PSYCHOPHYSIOLOGICAL CORRELATES OF HUMAN INFORMATION PROCESSING UNDER ALTERED STATES OF CONSCIOUSNESS

FINAL REPORT

1 July, 1965 - 30 June 1966

for

Air Force Office of Scientific Research
Washington, D. C.

Under Grant AF-AFOSR-951-65

by

Robert Roessler, M. D.

and

Neil R. Burch, M. D.

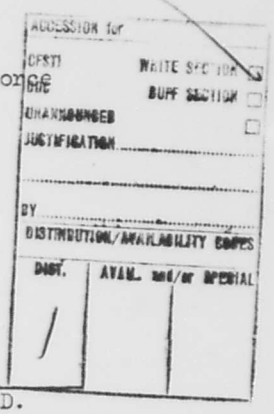
Psychophysiology Division
Houston State Psychiatric Institute

and

Department of Psychiatry
Baylor University College of Medicine

Houston, Texas

This report has been approved for submission to the Air Force Office of Scientific Research.



Neil R. Burch, M. D.
Principal Investigator

This report will cover the work accomplished under this grant in the six month interval since the Interim Report of March 1966.* During this period this work has focused on two main areas:

I. Basic Stress Research

Preparation of scientific papers for publication and continued analysis of the data generated in the major experiment conducted during the first grant year.

A. Further analyses of the skin resistance,
B. Heart rate,
C. Pulse wave velocity, and,
D. Catecholamines).

II. Polygraph Study

A. Introduction
B. Polygraph Study Design,
C. Measures and Physical Situation

A revision of the scientific paper mentioned in the March, 1966, Interim Report was completed. This paper, entitled "Personality and Arousal Correlates of Specific GSR's" has been accepted for publication in the journal Psychophysiology and will appear in print in the near future.

Another paper, "Psychophysiological Indices of Stress Tolerance" was presented in the predictive medicine section of a symposium on Biomedical Instrumentation, sponsored by the Instrument Society of America. This paper incorporated some of the results of this research as well as earlier work and will be published as a chapter in a book to be published by Plenum Press.

The reader is referred to the September, 1965 First Annual Report for a detailed discussion of the design of the experiment, further results of which are reported below. Briefly, 32 medical and dental students were tested on four occasions at monthly intervals. They were subjected to multiple presentations of five different intensities of constant frequency sound and five different intensities of white light. The physiological measures recorded in each session were one channel of the EEG (left-occipital-parietal), basal skin resistance, galvanic skin response, electrocardiogram (lead 1), finger plethysmogram and muscle potential. In addition, urines were collected and the levels of norepinephrine and epinephrine determined on the second and third testings. The first testing was directed towards investigating the effects of unfamiliarity with the laboratory situation; the second testing was a basal one; the second testing was a basal one; the third was immediately prior to comprehensive examinations in the student's course work and was assumed to be a

* The March 1966 Interim Report is included in this report as Appendix A.

condition of real life stress; the fourth and final testing was again a basal one. In addition to the physiological measures, extensive psychological test data was also obtained on each subject, including the Minnesota Multiphasic Personality Inventory, the California Personality Inventory, the Wechsler Adult Intelligence Scale, the Barrier score from the Holtzman Ink Blot Test, the Atkinson-McClelland Need Achievement score from the Thematic Apperception Test, the Clyde Mood Scale and a so-called "Inventory of Attitudes" designed to elicit the amount of anxiety precipitated by the specific stimulus of impending examinations. Previous reports have presented the results of the basal skin resistance and GSR data from this experiment, the psychological test data and the interrelationships between these two types of information. This portion of this report will focus upon:

A. Further analyses of the skin resistance data
B. Heart rate
C. Pulse wave velocity, and,
D. Catecholamines

The results obtained from the analysis of the aforementioned physiological measures will be presented in graphic form on the accompanying figures. Tables of the relevant statistical analyses have not been included but probability levels related to the differences shown are indicated on the figures.

A. Further analyses of skin resistance data.

1. In the March, 1966 Interim Report, reference was made to work on the development of a computer program for analysis of variance for repeated measures. That program was completed and was applied to the re-analysis of the GSR data previously reported. As predicted, the results did not differ appreciably from those previously reported; levels of confidence for the differences previously reported were reduced in some instances and in a few instances failed to achieve usually acceptable levels of statistical significance. None of the previously reported major conclusions in regard to the effect of intensity, modality of stimulation, habituation effects, psychological group differences or level of consciousness effects were altered, however.

2. Basal skin resistance differences

The March, 1966 Interim Report also referred to differences in basal skin resistances between high and low ego strength groups and between alert and drowsy groups in connection with the covariance correction of GSR differences. These basal skin resistance differences are of interest in their own right, however, and are presented in Figures 1 A through 3 B. Figure 1 A presents the mean basal skin resistance prior to sound stimulation of two groups of subjects, ten high ego strength and ten low ego strength, each group balanced for the alert-drowsy dimension. As noted on the abcissa of this graph, the differences are significant only during the March

(real life stress) testing. This finding might well be attributable to chance were it not for the parallel significant difference shown for the mean basal skin resistance levels prior to light stimulation shown in Figure 1 B and the similar differences shown in Figures 2 A and 2 B. In the latter instances, only alert subjects were compared and the differences were significant in every instance except the February testing, sound, and the April testing, light.

Figures 3 A and 3 B depict the differences when groups are comprised on the basis of the alert-drowsy dimension. Drowsy subjects have higher mean skin resistance levels than alert subjects and these differences are significant, except in those instances when the N is reduced because of a small number of either alert or drowsy subjects in a particular testing.

We regard these findings to be potentially important in at least three ways. First, they emphasize once again the importance of more accurately defining the level of consciousness in interpreting physiological data; it seems quite probable to us that a more refined definition of level of consciousness, particularly along the alert end of the consciousness continuum, will permit more accurate weighting of this variable in the interpretation of skin resistance data and other physiological measures as well. Second, the differences in groups defined on the basis of psychological criteria points up once again the importance of taking psychological factors into account. Of particular interest in this respect is the sharp rise in skin resistance (i.e., fall in conductance) of the low Es group on the March testing. As we shall see later, this finding is parallel to changes in catecholamine levels on that testing. Third, the basal skin resistance appears to provide information in addition to that provided by the GSR alone; this suggests that both should be recorded in any application where there is an interest in the effects of stimulus intensity.

B. Heart Rate

As we indicated in earlier progress reports, heart rate and eleven pulse-wave parameters (Cf. C. Pulse wave velocity) on the January testing were scored on the Oskar K. For this first testing, a computer program was therefore written to convert R-R intervals to millimeters and for the February, March and April testings these intervals were hand scored to the nearest 0.5 mm. This hand scoring, as might be guessed, was an extremely time consuming process.

In general, the findings in relation to heart rate were disappointing. Although differences in relation to intensity, modality of stimulation and psychological grouping were found which paralleled those already reported for the galvanic skin response, the differences often failed to achieve statistical significance. However, because of their consistency, they are presented in Figures 4 A through 7 B. These figures show differences in relation to intensity of stimulation

across all runs and differences in runs across all intensities. Within runs (testings) values showed considerable variability and generally failed to achieve statistical significance. All graphs (4 A - 7 B) show change in heart rate from pre-stimulus levels in millimeters; however, as indicated on the legend of Figure 4 A, each mm. of change represents 1.97 beats per minute of change from pre-stimulus levels.

The first step in the examination of the heart rate data was the plotting of beat by beat changes during each ten second epoch following each two seconds of sound or light stimulation. This plotting revealed that there was a tri-phasic response to these forms of simple stimulation. There was an initial acceleration within the first five to six beats following the onset of stimulation (the exact point depended upon each individual's pre-stimulus rate); followed by a deceleration during beats six, seven, eight and nine; followed in turn by another acceleration in the last 3 beats of each stimulus epoch. Four heart rate means were therefore calculated for each stimulus epoch: 1) The mean of the two fastest beats in the first five beats of each stimulus epoch, 2) the mean of the two slowest beats among six, seven, eight and nine, 3) the mean of the fastest two of the last three beats in each stimulus epoch and 4) the mean of the two fastest beats in the full ten seconds following the onset of the stimulation. In general, the last mean corresponded to the first accelerative mean and differed very little from the mean of the two fastest in the last three beats of the epoch. Only the results of this mean of the two fastest beats in the stimulus epochs and the mean of the two slowest of six, seven, eight and nine are depicted in the following figures, therefore.

Figure 4 A shows the approximately linear relationship between stimulus intensity and cardiac acceleration, significant beyond the .001 level. Differences between the high and low ego strength group are also shown but are not significant. Figure 4 B shows the mean acceleration across all intensities of stimulation on each testing, January through April. Again, the differences between the groups constituted on the basis of psychological criteria is evident and consistent, but not significant. Moreover, there is no significant difference between the testings although the rise of the high ego strength group on the March testing is apparent. The failure to achieve statistical significance is related to two factors -- the relative unresponsiveness of heart rate to these forms of stimulation (the greatest mean acceleration never exceeded 6 beats per minute) and the large variance of the subjects within groups.

Figure 5 A shows the mean heart rate acceleration in response to light stimulation in relation to intensity. In this instance, both the intensity and the group by intensity interactions are significant. The variability that response is again evident, however,

along with an even lower level of responsivity than that obtained with sound stimulation.

Figure 5 B shows the heart rate acceleration to light stimulation across all intensities within each testing. Again the consistency of the group differences is evident but they fail to achieve significance. The difference between runs is significant, and is attributable to significantly higher rates during the February testing.

Figure 6 A shows the mean deceleration of heart rate in relation to the intensity of sound stimulation. Again, the means shown are across all testings. The scales on Figure 6 A through 7 B are inverted to emphasize the decelerative effect. Again, note the approximately linear relationship between the amount of deceleration and stimulus intensity. Also note the lesser amount of deceleration in the high ego strength group. This lesser deceleration is consistent (Cf. Fig. 6 B, 7 A and 7 B) but fails to achieve significance. Figure 6 B depicts differences between testings. The progressively increasing amount of deceleration from the January through April testing would suggest that this aspect of the stimulus effect may reflect a form of habituation to repeated exposure.

