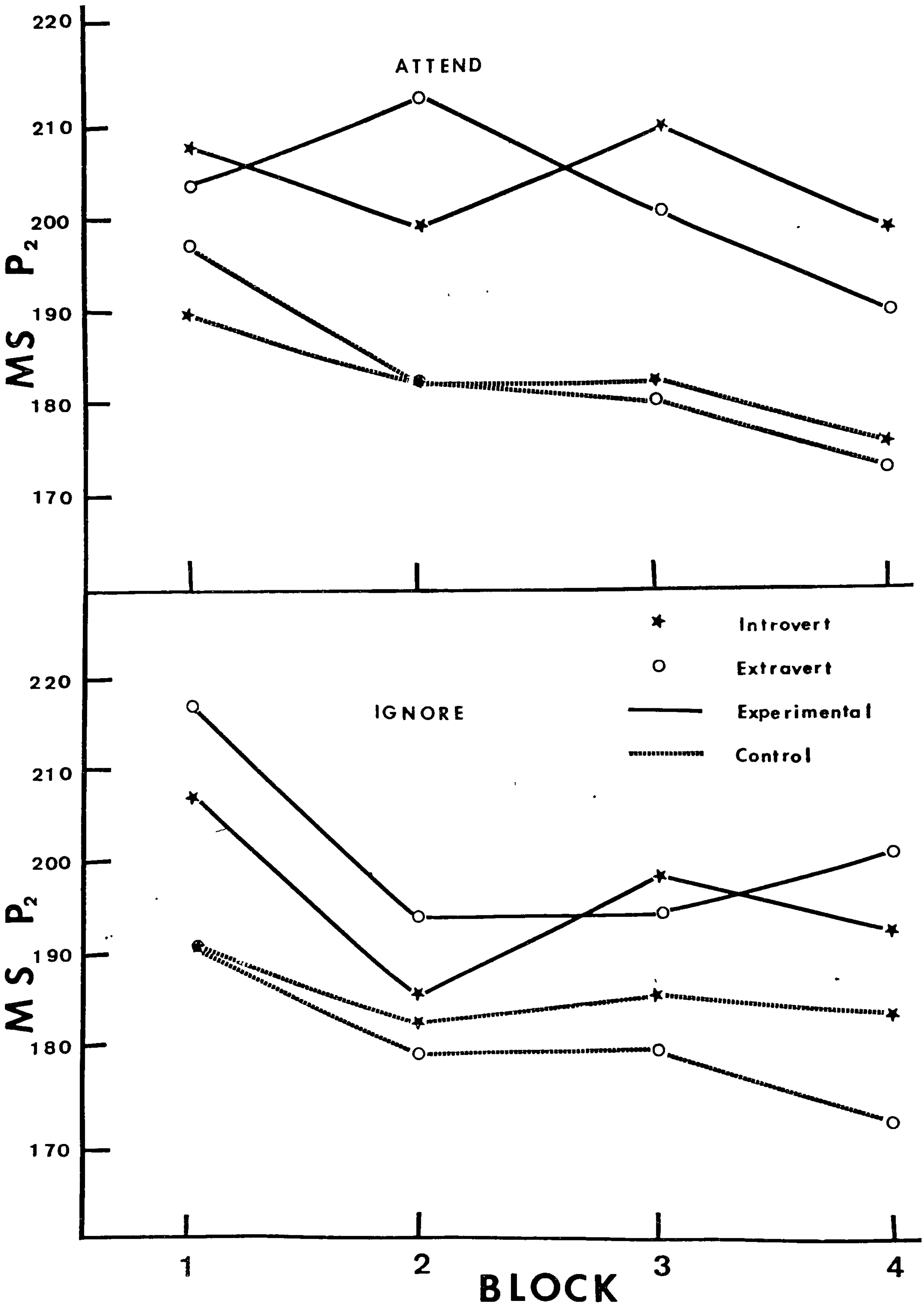

ATTEND
IGNORE
MS P_2
220
210
200
190
180
170
Introvert
Extravert
Experimental
Control
1
2
3
4
BLOCK

Table 10

Means and SD of P2 Latency for Introverts and Extraverts Under Attend and Ignore Conditions at the Experimental and Control Conditions for Four Blocks of Stimuli

Repetition			1	2	3	4
Introverts	Attend	Experimental	207.03 (18.76)	199.58 (18.15)	209.58 (16.85)	197.50 (15.00)
		Control	189.58 (18.27)	182.50 (18.40)	181.67 (17.49)	175.00 (12.61)
	Ignore	Experimental	207.08 (23.49)	186.25 (19.67)	197.08 (26.67)	192.50 (17.90)
		Control	190.83 (20.97)	182.08 (19.36)	185.83 (15.93)	184.58 (9.87)
Extraverts	Attend	Experimental	203.75 (16.53)	212.08 (12.87)	201.25 (22.88)	190.00 (20.34)
		Control	196.67 (21.88)	182.92 (17.12)	180.83 (21.72)	172.92 (11.17)
	Ignore	Experimental	215.83 (13.11)	193.75 (16.11)	195.83 (17.43)	201.25 (14.64)
		Control	190.00 (17.19)	179.58 (15.14)	180.42 (18.02)	174.58 (12.87)

NOTE: SDs are given in parentheses.

the following three levels, 185.42, 189.79, 188.23, but blocks two, three and four did not differ between their means. Under the attend condition the mean P2 latencies at the first three blocks, 199.22, 194.27, 193.33, were all significantly longer than the mean at the fourth level, 183.81. No significant difference was found when the attentional levels were compared.

The interaction between habituation-train, attentional level and blocks, with F ratio = (3/132) = 2.61, MSe = 236.52, showed that under the ignore condition mean P2 latencies were significantly longer under the experimental condition when compared to the control condition for blocks one and three, while under the attend condition P2 latencies were significantly longer under the experimental condition than under the control condition for all four blocks of stimuli. When blocks were compared no difference was found under both experimental and control conditions. When attentional levels were compared, no significant difference was found between attend and ignore conditions at either experimental or control condition, for the four levels of blocks.

Total Stimuli Analysis

Analysis of variance of average N1 - P2 amplitudes measured over the total 96 stimuli, comparing extraverts and introverts under attend and control conditions, showed no significant difference. As this interaction was the only relevant result to the experimental hypothesis, other effects in the analysis of total stimuli have not been carried. Table 11 shows N1 - P2 means amplitude for personality X habituation-train X attentional variable.