Figure 7 A shows the parallel deceleration of the response to light stimulation and in relation to intensity. It is evident that there is no intensity effect across all testings and there is a similar lack of intensity effect within the testings (not shown). Although the intensity group interaction is significant, it is obviously attributable to the crossover of the groups and is probably a chance difference. However, Figure 7 B once again reveals the consistent group differences when they are examined across all intensities within each testing. None of the differences depicted in this figure are significant, however.

The reliability of heart rate response over testings, January through April, was also examined. Kendall's W was computed on the ranks of each subject's mean heart rate acceleration over all intensities of stimulation within a run, for each run, and was highly significant ($p < .001$). This high degree of reliability of heart rate responsivity was found in relation to both modalities of stimulation. Interpretively, it seems to us that this high degree of reliability is more related to the individual's characteristic basic rate than to stimulation effects, per se.

In conclusion, heart rate is not very responsive to a broad range of sound and light stimulation. It seems unlikely, therefore, to be highly responsive to complex symbolic information. It is well established, of course, that it is highly responsive to thermal changes and to changes in muscular activity. It's usefulness in situations of interest to the sponsor would appear to be very questionable, however.

C. Pulse Wave Velocity

Figure 8 depicts graphically the scoring of the pulse wave velocity measures. A perpendicular line was first extrapolated from the peak of the EKG R wave to a line of arbitrary origin (X_1). Similarly, a perpendicular line was extended from the onset of the peripheral pulse wave form to the line of arbitrary origin (X_2). The distance ($X_2 - X_1$) therefore represents the time from the electrical activity represented by the R wave to the appearance of the shock wave at the tip of the finger. This measure of pulse wave velocity is similar to the one reported by Ellson, except that he and his group scored the time which would correspond to the difference between X_2 and X_1 on Figure 8. Correcting for this difference, we obtained values very similar to the ones he obtained. The sponsors of the research had expressed particular interest in exploring the usefulness of this measure. Although the analyses of it are not yet entirely complete, Tables 1 and 2 present findings in relation to intensity effects, modality of stimulation, and psychological groupings.

Each of the values in Tables 1 and 2 represent the difference in millimeters between the mean values of ($X_2 - X_1$) of the pre-stimulus epochs and the mean of the two largest values of ($X_2 - X_1$) during the stimulus epochs (D 1) and the mean of the two smallest values of ($X_2 - X_1$) during the stimulus epochs (D 2). The large amount of variance within subjects, modalities of stimulation, the two types of difference scores, intensity, and psychological groups is evident. Non-parametric statistics applied to all these comparisons failed to reveal any significant differences. Parametric analyses are currently in progress on all intensities but it would appear unlikely that they will reveal any differences. This failure to define a relationship of pulse wave velocity to any of the foregoing variables is in keeping with the findings of Ellson.

The additional X and Y parameters of the pulse wave form are currently being analyzed for relationships among each other and in relation to intensity. We are confident, from an inspection of our records, that the X_2 parameter (peak pulse amplitude) will show a stimulus effect. We are hopeful that an intensive examination of these parameters will reveal information of value comparable to that obtained with the blood pressure cuff employed in current field applications. It would have the advantage of less discomfort for the subject and permit continuous, extended recording.

D. Catecholamines

The determination of catecholamine levels was not a part of the proposed research. However, a colleague interested and experienced in catecholamine research (Roy B. Mefferd, Jr., Ph. D.), expressed an interest in the effects of real life stress (the anticipated examinations) upon the levels of epinephrine and norepinephrine. Carefully timed

collections of urine were therefore made on the February and March testings. The distribution of levels obtained was not normal, now was there homogeneity of variance between the high and low ego strength groups. Non-parametric statistics were therefore employed in the following comparisons. Mean levels of epinephrine, norepinephrine, and norepinephrine and epinephrine combined were therefore determined for: 1) all subjects with available data, 2) low ego strength subjects and, 3) high ego strength subjects. Tests of significance were based upon difference between the level of each catecholamine determined on the February testing and the level on the March testing. There was no significant difference when all subjects were compared, however, when the high ego strength subjects were compared to the low ego strength subjects, differences at or beyond the .05 level of probability were obtained (Mann - Whitney U test) and are depicted in Figures 9 A and 9 B.

Figure 9 A shows the mean levels of eleven high ego strength and eleven low ego strength subjects tested within ten days prior to the examinations. Since it had been observed that subjects tested early in that period showed little evidence of anxiously anticipating the examinations and since those subjects tested late in the period did show such evidence, it was specifically hypothesized that those subjects tested closest to the examinations (within five days) would show higher mean levels than the total group. That they did so is clear from Figure 9 B. The high ego strength subjects responded more, although the values of the low ego strength subjects did not differ significantly from the total group of low ego strength subjects.

As noted during the discussion of basal skin resistance findings, these catecholamine differences in relation to ego strength grouping parallel those of basal skin resistance. That is, if one transforms the skin resistance scores to conductance, the high ego strength subjects show both higher mean levels of skin conductance and higher catecholamine levels. Conversely, the low ego strength subjects show lower levels of catecholamines and lower levels of skin conductance. The psychophysiological implications of these findings are intriguing. Physiologically, they suggest a possible parasympathetic dominance in the low Es subjects. They also suggest the possibility that, within the range of activation of the subjects in this experiment, higher activation may be associated with a more adaptive response and lack of relative activation with less adaptive behavior. The behavioral implications are inference, of course, because, as we reported earlier, the two groups did not differ significantly in their academic achievement. A more immediate application to the problem under investigation is that at least two classes of persons must be distinguished - high and low responders. How these two classes of persons will respond to more complex symbolic information is a question to which we have addressed ourselves in the pilot work on simulated crime to be presented in the next portion of this report.

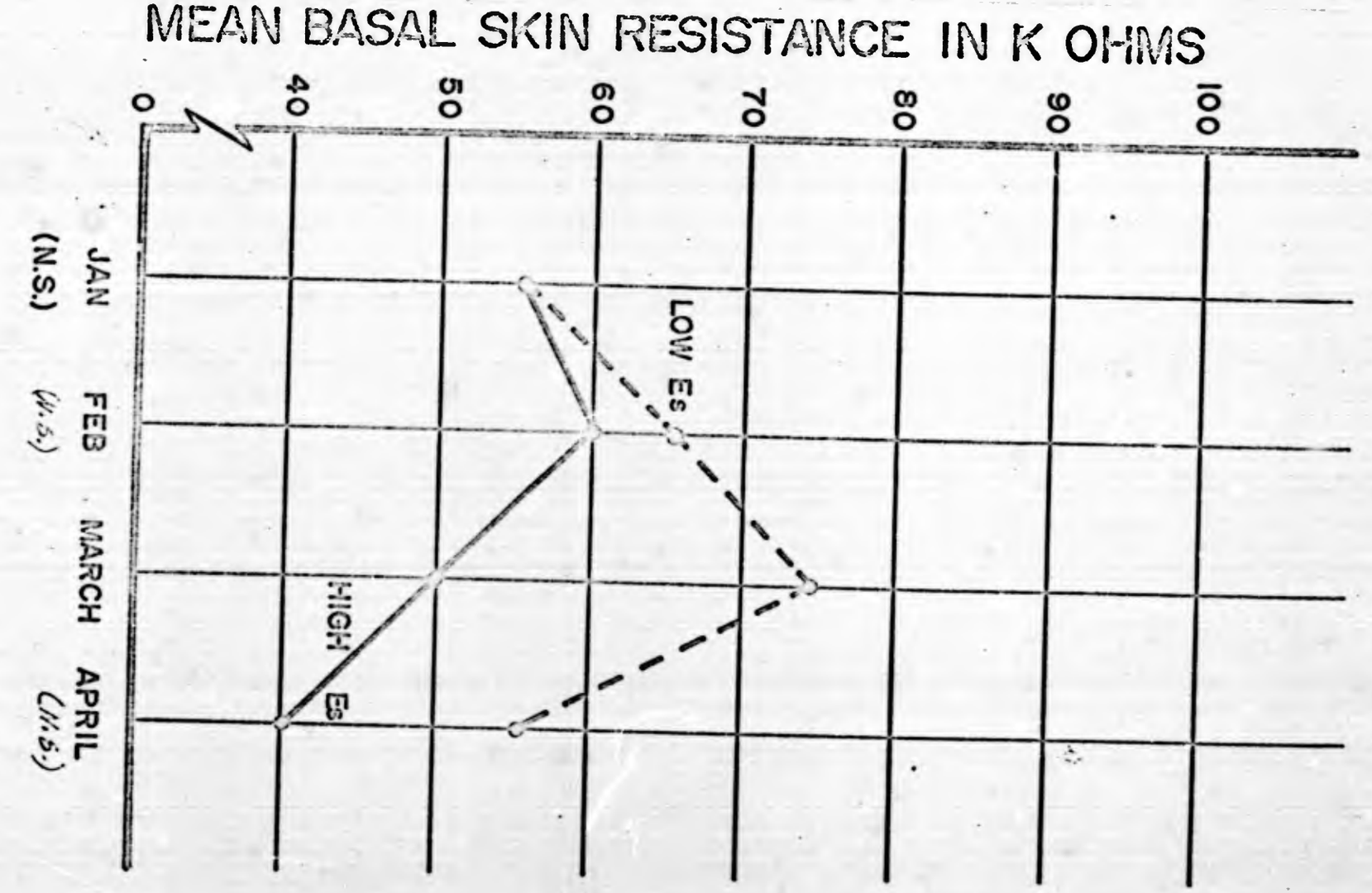


Figure 1 A Mean basal skin resistance prior to sound stimuli of two groups of subjects. Each testing compares 10 high Es Ss (250 observations) with 10 low Es Ss (250 observations). Each group on each testing contains equal numbers of alert and drowsy subjects. Note that the groups differ significantly only on the March testing (Cf. text.)