TABLE 11

Means of N1 - P2 Amplitude for Introverts and Extraverts Under Attend and Ignore conditions at the Experimental and Control Conditions for the Total of All Stimuli

		Experimental	Control
Introverts	Attend	19.90	9.43
	Ignore	20.52	10.43
Extraverts	Attend	18.65	8.65
	Ignore	20.23	9.59

Chapter IV

DISCUSSION AND INTERPRETATION OF RESULTS

Results are discussed following the statistical analysis order used in the previous chapter, that is stimulus sequence analysis, block sequence analysis and total stimuli analysis. In each of these sections, the significant findings related to extraversion are discussed first followed by attention and habituation effects. Finally, the implications of this study for further research with extraversion are pointed out.

Stimulus Sequence Analysis

Ritter et al. (1968) argued that the conventional averaged evoked response technique used to measure a large number of stimulus sequence responses in habituation studies, could not indicate the changes occurring at the beginning of the experimental session. These authors developed a technique which permits a stimulus by stimulus analysis of AER across short trains of stimuli. The technique also has the advantage of measuring habituation effect in a short period of time thus eliminating drowsiness usually present in long-term habituation and affecting the response decrease (Williams, Tepas, & Marlock, 1962).

Subsequent studies which used the short-term habituation technique showed that habituation of the human vertex response occurs rapidly. However no study has used a control condition to test the effect of short trains of stimuli against a "no-train" condition. The present study used such a control and defined the habituation effect as the interaction between habituation-train variable (with train and no-train levels) and the stimulus repetition (4 stimuli). Habituation is considered to be completed when there is no significant difference between experimental and control group.

In general, results of the stimulus sequence analysis indicated that the N1 - P2 amplitude component varied with extraversion dimension but was not affected by attention. When N1 - P2 was decomposed into N1 and P2, both components differentiated extraversion and introversion but only under the influence of attention. These results are considered in detail in four subdivisions as follows.

Extraversion and habituation effect. When peak-to-peak N1 - P2 amplitude was measured, responses to the first stimulus differed with personality dimension. Introverts had significantly larger initial responses than extraverts. However, habituation was reached at the same level of stimulus repetition for both groups. In general, N1 and P2 latencies became shorter with stimulus repetition. However, introverts showed a longer P2 latency than extraverts at the third stimulus and without attention effect.

These results are consistent with previous study of the habituation of the OR using EDR measures of habituation. Larger initial response for introverts has been reported in several electrodermal studies (e.g., Mangan & O'Gorman, 1969; Stelmack, Bourgeois, Chian & Pickard, 1979; Wigglesworth & Smith, 1976), and has been interpreted as evidence of greater cortical arousal for the introverts. But there are some questions whether this initial N1 - P2 amplitude in the present study is also an OR response.

From Naatanen's (1979) definition, the OR may be "the response to the first stimulus after an 'empty' period" (p. 63). The N1 - P2 response to the first stimulus after a delay of 56 seconds in the present study could therefore be interpreted as an orienting response, even if the stimulus is unchanged. Ohman and Lader (1977) maintained that evoked potential components in 50 to 200 msec latency are not related to orienting because of lack of relationship between attention and response decrement. In the same way, Ritter, Vaughan and Costa (1968) argued that P2 could not represent OR habituation, since no change in the P2 amplitude was noticed in a study using unexpected stimuli while a new positive component in the evoked potential at 300 msec was observed. These authors maintained that P3 component was an aspect of the orienting response but not N1 and P2 responses. Rust (1977), on the other hand, concluded from a study correlating AER with GSR and HR habituation scores, that all aspects of the evoked potential and not just P3 component are indices of the orienting reaction. At this point, it is not precisely clear whether one or many AER components are reflecting the orienting responses.

One may argue that this larger initial response is due to the anticipation effect for the introverts after each delay. However, previous literature suggests that anticipation of expected stimuli diminishes the responses while facilitation occurs with unexpected stimuli (Gastaut, 1953), which is not the case in the present study. Moreover, expectancy and uncertainty have been related with the development of P3 peak (Sutton, Braren, Zubin & John, 1965) thus limiting the possibility of having an expectancy effect in the enlarged N1 - P2 amplitude for the introverts.

There is some evidence that larger N1 - P2 amplitude is indicative of increased arousal. Being interrupted for a 56 seconds delay during a counting task could have resulted in a higher arousal level for the introverts and could be reflected in a larger N1 - P2 amplitude to the first stimulus after the delay. Eysenck hypothesized that introverts are more cortically aroused than extraverts and that extraverts are more cortically inhibited than their counterparts. Traditionally neurophysiological studies of cortical excitability have utilized the amplitude of evoked potentials as an index of cortical excitability (Shagass & Schwartz, 1966), and using a short-term habituation paradigm, Ohman and Lader (1977) showed that high level of arousal produced larger N1 - P2 response on the first stimulus with a rapid drop in amplitude on the second stimulus. These results fit nicely with the present findings for the introverts. They showed larger initial response than the extraverts, but reached habituation at the second stimulus, like the extraverts, thus producing a steeper slope than the extraverts. Moreover, introverts have already been found to perform better at the beginning of a task but with a decrease in arousal their performance declined (Harkins & Geen, 1975). Larger initial N1 - P2 response for the introverts could therefore be interpreted as indication that introverts are more cortically aroused thus supporting Eysenck's (1967) proposal.

When base-to-peak measures were analysed, N1 response decrement was not affected by personality, but P2 varied in the same direction as N1 - P2 component. The introverts showed again larger initial response than extraverts and they reached complete habituation by the third stimulus while extraverts with smaller initial response reached habituation at the fourth stimulus only. Larger initial N1 - P2 response for the introverts is therefore mainly due to the contribution of P2 component.

Extraversion and attention effect

Results demonstrated that N1 - P2 component was not affected by attention but peaks N1 and P2 analysed from a prestimulus baseline were altered by individual differences and attention levels, even if no main effect for attention and personality variables were noticed.

Results are rather puzzling. Under the ignore condition, introverts and extraverts did not differ in their N1 amplitude, but the introverts who ignored the tone had larger initial response than the other group of introverts who attended to the tone. Under attend condition, the extraverts had larger initial N1 amplitude than the introverts. In other words, the introverts who attended to a tone had smaller N1 response than the extraverts who attended, and than the introverts who ignored a tone. An inverse relationship was observed in the P2 amplitude. Introverts had larger initial responses than the extraverts when they both attended to a tone but no difference was observed when they ignored the tone. Unlike N1 responses, introvert ignore and introvert attend did not differ in their initial P2 amplitude. One may argue that the inverse relationship observed in N1 and P2 amplitude under the attend condition could be due to the measurement from the prestimulus baseline. Interpretation of the data suggests that this is an unlikely cause of the effect, since measurement from the baseline would also cause an inverse relationship for the ignore as well as for the attend conditions which is clearly not the case.