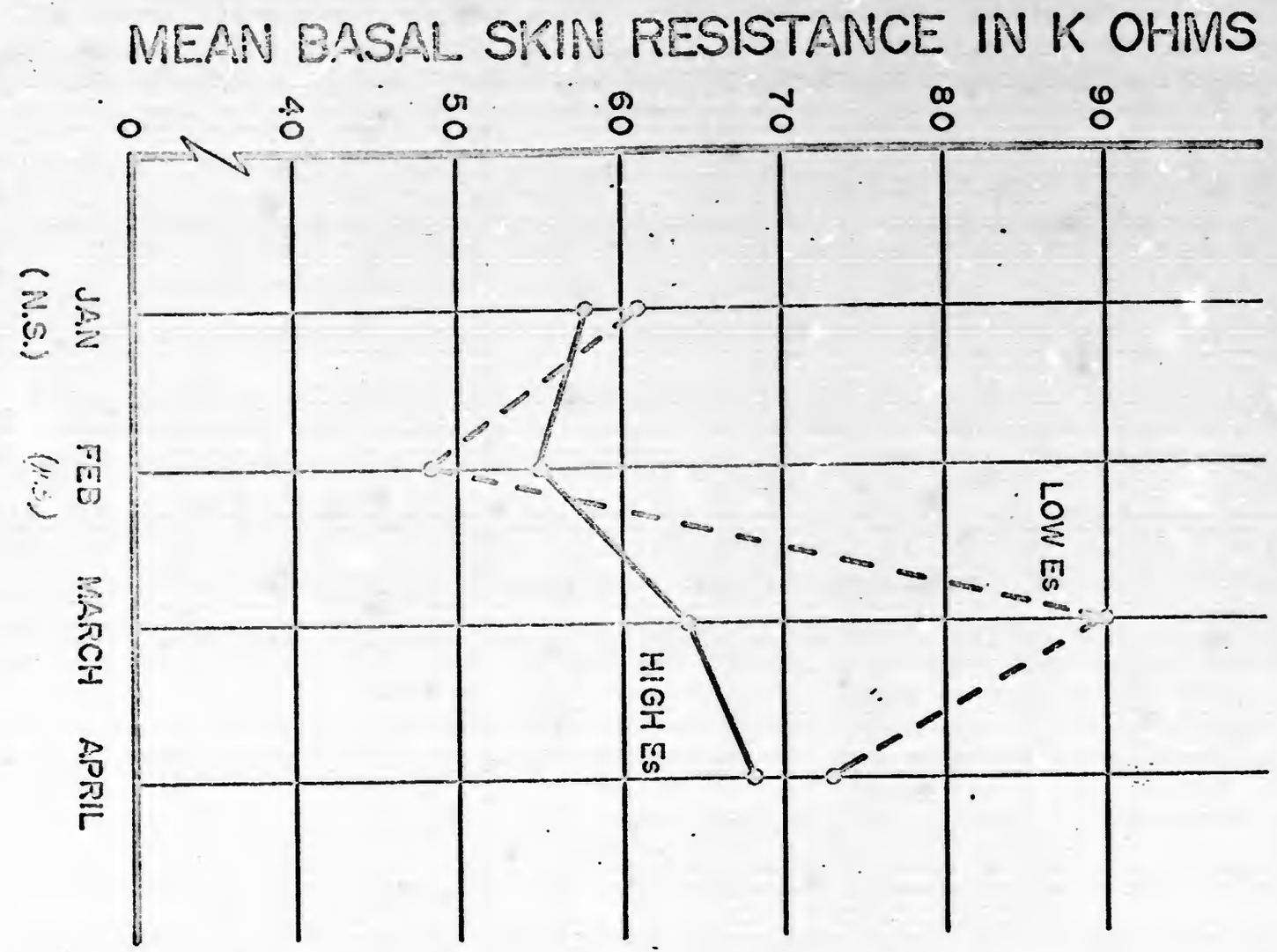


Figure 1 B

Mean basal skin resistance prior to light stimulation of high Es vs low Es groups. Each testing compares 10 high Es vs 10 low Es Ss. Note the significant differences on the March and April testings (Cf. text.)

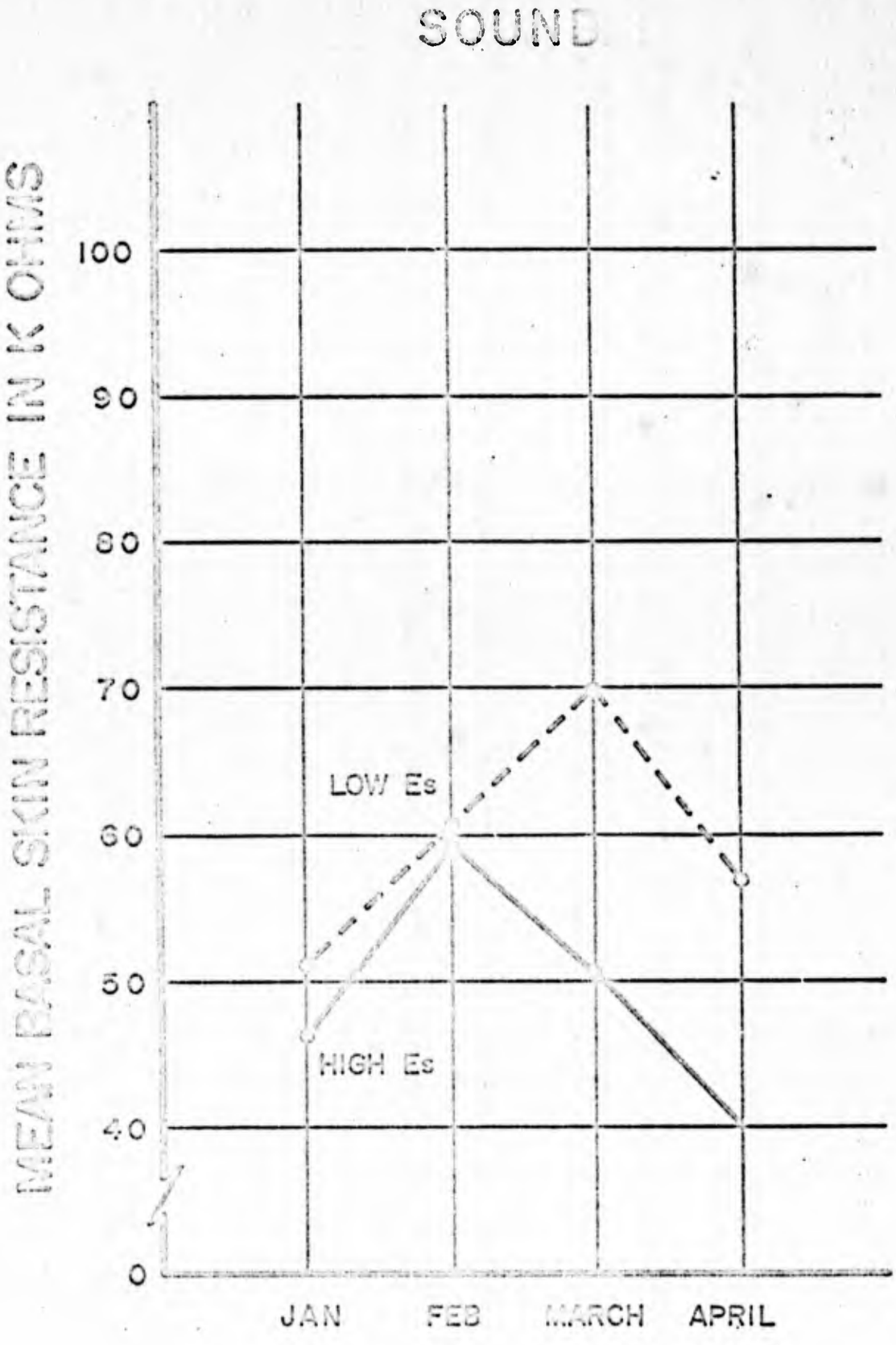


Figure 2 A. Mean basal skin resistance prior to stimulation of high vs low ego strength groups. The groups are comprised of alert subjects only.

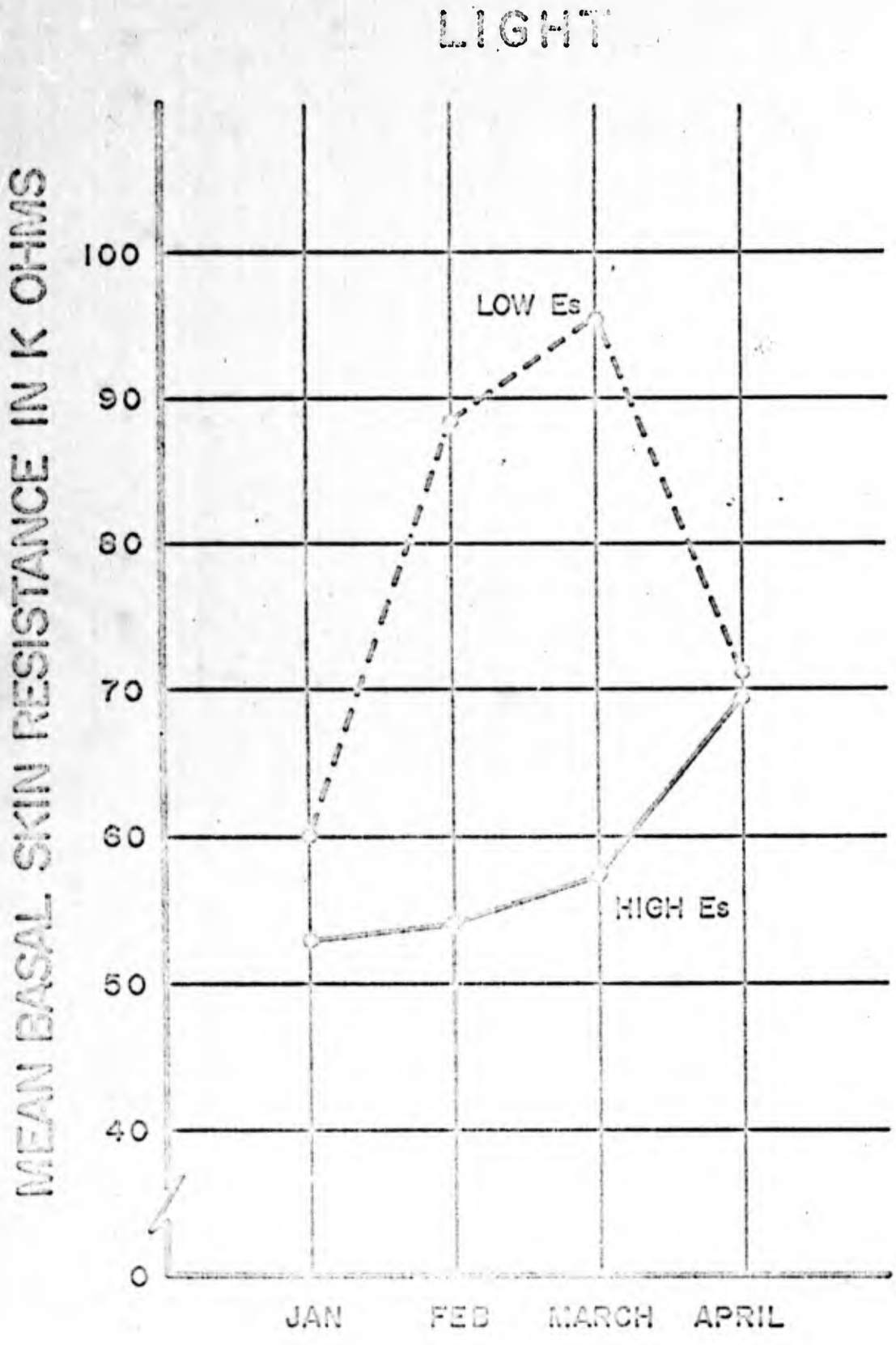


Figure 2 B. Mean basal skin resistance prior to light stimulation of high vs low ego strength groups. The groups are comprised of alert subjects only.

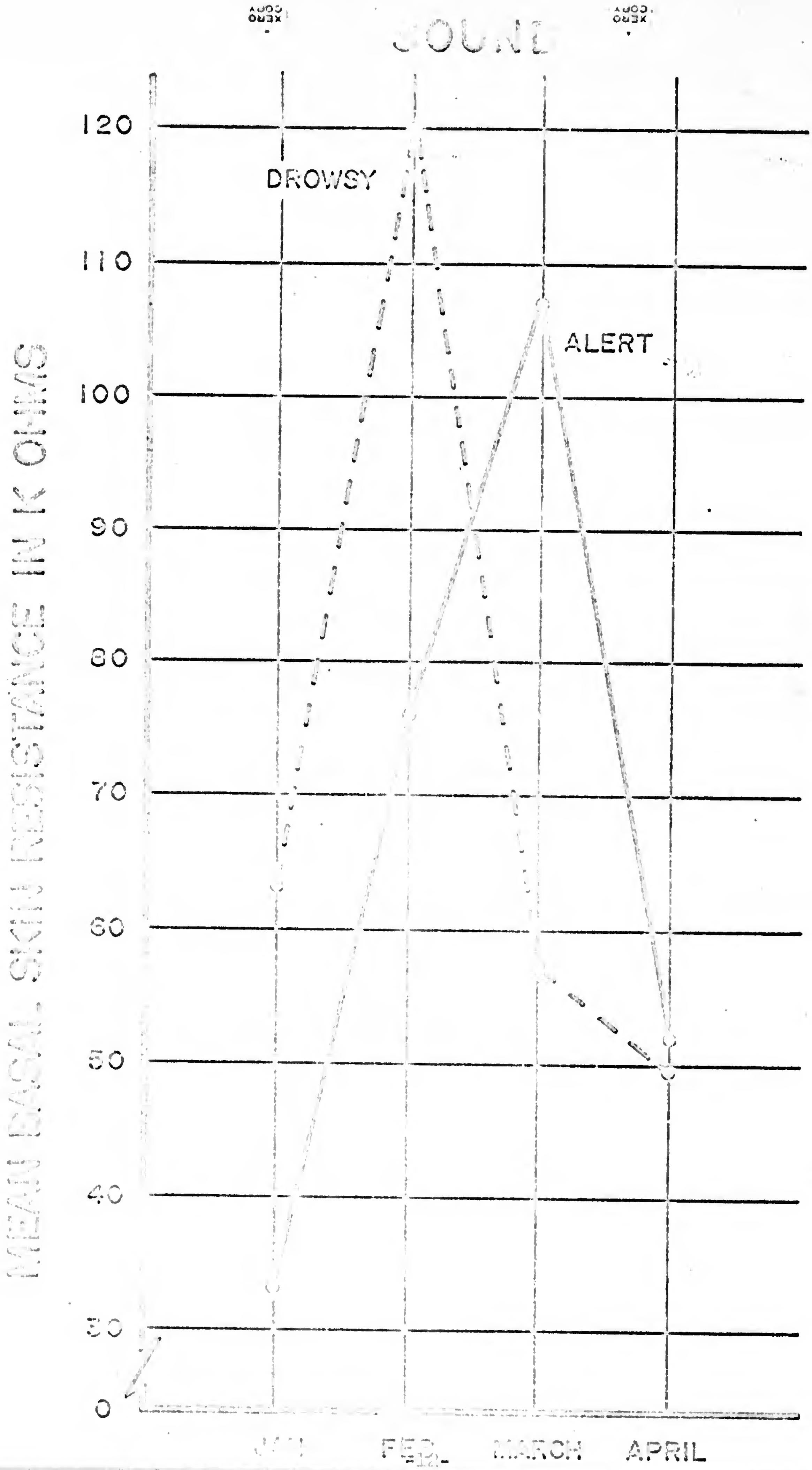


Fig. 3 A Mean basal skin resistance prior to sound stimuli of two groups of subjects, alert vs. drowsy All differences significant except the April comparison.

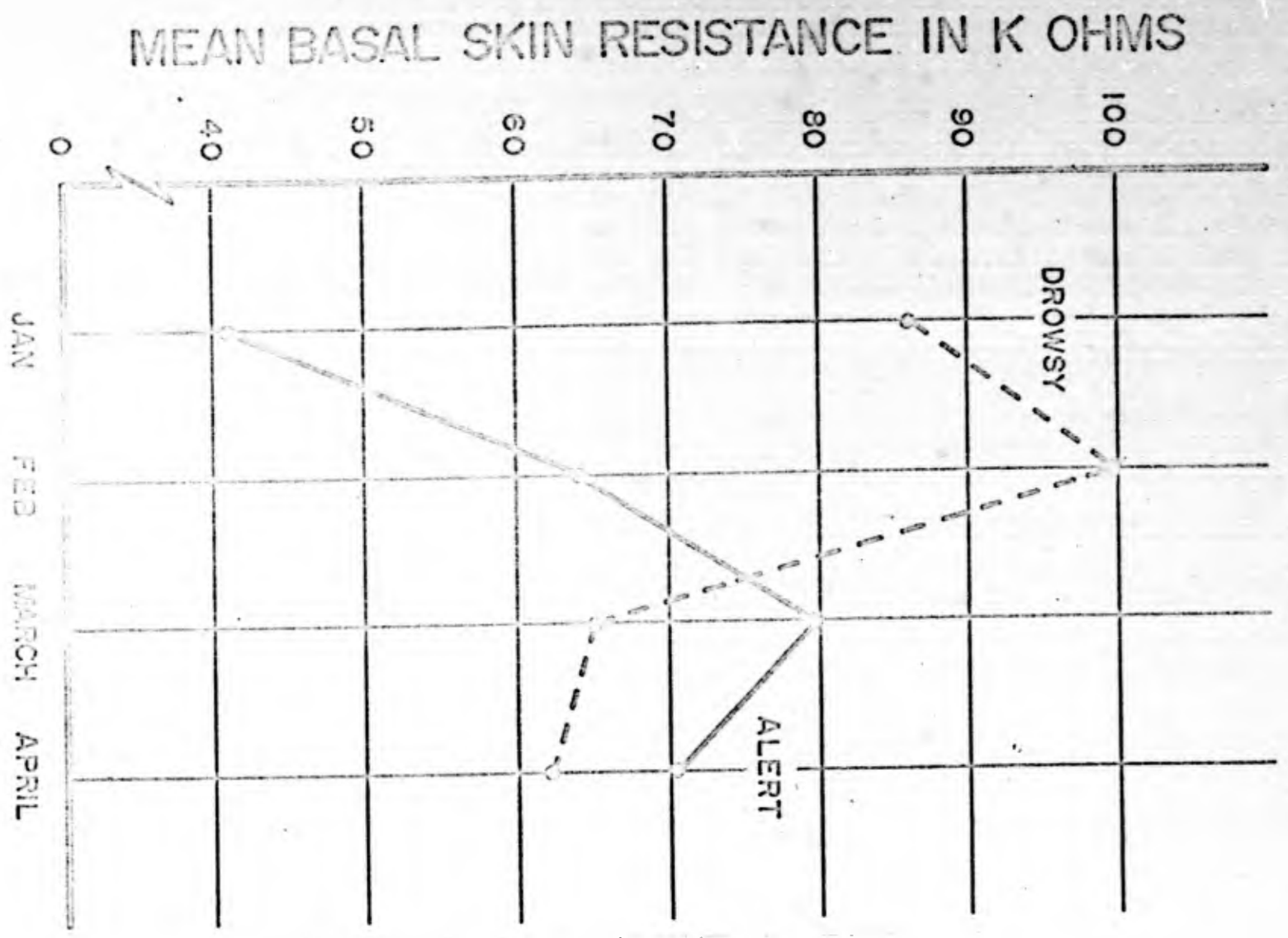


Fig. 3B - Mean basal skin resistance prior to light stimuli of two groups of subjects, alert vs. drowsy. All differences are significant.

Heart rate acceleration to five intensities of sound of a high Es group and a low Es group. Each value is the mean of five observations for each intensity for 9 Ss in each group over 4 testings - i.e. 20 observations/S, 180 observations for each group. Each mm. = 1.97 beats/minute of difference from pre-stimulus levels. Differences between groups are not significant but the intensity differences are highly significant ($p < .001$).