Introverts who displayed larger initial N1 amplitude did not show smaller initial P2 amplitude as would be expected with error from baseline, therefore demonstrating an inconsistency in the inverse relationship.

A common result emerging from most studies about changes in the evoked response accompanying fluctuations in attention is an increase N1 amplitude with increase in attention (Davis, 1964; Keating & Ruhm, 1971; Mast & Watson, 1968; Picton, Hillyard, Galambos, & Schiff, 1971; Satterfield, 1965; Sheatz & Chapman, 1969; Spong, Haider, & Lindsley, 1965; Wilkinson & Morlock, 1967) with a more pronounced N1 effect when the tones were fainter or masked with noise (Schwent, Hillyard, & Galambos, 1976). Hillyard and Picton (1979) proposed that the increase in task difficulty requires the subject "to commit more of his processing resources to the attended-channel, thus leaving fewer resources to process the irrelevant channels and increasing the selectivity of processing" (p. 22). In the present study, the stimulus (mantra) used to divert attention from the experimental stimuluation (Becker & Shapiro, 1981), was weak and was also masked by the repetitive auditory tone thus increasing the selectivity of processing. The introverts in their efforts to pay attention to the weak stimulus and ignore a much louder noise, could result in an enhanced N1 amplitude as demonstrated by Hillyard and Picton (1979). This leads to the suggestion that introverts show an increased selectivity in difficult tasks while the extraverts do not. When the task was relatively easy in the attend condition, the introverts did not differ in their responses.

Why the introverts display larger amplitude than extraverts at P2 component when they attend and not at the N1 component cannot be explained from the data provided by the present paradigm. A simpler experimental design manipulating only attention state could bring more conclusive results.

Attention was not reflected in a larger N1 amplitude for the attend as compared to the ignore condition as would be expected. Studies have shown that attention effects are found at shorter interstimulus intervals (range 200-1500 msec) with tone pips of about 50 msec duration at intensity lower than 60 dB (Schwent et al., 1976). With long ISI, the direction of binaural attention has not been found to have an influence upon the N1 wave. In the present paradigm an ISI of 1000 msec was used with an 80 dB intensity pure tone of 200 msec duration. Therefore, attention effect cannot be expressed in the present study.

Extraversion, habituation and attention

P2 was the only component to be affected in its shape of habituation by both individual differences and attention effect. Under the attend condition the introverts started at a higher level of P2 amplitude and then converged with the extraverts by the third stimulus resulting both in a significant interaction between habituation train and stimulus repetition variables. Under the ignore condition, the introverts and extraverts did not differ in their P2 initial response, but the introverts reached complete habituation at the second stimulus while the extraverts reached it at the last (fourth) stimulus only.

Direction of attention in a previous short-term habituation study (MacLean, Ohman, & Lader, 1975) showed a more rapid habituation to the non-attended than to the attended stimulus in the high activation condition. These authors concluded that the N1-P2 component was directly related to both attention and activation. Present results show similar effect at the P2 component with introverts, under the ignore condition. Faster response decrement for introverts in the ignore and not in the attend condition demonstrate the possibility that in the ignore condition the use of a "mantra" was more arousal for the introverts. The results are then in agreement with Ohman's suggestion that level of arousal can alter the shape of the habituation. Present results indicate clearly that personality dimension should also be taken into consideration in future research. Moreover, some previous results also showed striking interindividual variability and attention relationship in short-term evoked potential habituation (Fruhstorfer et al., 1970; Tecce, 1970) leading to the suggestion that individual differences, attention and arousal level can all contribute to change the form of habituation.

Habituation effect. The findings showed a significant rapid decrease in amplitude in the experimental condition accompanied by significant decrease in latencies for all components studied. As previous research has also shown, a very large amplitude to the first stimulus appeared in all conditions (Fruhstorfer et al., 1970; Ohman et al., 1972).

Amplitude of N1 - P2 component decreased abruptly and significantly from the first to the second stimulus and stayed constant thereafter but did not reach complete habituation at any level of repetition used in the study. Therefore, even if there was a rapid N1 - P2 amplitude decrease, full habituation has not been reached within the four levels of stimulus repetition. Ohman and Lader (1972) seem to be the only authors to report peak-to-peak measures. They observed vertex potentials during trains of 10 stimuli of 1 msec duration at 70 dB intensity during conditions of attention directed towards or away from the stimuli, with mean interstimulus intervals (ISI) of 3 or 10 sec. In all conditions, a slow but significant curve decrease was observed but did not reach an asymptote for the 10 stimuli. With peak-to-peak measures, a longer train of stimuli might be required to obtain full habituation even if individual peak measures are known to reach asymptote level at the third stimulus (Fruhstorfer, 1970, 1971). In Ohman and Lader's experimental paradigm, a relatively long train of stimuli (10) was used but amplitude decrement did not reach asymptotic level. However, the authors used longer interstimulus intervals (3 sec and 10 sec) which could result in a slower habituation effect. It was already demonstrated that amplitude decrease is dependent on the number of stimulus presentations and on the interval between the stimuli. With a stimulus interval of 3 sec, the decrease in N1 and P2 was found to be less rapid and less pronounced (Fruhstorfer, 1970). In the present study, with the use of short ISI (1 sec) it is believed that full habituation of N1 - P2 could have been obtained if more stimuli were given in a train.

When N1 and P2 components were analysed from a prestimulus baseline, full habituation was obtained. N1 amplitude decreased rapidly and significantly from the first to the second stimulus. It increased slightly on the last stimulus although it was significantly smaller than for the first stimulus response. Complete habituation was reached on the last two stimuli. P2 component followed a significant monotonic decrease in amplitude size, reaching habituation by the last stimulus. These results are in agreement with previous studies using similar stimulus paradigm and showing rapid decrease in N1 and P2 amplitude responses on the first four stimuli (Fruhstorfer et al., 1970, 1971; Picton et al., 1976; Ritter et al., 1968; Roth & Kapell, 1969). Habituation seems to be more evident when N1 - P2 is decomposed into N1 and P2 components, at least in this research.

Both N1 and P2 latencies become significantly shorter at the second stimulus and remained approximately at the same level afterward. Shorter latencies with decrease in corresponding amplitude had already been found in several studies (Fruhstorfer et al., 1971; Ohman et al., 1972, 1975) and are confirmed in the present results.