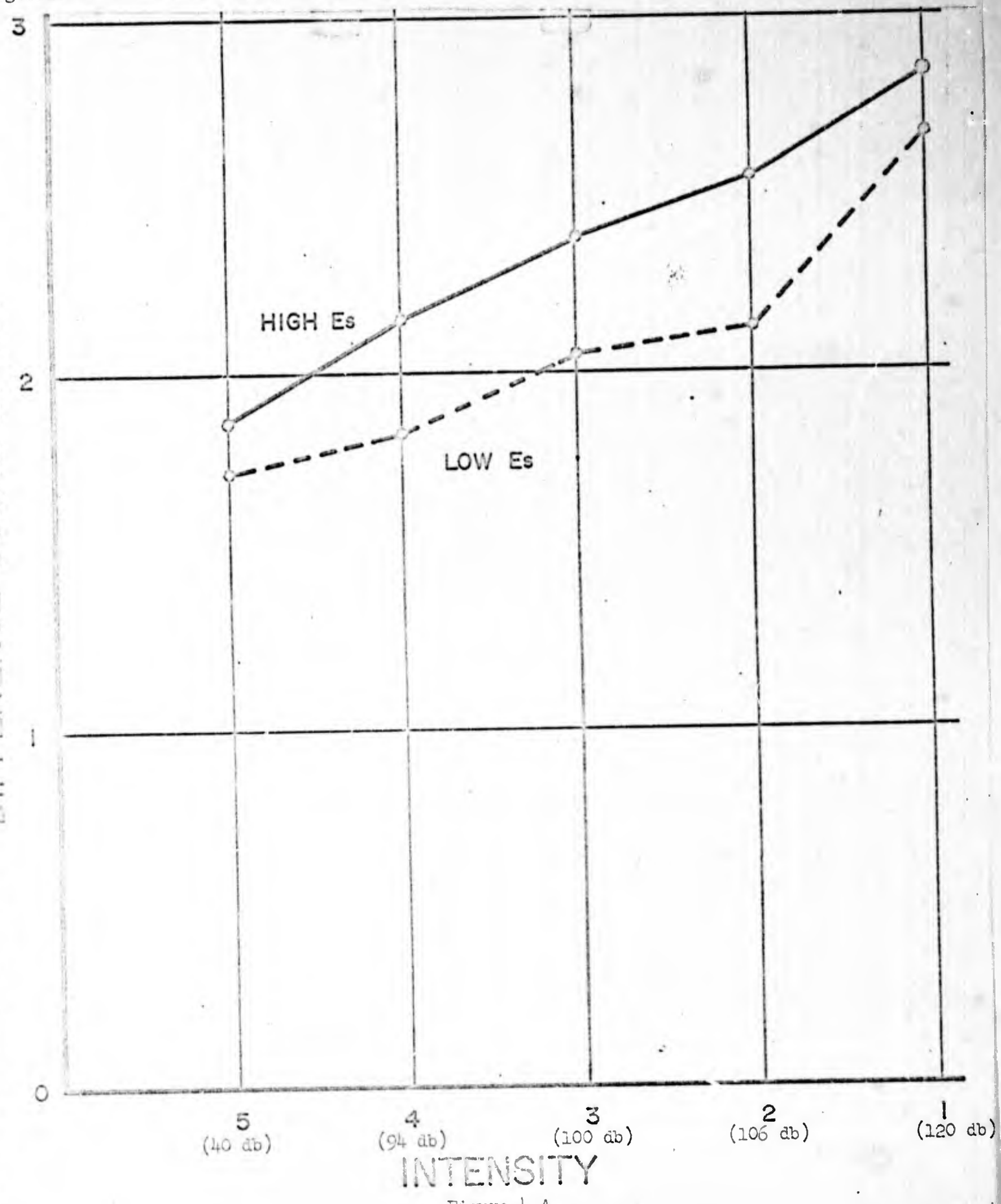
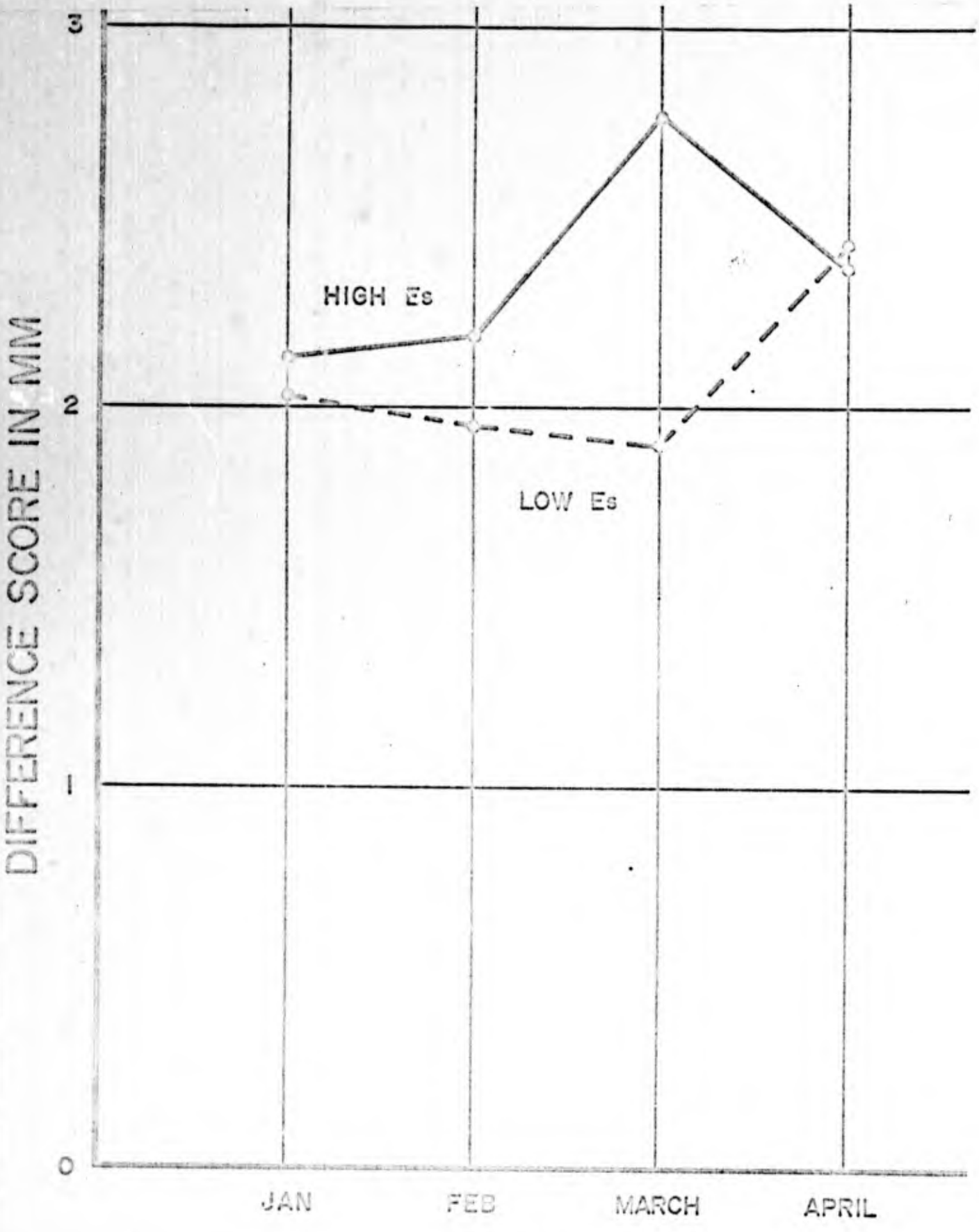


Figure 4 A

Mean heart rate acceleration to sound stimulation of high and low Es groups over all intensities on each of four testings, January - April. Neither groups nor runs differ significantly.



RUNC

 Figure 4 B

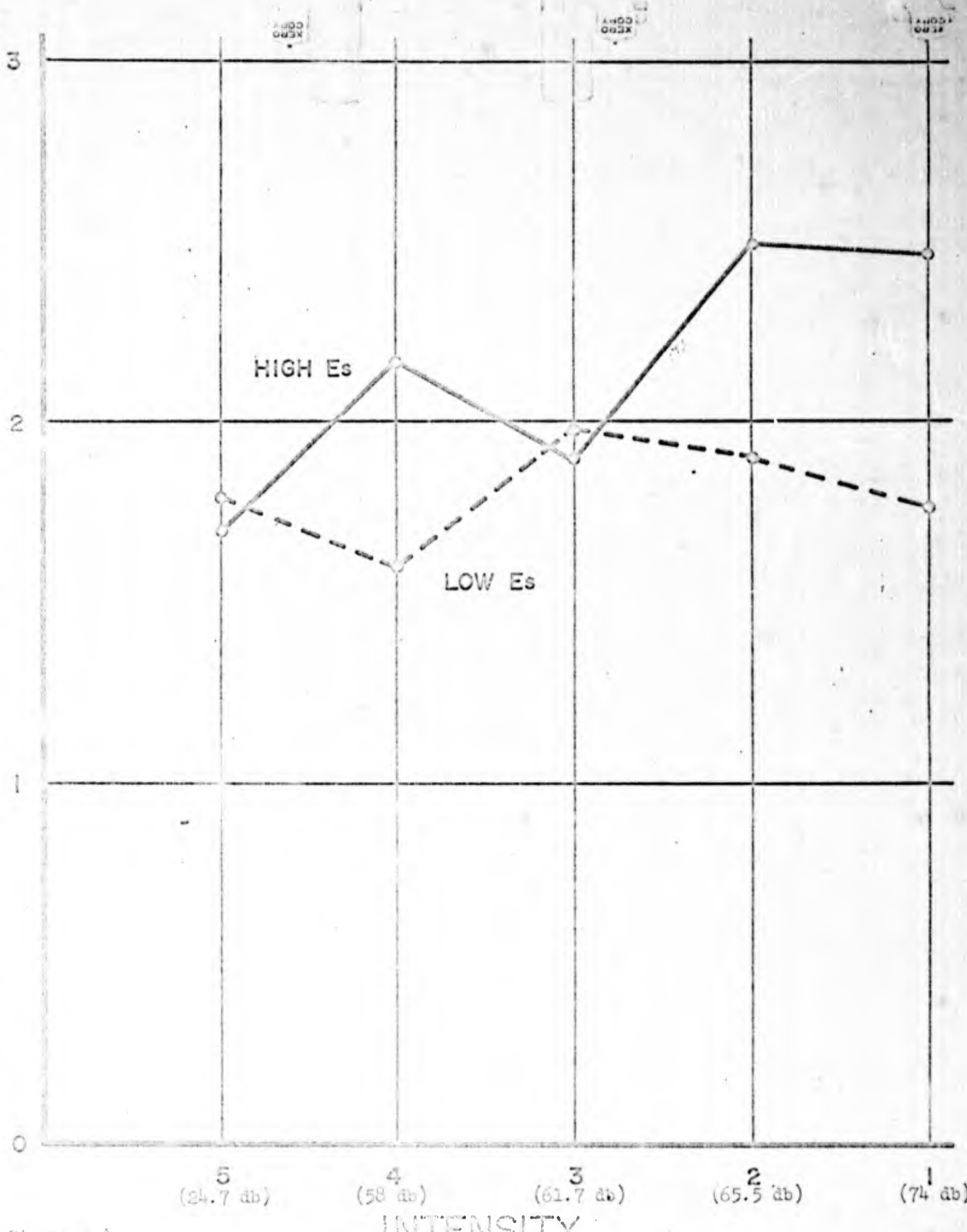


Figure 5 A

Mean heart rate deceleration to five intensities of light of a high Es group and a low Es group. Each value is the mean of five observations for each intensity for 8 Ss in each group over 4 testings - i.e., 120 observations. Intensity and group x intensity interactions are significant ($p < .05$).