Block Sequence Analysis

To study long-term changes of the responses over the whole experimental session, successive averages over 24 stimulus presentations were calculated giving blocks of 24 stimuli for each condition and subject. Results showed an overall decrease in peak-to-peak and peak-to-base amplitude accompanied by shortening latencies. N1 and P2 amplitude decrement was affected by attention variable but not by individual differences, while peak-to-peak measures (N1 - P2) were not affected by personality or by attention.

Habituation and attention effect. No long-term response decrement was noted under the attend condition but under the ignore condition there was a rapid N1 amplitude decrease and a slight P2 increase at the fourth stimulus block, with greater N1 amplitude in the attend condition for the first block, but larger P2 amplitude in the ignore condition for the last block of stimuli.

From the few previous studies which combined trains of stimuli to observe attention effect on long-term habituation, no clear-cut results have been reported. Ohman and Lader (1972), observed larger N1 - P2 amplitude in the attend than in the ignore condition but the shape of habituation was altered by the activation level and not by the manipulation of attention. Arousal and attention are known to affect the short-term habituation and for the reasons already discussed in the stimulus-by-stimulus analysis, the ignore task used in the present study could also produce different individual arousal levels and account for the long-term as well as for the short-term results. Thus, instructions and stimulus used seem critical for the observation of attention effect in long-term as well as in short-term habituation.

Habituation effect. In general there was an overall decrease in N1 - P2, N1 and P2 amplitude with stimulus repetition demonstrating a long-term habituation through the sessions. Results are in agreement with Ohman et al.'s (1975) findings, showing a curved decrease over successive blocks of trains. However, no complete long-term habituation was obtained since no significant habituation-train X block interaction was found in the present study suggesting that even if there were decremental effects from one train to the next, the same short-term process was operating in each train.

Total Stimuli Analysis

One main goal of the present study was the replication of previous findings (Stelmack, Achorn, & Michaud, 1977) reflected in the N1 - P2 amplitude of individual differences under attend and control conditions. This interaction was not significant but in long-term habituation effect as illustrated in Figure 9 under attend and control conditions the direction of differences was in the same direction as in the previous study. The introverts had higher N1 - P2 amplitude than extraverts but the differences were not statistically significant. A sample of 12 subjects instead of 15 was used in the present study and the difference in experimental paradigm with alternating high and low frequency in previous results as compared to the same repetitive low frequency tone in the present study could contribute to discrepancies in results.

It is well known that monotonous stimulation decreases level of arousal (Bohlin, 1971, 1973). Thus amplitude changes in EPs might reflect changes in arousal. High arousal could have been maintained by alternating high and low frequency in previous study (Stelmack et al., 1977) resulting in a more constant large N1 - P2 amplitude while the continuous repetition of the same stimulus in the present paradigm might have caused a decrease of response magnitude with the decrease of arousal.

As elaborated in the first chapter of this study, Eysenck associated arousal functions with differences in cortical activity, predicting that introverts would be more sensitive to external stimulation reflected in lower absolute threshold of arousal. Some studies such as Stelmack and Campbell (1974) suggest that the differences in personalities are demonstrated in the greater sensitivity of introverts to absolute levels of intensity. If introverts have a lower threshold of sensitivity, the equal intensities applied to the two groups of personality should then be perceived higher by the introverts thus resulting in a higher effect on the accompanying N1 - P2 amplitude under attend and ignore conditions which is not the case in the present study. However, introverts were found to display larger initial N1 - P2 amplitude response than extraverts with larger P2 amplitude in the attend condition.

The hypothesis that introverts perform better than extraverts at the beginning of a test but decline in performance with decrease of arousal (Harkins & Geen, 1975) seems to be a possible explanation for the present findings. The initial N1 - P2 amplitude could be enhanced with increased arousal at the beginning of each train of stimulus with larger initial P2 amplitude when they are required to count the stimulus. This leads to the suggestion that arousal is especially expressed in the P2 component, with larger amplitude associated with greater cortical arousal.

Another alternative might be that dishabituation was maintained by the alternating high and low frequency in previous findings, resulting in constant larger N1 - P2 responses. This hypothesis is supported by the larger initial responses observed in the present paradigm and could be tested by repeating the former research using a continuous versus an alternating series of tones.

Future research might focus upon the relationship between individual differences and selective attention reflected in the late components. This would enable better understanding of sensory processing along the extraversion dimension. Because the stimulus paradigm was not identical in both present and previous studies, results found could be attributed to differences in arousal levels. A repetition of previous study (Stelmack et al., 1977) utilizing an ignore group may provide information regarding the attention effect to the contribution of larger N1 - P2 amplitude. Finally a replicaton of the study of the relation between personality, attention and habituation reflected in N1 - P2 amplitude should be attempted since the present study is the first of its kind. Studies by other investigators in different settings are necessary to make its results more reliable and general.

In summary, the results of this study showed no main effects for extraversion and attention in the analyses of latency and amplitude measures for any of the components considered. An habituation X personality X attention interaction showed that the introverts at the first stimulus of a train, had smaller N1 and larger P2 amplitudes than the extraverts when they attended to the stimulus but not when they ignored it. In the same way, the introverts had larger initial N1 - P2 amplitude than extraverts but with no attention effect.

Present findings suggest that if larger N1 - P2 amplitude observed in the previous result (Stelmack et al.'s, 1977) reflects greater sensitivity for the introverts, this sensitivity is not expressed in constant larger amplitude or in slower amplitude decrement but in larger initial response amplitude for the introverts. Fluctuation of this initial response seems to be related to the interaction of attention with stimulus set resulting in a more cortical arousal reflected in larger P2 responses for introverts.

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APPENDIX I

EYSENCK PERSONALITY QUESTIONNAIRE

EPQ

(Adult)

Name ______________________ Age ________ Sex ________

Occupation ______________________ Date ______________

Firm ______________________ Marital Status ______________

Health Status ______________________________________

Weight ______________ Height ______________ Code ______________

INSTRUCTIONS

Please answer each question by marking an [X] beside the "YES" or the "NO" following the question. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

PLEASE REMEMBER TO ANSWER EACH QUESTION

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IN EVERY QUESTION, MARK JUST ONE BOX.

1. Do you have many different hobbies? . . . YES ☐ NO ☐
2. Do you stop to think things over before doing anything? . . . YES ☐ NO ☐
3. Does your mood often go up and down? . . . YES ☐ NO ☐
4. Have you ever taken the praise for something you knew someone else had really done? . . . YES ☐ NO ☐
5. Are you a talkative person? . . . YES ☐ NO ☐
6. Would being in debt worry you? . . . YES ☐ NO ☐
7. Do you ever feel "just miserable" for no reason? . . . YES ☐ NO ☐
8. Were you ever greedy by helping yourself to more than your share of anything? . . . YES ☐ NO ☐
9. Do you lock up your house carefully at night? . . . YES ☐ NO ☐
10. Are you rather lively? . . . YES ☐ NO ☐
11. Would it upset you a lot to see a child or an animal suffer? . . . YES ☐ NO ☐
12. Do you often worry about things you should not have done or said? . . . YES ☐ NO ☐
13. If you say you will do something, do you always keep your promise no matter how inconvenient it might be? . . . YES ☐ NO ☐
14. Can you usually let yourself go and enjoy yourself at a lively party? . . . YES ☐ NO ☐
15. Are you an irritable person? . . . YES ☐ NO ☐
16. Have you ever blamed someone for doing something you knew was really your fault? . . . YES ☐ NO ☐
17. Do you enjoy meeting new people? . . . YES ☐ NO ☐
18. Do you believe insurance plans are a good idea? . . . YES ☐ NO ☐
19. Are your feelings easily hurt? . . . YES ☐ NO ☐
20. Are *all* your habits good and desirable ones? . . . YES ☐ NO ☐
21. Do you tend to keep in the background on social occasions? . . . YES ☐ NO ☐
22. Would you take drugs which may have strange or dangerous effects? . . . YES ☐ NO ☐
23. Do you often feel "fed-up"? . . . YES ☐ NO ☐
24. Have you ever taken anything (even a pin or button) that belonged to someone else? . . . YES ☐ NO ☐
25. Do you like going out a lot? . . . YES ☐ NO ☐
26. Do you enjoy hurting people you love? . . . YES ☐ NO ☐
27. Are you often troubled about feelings of guilt? . . . YES ☐ NO ☐
28. Do you sometimes talk about things you know nothing about? . . . YES ☐ NO ☐
29. Do you prefer reading to meeting people? . . . YES ☐ NO ☐
30. Do you have enemies who want to harm you? . . . YES ☐ NO ☐
31. Would you call yourself a nervous person? . . . YES ☐ NO ☐
32. Do you have many friends? . . . YES ☐ NO ☐
33. Do you enjoy practical jokes that can sometimes really hurt people? . . . YES ☐ NO ☐
34. Are you a worrier? . . . YES ☐ NO ☐
35. As a child did you do as you were told immediately and without grumbling? . . . YES ☐ NO ☐
36. Would you call yourself happy-go-lucky? . . . YES ☐ NO ☐
37. Do good manners and cleanliness matter much to you? . . . YES ☐ NO ☐
38. Do you worry about awful things that might happen? . . . YES ☐ NO ☐
39. Have you ever broken or lost something belonging to someone else? . . . YES ☐ NO ☐
40. Do you usually take the initiative in making new friends? . . . YES ☐ NO ☐
41. Would you call yourself tense or "highly-strung"? . . . YES ☐ NO ☐
42. Are you mostly quiet when you are with other people? . . . YES ☐ NO ☐
43. Do you think marriage is old-fashioned and should be done away with? . . . YES ☐ NO ☐
44. Do you sometimes boast a little? . . . YES ☐ NO ☐
45. Can you easily get some life into a rather dull party? . . . YES ☐ NO ☐

GO RIGHT ON TO THE NEXT PAGE.

46. Do people who drive carefully annoy you? YES ☐ NO ☐
47. Do you worry about your health? YES ☐ NO ☐
48. Have you ever said anything bad or nasty about anyone? YES ☐ NO ☐
49. Do you like telling jokes and funny stories to your friends? YES ☐ NO ☐
50. Do most things taste the same to you? YES ☐ NO ☐
51. As a child did you ever talk back to your parents? YES ☐ NO ☐
52. Do you like mixing with people? YES ☐ NO ☐
53. Does it worry you if you know there are mistakes in your work? YES ☐ NO ☐
54. Do you suffer from sleeplessness? YES ☐ NO ☐
55. Do you always wash before a meal? YES ☐ NO ☐
56. Do you nearly always have a "ready answer" when people talk to you? YES ☐ NO ☐
57. Do you like to arrive at appointments in plenty of time? YES ☐ NO ☐
58. Have you often felt listless and tired for no reason? YES ☐ NO ☐
59. Have you ever cheated at a game? YES ☐ NO ☐
60. Do you like doing things in which you have to act quickly? YES ☐ NO ☐
61. Is (or was) your mother a good woman? YES ☐ NO ☐
62. Do you often feel life is very dull? YES ☐ NO ☐
63. Have you ever taken advantage of someone? YES ☐ NO ☐
64. Do you often take on more activities than you have time for? YES ☐ NO ☐
65. Are there several people who keep trying to avoid you? YES ☐ NO ☐
66. Do you worry a lot about your looks? YES ☐ NO ☐
67. Do you think people spend too much time safeguarding their future with savings and insurances? YES ☐ NO ☐
68. Have you ever wished that you were dead? YES ☐ NO ☐
69. Would you dodge paying taxes if you were sure you could never be found out? YES ☐ NO ☐
70. Can you get a party going? YES ☐ NO ☐
71. Do you try not to be rude to people? YES ☐ NO ☐
72. Do you worry too long after an embarrassing experience? YES ☐ NO ☐
73. Have you ever insisted on having your own way? YES ☐ NO ☐
74. When you catch a train do you often arrive at the last minute? YES ☐ NO ☐
75. Do you suffer from "nerves"? YES ☐ NO ☐
76. Do your friendships break up easily without it being your fault? YES ☐ NO ☐
77. Do you often feel lonely? YES ☐ NO ☐
78. Do you always practice what you preach? YES ☐ NO ☐
79. Do you sometimes like teasing animals? YES ☐ NO ☐
80. Are you easily hurt when people find fault with you or the work you do? YES ☐ NO ☐
81. Have you ever been late for an appointment or work? YES ☐ NO ☐
82. Do you like plenty of bustle and excitement around you? YES ☐ NO ☐
83. Would you like other people to be afraid of you? YES ☐ NO ☐
84. Are you sometimes bubbling over with energy and sometimes very sluggish? YES ☐ NO ☐
85. Do you sometimes put off until tomorrow what you ought to do today? YES ☐ NO ☐
86. Do other people think of you as being very lively? YES ☐ NO ☐
87. Do people tell you a lot of lies? YES ☐ NO ☐
88. Are you touchy about some things? YES ☐ NO ☐
89. Are you always willing to admit it when you have made a mistake? YES ☐ NO ☐
90. Would you feel very sorry for an animal caught in a trap? YES ☐ NO ☐