Mean heart rate acceleration to light stimulation of high and low Es groups over all intensities on each of four testings. Testings differ significantly ($p < .05$) but groups by runs do not.

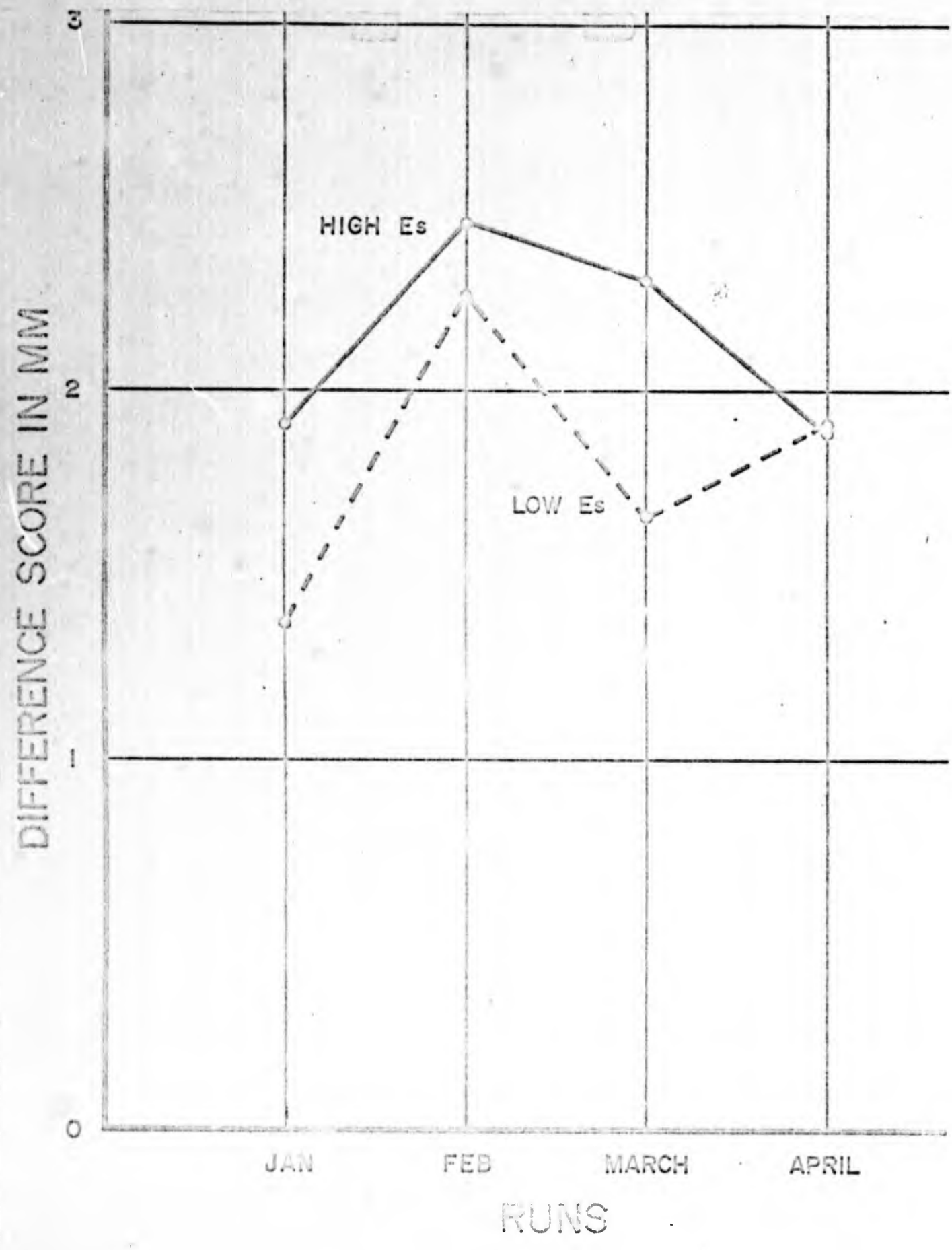


Figure 5 B

Mean heart rate deceleration to five intensities of sound, high vs low Es groups. Each value is the mean of five observations for each intensity for 9 Ss over 4 testings - i.e., 180 observations for each group. Differences between groups are not significant but the intensity effect is ($p < .001$).