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS

SCORING CATEGORY:

1	2	3	4

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San Diego, California 92107

EPQ 001

APPENDIX 2

POST EXPERIMENTAL QUESTIONNAIRE

Name: _ _ _ _ _ _ _ _ _ _ _   Age: _ _ _ _ _   Threshold:
Date: _ _ _ _ _ _ _ _ _ _ _   EPI score: _ _ _ _ _   asc. _ _ _ desc. _ _
Student no. _ _ _ _ _ _ _ _   Condition: _ _ _ _ _

1. Did you already practice the Transcendental Meditation?

   Yes ☐   No ☐

2. How many "tones" did you receive?

1st part		2nd part
☐	Number	☐
☐	No idea	☐

3. How did you find the instructions?

   Clear ☐   Ambiguous ☐   Hard to apply ☐   Easy to apply ☐

4. How was the intensity of the sound?

1st part		2nd part
☐	loud	☐
☐	low	☐
☐	medium	☐

5. How did you perceive the sound?

1st part		2nd part
☐	pleasant	☐
☐	unpleasant	☐
☐	medium	☐

6. Which order of conditions did you receive?

   ☐ Continuous -------------followed by series ---- ---- ---- ----

   ☐ Series ---- ---- ---- followed by continuous -----------------

7. Give your comments if you want.

Thank you for your cooperation

APPENDIX 3

ANALYSES OF VARIANCE DATA OF AER COMPONENTS

Analysis of Variance of N1 - P2 Amplitude for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Repetition

Sources of Variation	SS	df	ms	F ratio
Mean	82672.17	1	82672.17	476.50
Personality	62.01	1	62.01	0.36
Attentional Level	100.35	1	100.35	0.58
PA	4.38	1	4.38	0.03
Error	7633.96	44	173.49	
Habituation-Train	10214.55	1	10214.54	161.33*
HP	0.12	1	0.11	0.00
HA	0.52	1	0.52	0.01
HPA	7.05	1	7.05	0.11
Error	2785.89	44	63.32	
Repetition	5220.43	3	1740.14	54.27*
RP	154.07	3	51.36	1.60
RA	33.82	3	11.27	0.35
RPA	16.14	3	5.38	0.17
Error	4232.22	132	32.06	
HR	5212.22	3	1737.41	57.66*
HRP	255.66	3	85.22	2.83*
HRA	119.68	3	39.89	1.32
HRPA	41.54	3	13.85	0.46
Error	3977.73	132	30.13	

* $p < .05$

Analysis of Variance of N1 Amplitude for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Repetition

Sources of Variation	SS	df	ms	F ratio
Mean	31021.45	1	31021.45	395.59
Personality	5.50	1	5.50	0.07
Attentional Level	15.62	1	15.62	0.20
PA	112.72	1	112.72	1.44
Error	3450.38	44	78.42	
Habituation-Train	2364.49	1	2364.49	102.84*
HP	0.34	1	0.35	0.02
HA	0.84	1	0.84	0.04
HPA	158.51	1	158.51	6.89*
Error	1011.67	44	22.99	
Repetition	2073.37	3	691.12	39.70*
RP	24.43	3	8.14	0.47
RA	47.25	3	15.75	0.90
RPA	20.13	3	6.71	0.39
Error	2298.08	132	17.41	
HR	1911.15	3	637.05	33.99*
HRP	38.15	3	12.72	0.68
HRA	39.99	3	13.33	0.71
HRPA	140.77	3	46.92	2.50
Error	2474.22	132	18.74	

* $p < .05$

Analysis of Variance of P2 Amplitude for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Repetition

Sources of Variation	SS	df	ms	F ratio
Mean	12408.99	1	12408.98	110.60
Personality	104.51	1	104.51	0.93
Attentional	36.77	1	36.76	0.33
PA	161.48	1	161.48	1.44
Error	4936.64	44	112.19	
Habituation-Train	2750.39	1	2750.39	58.96*
HP	0.06	1	0.06	0.00
HA	2.69	1	2.69	0.06
HPA	232.53	1	232.52	4.98*
Error	2052.43	44	46.65	
Repetition	793.55	3	264.52	14.36*
RP	186.14	3	62.05	3.37*
RA	129.77	3	43.26	2.35
RPA	60.32	3	20.11	1.09
Error	2431.03	132	18.42	
HR	1024.09	3	341.36	12.77*
HRP	283.06	3	94.55	3.54*
HRA	68.41	3	22.80	0.85
HRPA	220.19	3	73.39	2.75*
Error	3529.32	132	26.74	

* $p < .05$

Analysis of Variance of N1 Latency for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Repetition

Sources of Variation	SS	df	ms	F ratio
Mean	5088755.27	1	5088755.27	9396.98
Personality	120.38	1	120.38	0.22
Attentional Level	23.50	1	23.50	0.04
PA	1.63	1	1.63	0.00
Error	23827.34	44	541.53	
Habituation-Train	386.00	1	386.00	3.98*
HP	143.81	1	143.81	1.48
HA	11.00	1	11.02	0.11
HPA	309.96	1	309.96	3.20
Error	4264.84	44	96.92	
Repetition	8140.29	3	2713.43	20.48*
RP	242.90	3	80.96	0.61
RA	784.57	3	261.52	1.97
RPA	728.32	3	242.77	1.83
Error	17488.28	132	132.48	
HR	6461.65	3	2153.88	20.36*
HRP	100.71	3	33.57	0.32
HRA	407.48	3	135.82	1.28
HRPA	313.73	3	104.58	0.99
Error	13963.28	132	105.78	

* $p < .05$

Analysis of Variance of P2 Latency for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Repetition

Sources of Variation	SS	df	ms	F ratio
Mean	13754311.52	1	13754311.52	17739.50
Personality	14.65	1	14.65	0.02
Attentional Level	1221.94	1	1221.94	1.58
PA	70.89	1	70.89	0.09
Error	34115.36	44	775.35	
Habituation-Train	14937.56	1	14937.56	34.02*
HP	34.44	1	34.44	0.08
HA	79.75	1	79.75	0.18
HPA	1151.63	1	1151.63	2.62
Error	19318.49	44	439.06	
Repetition	14537.17	3	4845.72	13.64*
RP	761.13	3	253.71	0.71
RA	461.13	3	153.71	0.43
RPA	1322.59	3	440.86	1.24
Error	46896.09	132	355.27	
HR	8127.79	3	2709.26	9.51*
HRP	2464.25	3	821.42	2.88*
HRA	601.23	3	200.41	0.70
HRPA	608.52	3	202.84	0.71
Error	37588.80	132	284.76	