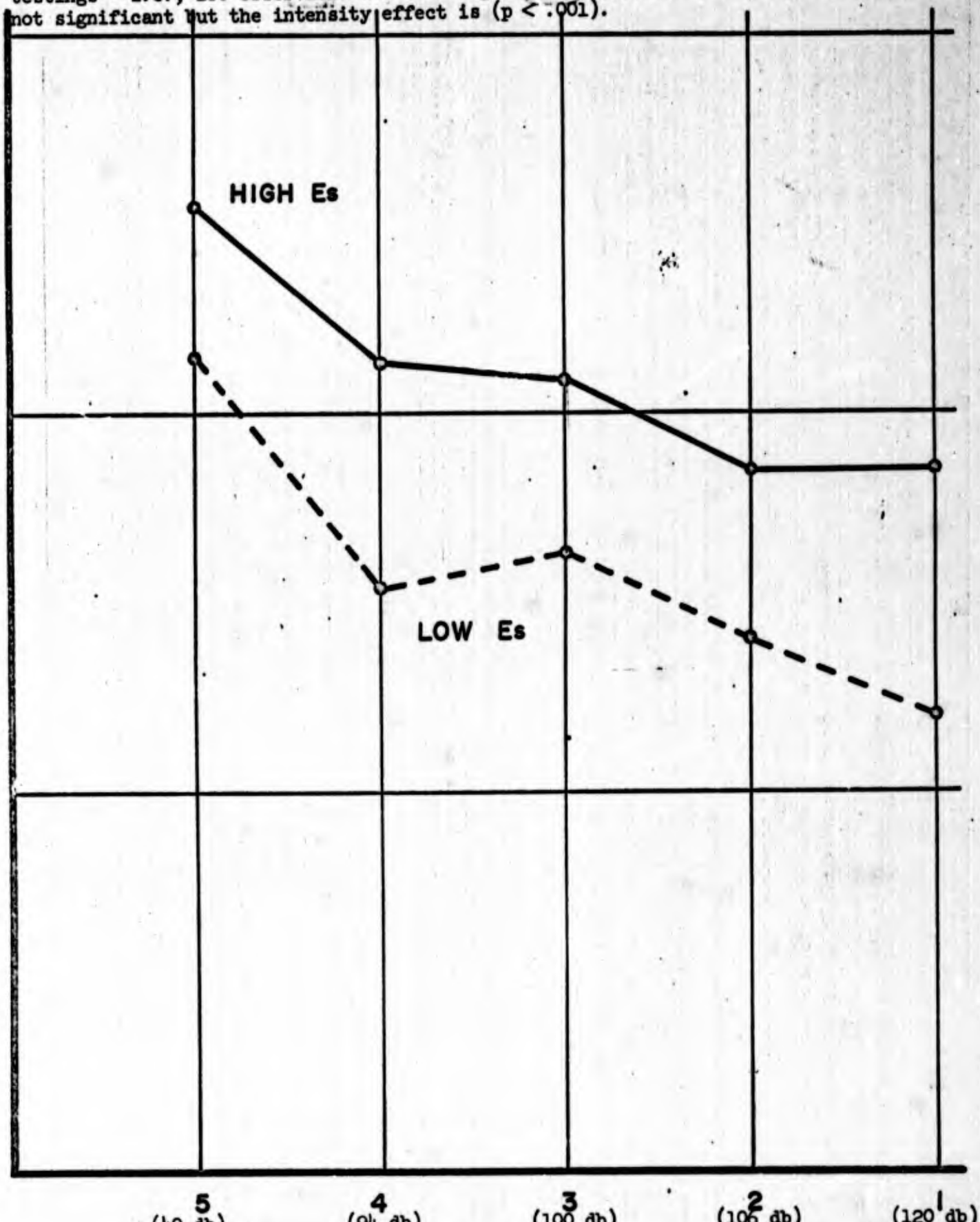


Figure 6 A

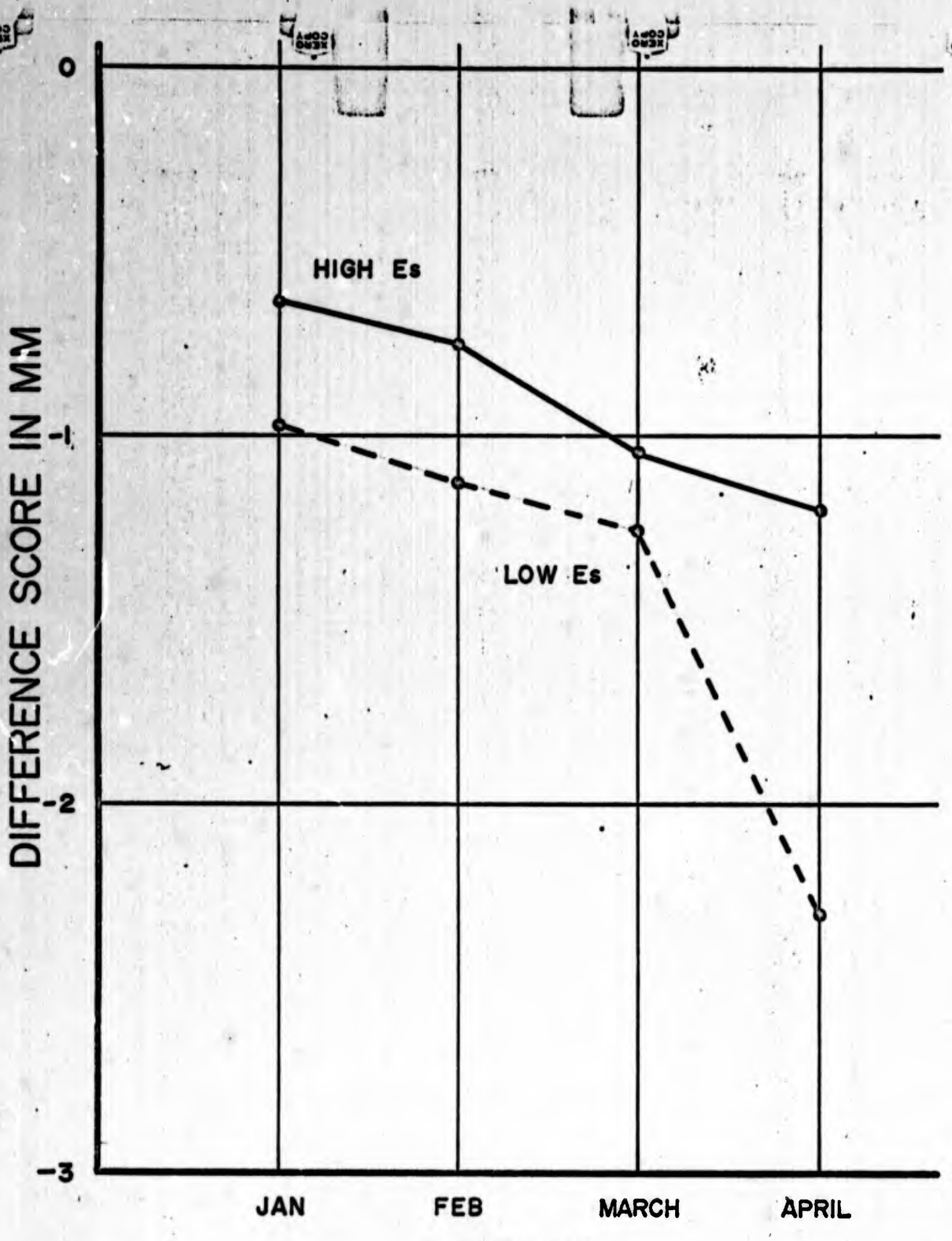


Figure 6 B

Mean heart rate deceleration to sound stimulation, high vs low Es groups over all intensities on each of four testings. Group differences are not significant but test differences are ($p < .05$).

Mean heart rate deceleration to five intensities of light, high vs low Es groups. Each value is the mean of 120 observations -- i.e., 6 Ss, 5 presentations within tests, four tests. Intensity X group interaction is significant ($p < .01$) but the intensity effect is not.

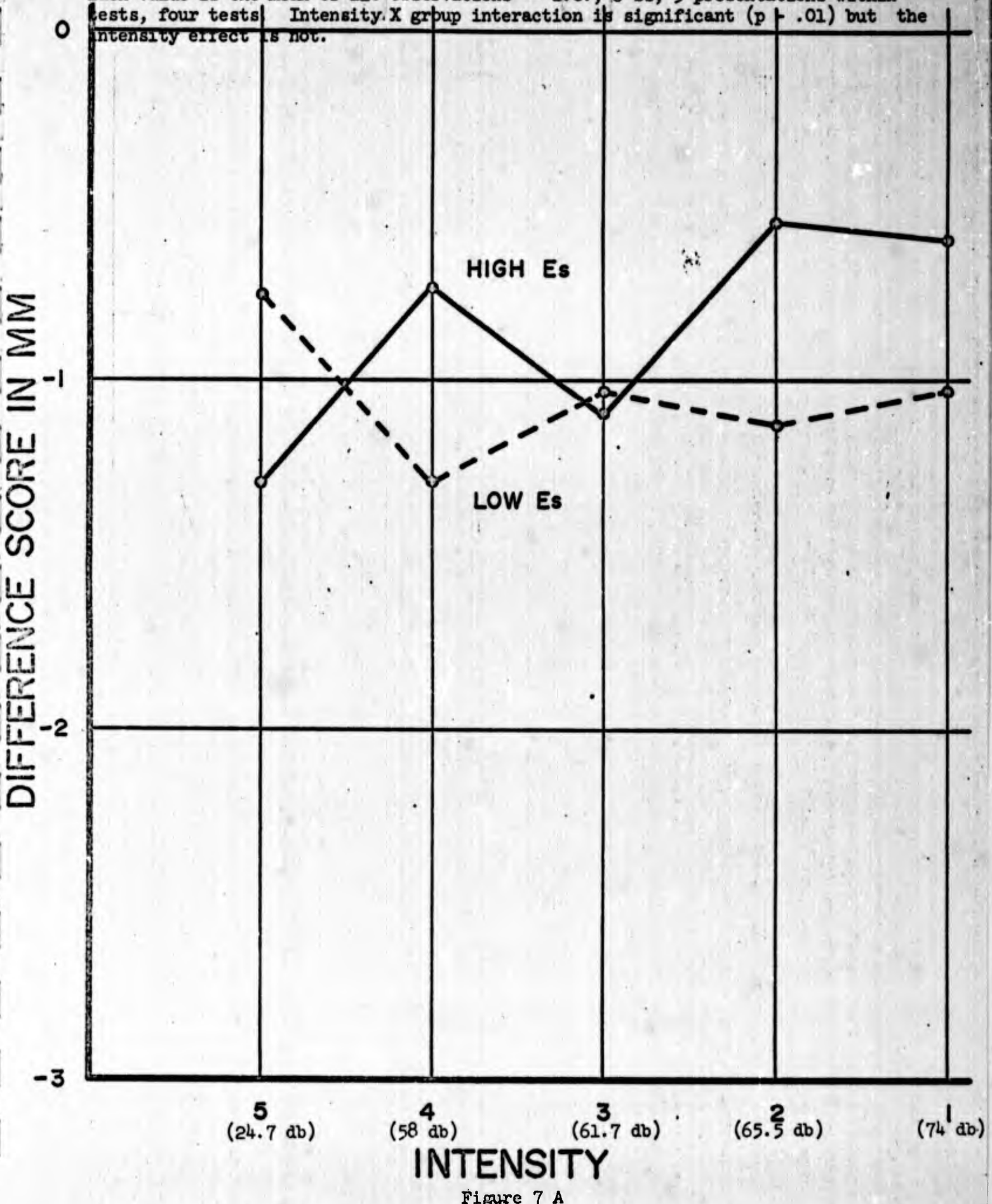


Figure 7 A

Mean heart rate deceleration to light stimulation of high vs low Es groups over all testings. Neither the group nor test effects or their interactions are significant.