* $p < .05$

Analysis of Variance of N1 - P2 Amplitude for Introvert and Extravert Groups under Attend and Ignore Conditions for Experimental and Control Conditions at Four Levels of Blocks

Sources of Variation	SS	df	ms	F ratio
Mean	71187.08	1	71187.08	486.44
Personality	0.61	1	0.61	0.00
Attentional Level	131.14	1	131.14	0.90
PA	18.48	1	18.48	0.13
Error	6439.07	44	146.34	
Habituation-Train	6568.11	1	6568.11	123.25*
HP	98.39	1	98.39	1.85
HA	2.90	1	2.90	0.05
HPA	32.98	1	32.98	0.62
Error	2344.86	44	53.29	
Blocks	234.17	3	78.05	4.73*
BP	25.56	3	8.52	0.52
BA	29.56	3	9.85	0.60
BPA	24.59	3	8.19	0.60
Error	2179.64	132	16.51	
HB	47.00	3	15.67	1.03
HBP	69.94	3	23.31	1.53
HBA	91.09	3	30.37	1.99
HBPA	17.25	3	5.75	0.38
Error	2013.35	132	15.25	

* $p < .05$

Analysis of Variance of N1 Amplitude for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Blocks

Sources of Variation	SS	df	ms	F ratio
Mean	27482.20	1	27482.20	380.58
Personality	10.94	1	10.94	0.15
Attentional	42.17	1	42.17	0.58
PA	79.27	1	79.27	1.10
Error	3177.30	44	72.21	
Habituation-Train	1475.96	1	1475.96	65.88*
HP	7.16	1	7.16	0.32
HA	2.49	1	2.49	0.11
HPA	65.95	1	65.95	2.94
Error	985.77	44	22.40	
Blocks	407.63	3	135.88	9.91*
BP	8.59	3	2.86	0.21
BA	228.10	3	76.03	5.55*
BPA	70.75	3	23.58	1.72
Error	1809.75	132	13.71	
HB	6.17	3	2.06	0.13
HBP	9.37	3	3.13	0.19
HBA	118.71	3	39.57	2.45
HBPA	20.88	3	6.96	0.43
Error	2127.69	132	16.12	

* $p < .05$

Analysis of Variance of P2 Amplitude for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Blocks

Sources of Variation	SS	df	ms	F ratio
Mean	10207.42	1	10207.42	99.00
Personality	6.36	1	6.37	0.06
Attentional	24.57	1	24.57	0.24
PA	174.32	1	174.32	1.69
Error	4536.73	44	103.10	
Habituation-Train	1816.89	1	1816.89	46.97*
HP	52.47	1	52.48	1.36
HA	0.01	1	0.02	0.00
HPA	192.22	1	192.22	4.97*
Error	1702.10	44	38.68	
Blocks	37.80	3	12.60	0.74
BP	59.57	3	19.86	1.17
BA	174.45	3	58.15	3.43*
BPA	34.95	3	11.65	0.69
Error	2238.49	132	16.96	
HB	41.26	3	13.75	1.24
HBP	36.48	3	12.16	1.09
HBA	56.60	3	18.86	1.70
HBPA	61.05	3	20.35	1.83
Error	1466.46	132	11.10	

* $p < .05$

Analysis of Variance of N1 Latency for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Blocks

Sources of Variation	SS	df	ms	F ratio
Mean	5144161.52	1	5144161.52	8093.99
Personality	40.69	1	40.69	0.06
Attentional Level	28.71	1	28.71	0.05
PA	539.13	1	539.13	0.85
Error	27964.32	44	635.55	
Habituation-Train	953.19	1	953.19	6.77*
HP	470.38	1	470.38	3.34
HA	28.71	1	28.71	0.20
HPA	587.57	1	587.56	4.17*
Error	6194.53	44	140.78	
Blocks	277.28	3	92.43	0.99
BP	234.57	3	78.19	0.84
BA	158.01	3	52.67	0.57
BPA	344.47	3	114.82	1.23
Error	12288.80	132	93.09	
HB	54.36	3	18.12	0.15
HBP	163.22	3	54.40	0.44
HBA	14.26	3	4.75	0.04
HBPA	146.03	3	48.68	0.40
Error	16175.26	132	122.54	

* $p < .05$

Analysis of Variance of P2 Latency for Introvert
and Extravert Groups under Attend and Ignore Conditions
for Experimental and Control Conditions at Four Levels of Blocks

Sources of Variation	SS	df	ms	F ratio
Mean	14139268.82	1	14139268.82	18723.95
Personality	3.19	1	3.19	0.00
Attentional Level	242.25	1	242.25	0.32
PA	18.82	1	18.82	0.02
Error	33226.30	44	755.14	
Habituation-Train	29487.57	1	29487.56	72.76*
HP	366.21	1	366.21	0.90
HA	515.69	1	515.69	1.27
HPA	1083.39	1	1083.39	2.67
Error	17831.51	44	405.26	
Blocks	10173.11	3	3391.04	15.10*
BP	1234.57	3	411.52	1.83
BA	2466.34	3	822.11	3.66*
BPA	214.78	3	71.59	0.32
Error	29639.32	132	224.54	
HB	124.15	3	41.38	0.17
HBP	649.67	3	216.56	0.92
HBA	1854.36	3	618.12	2.61*
HBPA	603.32	3	201.11	0.85
Error	31221.62	132	236.52	

* $p < .05$

APPENDIX 4

SUMMARY TABLES OF SIGNIFICANT DATA

Means of N1 - P2 Amplitude (μV) for Habituation-Train Effects at Four Levels of Repetition

Repetition	1	2	3	4
Experimental	32.58	16.05	15.63	15.06
Control	9.52	9.34	9.56	9.58

Means of N1 - P2 Amplitude (μ V) for Personality
Dimensions at Experimental and Control Conditions
for Four Levels of Repetition

Repetition		1	2	3	4
Introverts	Experimental	35.13	16.87	14.88	13.97
	Control	9.60	9.93	9.92	10.29
Extraverts	Experimental	30.03	15.23	16.37	16.15
	Control	9.46	8.75	9.20	8.88

Means of N1 Amplitude (μV) for Habituation
Effects at Four Levels of Repetition

Repetition	1	2	3	4
Experimental	19.25	7.76	9.09	9.80
Control	6.72	6.70	6.41	6.20

Means of N1 Amplitude (μV) for Personality Dimensions at Attend and Ignore Conditions under the Experimental and Control Conditions When Analysed Stimulus by Stimulus

		Experimental	Control
Introverts	Attend	9.98	6.27
	Ignore	12.66	6.56
Extraverts	Attend	12.64	6.24
	Ignore	10.59	6.95

Means of P2 Amplitude (μV) for Habituation-Train Effects at Four Levels of Repetition

Repetition	1	2	3	4
Experimental	18.53	8.30	6.54	5.28
Control	2.81	2.69	3.15	3.38

Means of P2 Amplitude (μV) for Introvert and Extravert Groups at Four Levels of Repetition

Repetition	1	2	3	4
Introverts	9.77	5.40	4.94	4.23
Extraverts	6.38	5.09	4.75	4.43

Means of P2 Amplitude (μV) for Introvert and Extravert Groups
Under Attend and Ignore Conditions and Under
Experimental and Control Conditions
When Analysed Stimulus by Stimulus

		Experimental	Control
Introverts	Attend	9.93	3.16
	Ignore	7.86	3.87
Extraverts	Attend	6.01	2.40
	Ignore	9.65	2.60

Means of P2 Amplitude (μV) for Introvert and
Extravert Groups under Experimental and Control Conditions
for Four Levels of Repetition

Repetition		1	2	3	4
Introverts	Experimental	16.49	8.46	5.92	4.71
	Control	3.02	3.33	3.96	3.76
Extraverts	Experimental	10.17	8.13	7.15	5.85
	Control	2.60	2.05	2.34	3.00

Means of N1 Latency (msec) Under Experimental and Control Conditions at Four Levels of Repetition

Repetition	1	2	3	4
Experimental	130.83	110.94	109.38	113.33
Control	115.31	108.33	114.58	111.77

Means of P2 Latency (msec) Under Experimental and Control Conditions at Four Levels of Repetition

Repetition	1	2	3	4
Experimental	213.44	191.04	191.67	185.83
Control	185.21	181.56	185.42	179.90

Means of P2 Latency (msec) for Introvert and
Extravert Groups under Experimental and Control Conditions
for Four Levels of Repetition

Repetition		1	2	3	4
Introverts	Experimental	214.64	188.96	195.83	184.38
	Control	184.79	186.90	182.92	177.08
Extraverts	Experimental	212.08	193.13	187.50	187.29
	Control	185.63	176.25	187.92	182.71

Means of N1 - P2 Amplitude (μV) for Experimental and Control Conditions at Four Blocks of Stimuli

Blocks	1	2	3	4
Experimental	7.73	6.37	6.95	6.69
Control	5.47	4.74	4.99	4.06

Means of N1 Amplitude (μ V) for Experimental and Control Conditions at Four Blocks of Stimuli

Blocks	1	2	3	4
Experimental	11.91	10.47	10.07	8.99
Control	8.13	6.52	6.59	5.41

Means of N1 Amplitude (μV) for Ignore and Attend Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Attend	8.67	7.82	8.21	7.79
Ignore	11.45	9.40	7.78	6.61

Means of P2 Amplitude (μV) for Experimental and Control Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Experimental	6.37	7.51	6.83	7.87
Control	2.66	2.32	3.47	3.47

Means of P2 Amplitude (μV) for Ignore and Attend Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Attend	4.59	5.12	4.79	4.37
Ignore	4.44	4.71	5.51	6.97

Means of P2 Amplitude (μV) for Introvert and Extravert Groups Under Ignore and Attend Conditions and Under Experimental and Control Conditions When Analysed by Blocks of Stimuli

		Experimental	Control
Introverts	Attend	7.48	5.19
	Ignore	5.96	3.77
Extraverts	Attend	5.94	2.26
	Ignore	9.20	2.71

Means of N1 Latency (msec) for Experimental and Control Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Experimental	118.45	117.08	116.77	116.56
Control	115.21	113.75	114.89	112.81

Means of N1 Latency (msec) for Introvert and Extravert Groups
Under Ignore and Attend Conditions and Under
Experimental and Control Conditions
When Analysed by Blocks of Stimuli

		Experimental	Control
Introverts	Attend	118.85	114.90
	Ignore	112.92	115.00
Extraverts	Attend	116.88	113.44
	Ignore	120.63	113.33

Means of P2 Latency (msec) of Experimental and Control Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Experimental	208.44	197.92	200.94	195.31
Control	191.77	181.77	182.19	176.77

Means of P2 Latency (msec) for Attend and Ignore
Conditions at Four Levels of Blocks

Blocks	1	2	3	4
Attend	199.27	194.27	193.33	183.85
Ignore	200.94	185.42	189.79	188.23

Means of P2 Latency (msec) for Attend and Ignore Conditions under Experimental and Control Conditions at Four Levels of Blocks

Blocks		1	2	3	4
Attend	Experimental	205.42	205.83	205.42	193.75
	Control	193.12	182.71	181.25	173.96
Ignore	Experimental	211.46	190.00	196.46	196.88
	Control	179.58	183.13	180.83	190.42

APPENDIX 5

EPI SCORES

EPI SCORES

		ATTEND			IGNORE		
		E	N	P	E	N	P
INTROVERTS	1	6	8	3	7	12	2
	2	2	17	1	5	20	0
	3	8	17	1	4	11	1
	4	7	12	2	8	8	6
	5	9	16	4	7	4	3
	6	4	17	3	6	5	7
	7	9	15	5	4	8	1
	8	4	15	7	7	12	2
	9	6	10	1	3	18	2
	10	9	1	4	9	4	5
	11	5	21	2	8	10	4
	12	5	10	7	9	8	7
	$\overline{X}$	6.16	13.25	3.33	6.41	10.00	3.30
	α	2.19	5.36	2.14	2.02	5.06	2.42
EXTRAVERTS	1	20	6	0	19	10	4
	2	20	17	7	19	11	6
	3	20	11	2	20	6	2
	4	20	2	4	20	11	2
	5	20	15	2	20	10	0
	6	19	7	1	19	9	2
	7	20	15	6	19	5	7
	8	19	20	5	20	10	3
	9	20	15	9	20	10	8
	10	21	11	3	20	3	7
	11	20	2	1	20	10	6
	12	21	7	2	20	17	9
	$\overline{X}$	20.00	12.00	3.50	19.66	9.33	4.66
	α	.60	5.80	2.74	.49	3.52	2.87