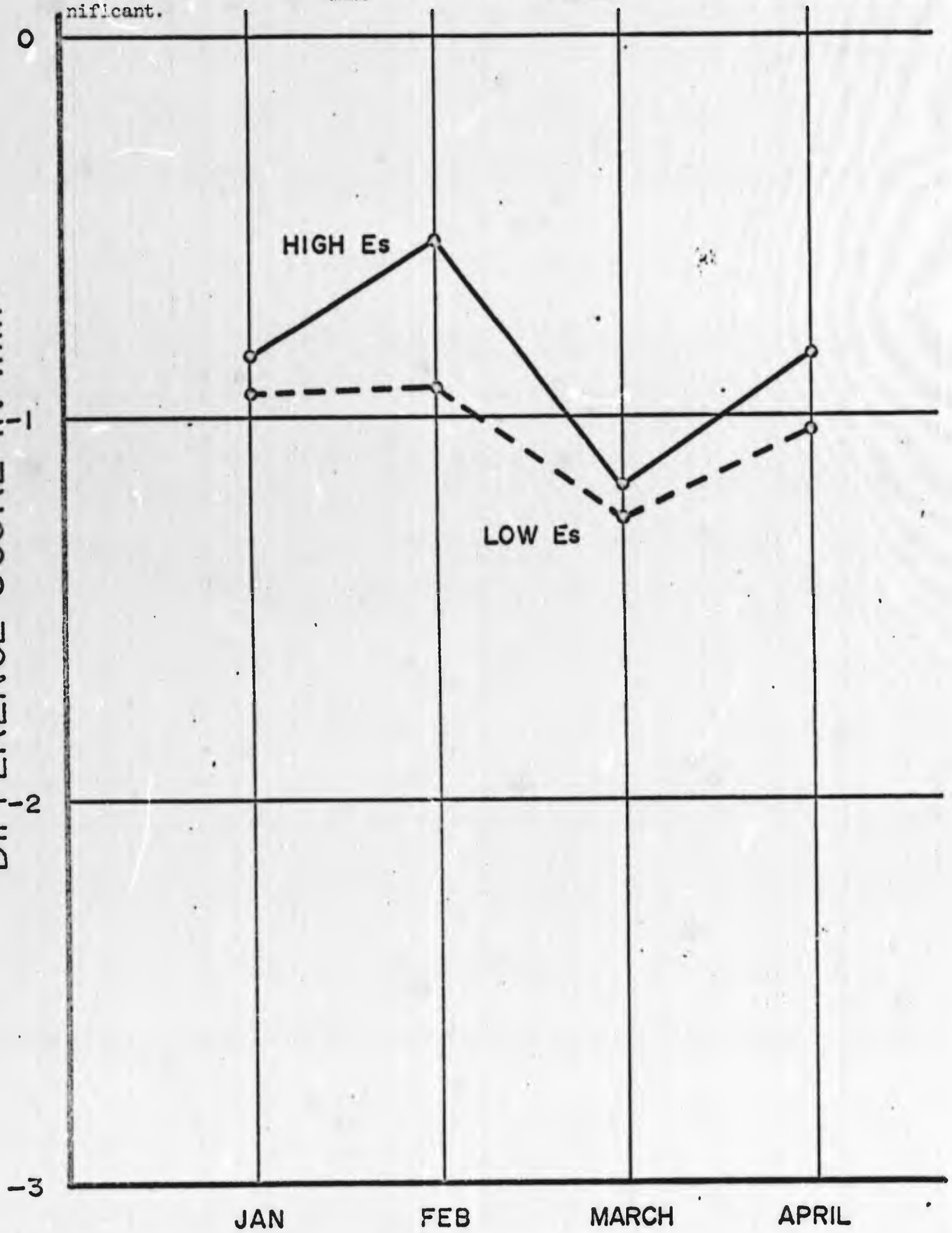


Figure 7 B

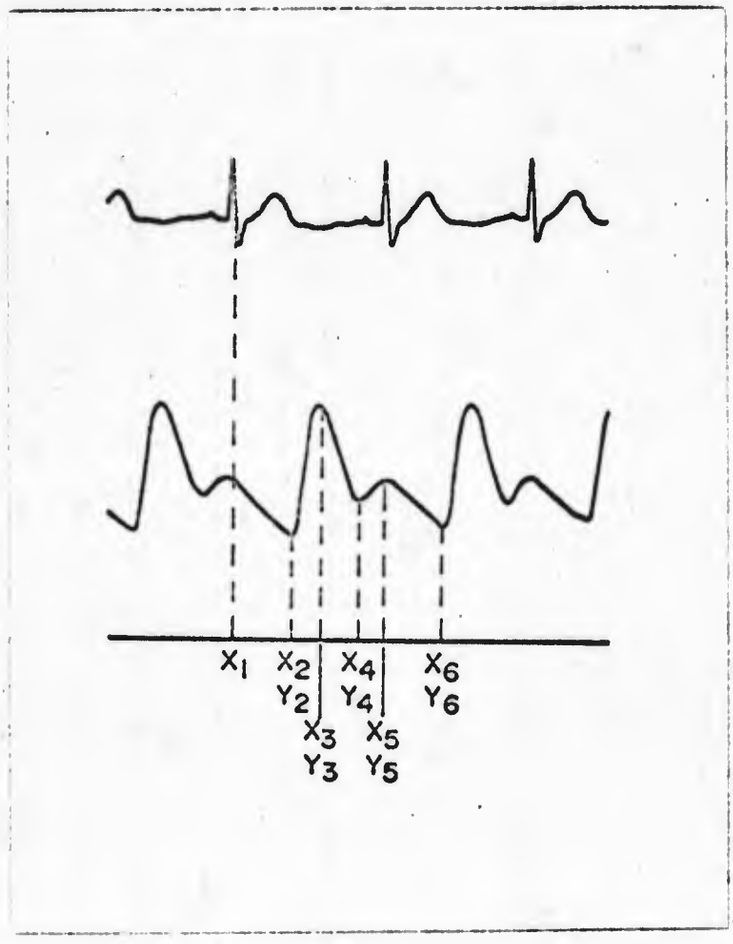


Figure 8. Scoring of pulse wave velocity and pulse wave parameters.

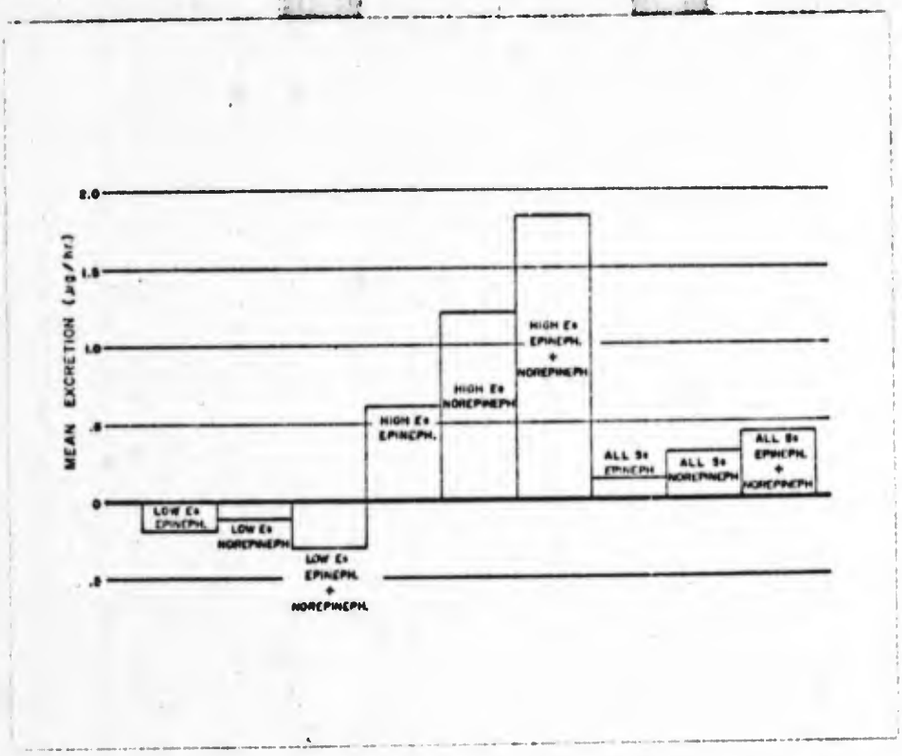


Figure 9 B

1. Effect of anticipation of examinations upon epinephrine and norepinephrine levels of a group of four high ego strength subjects and a group of four low ego strength subjects tested within five days prior to the examinations. Note the higher levels of catecholamines of this group of high Es Ss as compared to the total group of high Es Ss tested within ten days of the examinations.

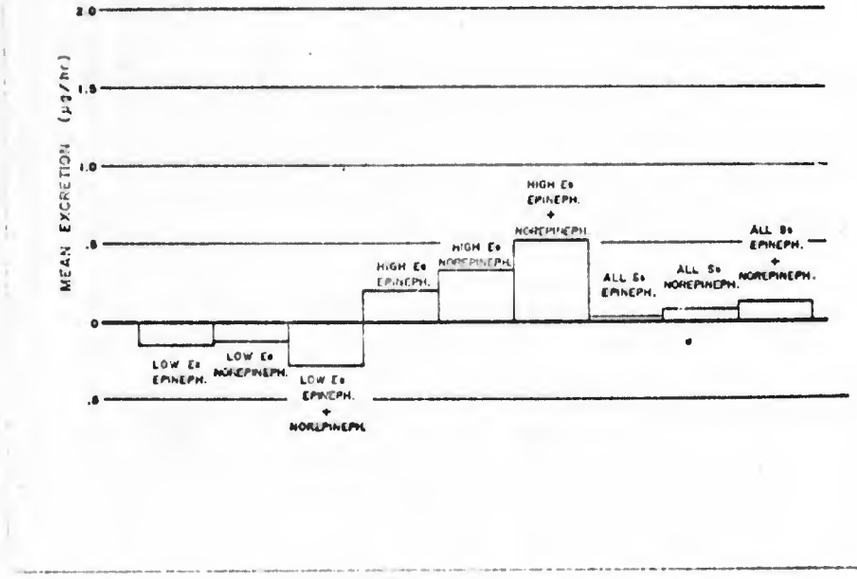


Figure 9 A

2. Effect of anticipation of examinations upon epinephrine and norepinephrine levels of a group of eleven high ego strength Ss and a group of eleven low ego strength Ss tested within ten days prior to the examinations.

TABLE 1

PULSE WAVE VELOCITY

(Sound $\bar{X}$)

High Es (X_2-X_1)

D_1 (2 largest values in stimulus epochs)		D_2 (2 smallest values in stimulus epochs)		
Intensity 1	Intensity 5	Intensity 1	Intensity 5	S No.
.94	.754	-1.13	-.81	54010
1.10	.81	-.69	-.58	54014
.73	1.325	-.62	-.387	54046
.72	.38	-.88	-.74	54140
.95	.36	-.33	-.92	54152
.33	.57	-.83	-.48	58004
.27	.57	-.86	-.49	58116
.14	.21	-1.11	-.96	60097
$\bar{X}$ = .648	.623	-.806	-.671	

Low Es (X_2-X_1)

D_1		D_2		
Intensity 1	Intensity 5	Intensity 1	Intensity 5	S No.
.44	.03	-.72	-1.14	50039
.77	.21	-.40	-.88	50040
.50	.36	-.74	-.48	51146
.32	.55	-.76	-.41	42031
.26	.29	-.89	-1.03	43091
.50	.364	-.68	-.74	54110
.77	.70	-.25	-.19	48006
1.10	.70	-.48	-.50	48015
1.02	.62	-.81	-.77	49001
$\bar{X}$ = .631	.424	-.637	-.682	
X_G = .640	.524	-.722	-.676	

TABLE 2

PULSE WAVE VELOCITY

(Light $\bar{X}$)

High Es (X_2-X_1)

D_1 (2 largest values in stimulus epochs)		D_2 (2 smallest values in stimulus epochs)		
Intensity 1	Intensity 5	Intensity 1	Intensity 5	S No.
1.06	1.13	-.68	-.64	54010
.68	.88	-.41	-.97	54014
.63	1.07	-.69	-.63	54046
.60	.56	-1.10	-.72	54140
.42	.52	-.68	-.73	54152
.71	.72	-.15	-.44	58004
.23	.18	-.86	-.78	58166
.24	.12	-.94	-1.15	60097
$\bar{X}$ .571	.648	-.678	-.758	

Low Es (X_2-X_1)

D_1		D_2		
Intensity 1	Intensity 5	Intensity 1	Intensity 5	S No.
.94	.776	-.38	-.38	49001
.45	.72	-.60	-.63	50039
.76	.52	-.30	-.39	50040
.26	.38	-.80	-.96	51146
.14	.13	-1.32	-1.18	42031
.36	.08	-.69	-.81	43091
.45	.466	-.64	-.65	45110
.64	.52	-.34	-.58	48006
.344	.41	-1.06	-.86	48015
$\bar{X}$ = .482	.446	-.681	-.716	
$\bar{X}_G$ = .526	.547	-.680	-.737	

II. Polygraph Study

A. Introduction

As part of the overall investigation of psychophysiological responses to stimulus fields of various complexity, we have derived an experimental design to study the relatively complex stimulus field of interpersonal interaction in the 2-man group. The stimulus field generated by interpersonal interaction under the constraints of a formal interrogation situation is perhaps midway in the spectrum of field complexity. The simple 2-second light and sound stimulus reported in section I may be seen as being at one extreme of the spectrum while spontaneous interpersonal interaction without communication constraints in the small group of group psychotherapy may be seen as one of the most complex fields.

Our studies of interpersonal interaction between patient and therapist during the psychiatric interview show the need for 2-man group study in which the stimulus field is more ameanable to experimental control than is true in the psychiatric interview. The 2-man group, in the polygraph interrogation paradigm offers a stimulus field which can be progressively more standardized by increasing communication constraints in the interpersonal interaction, removing direct interpersonal interaction by remote and recorded interrogation, and finally, presenting a set of standardized visual slides as the stimulus field. The principal experimental difficulty in attempting to relate the psychophysiological responses of a subject to a complex stimulus field is in establishing the semantic information or value and meaning of a given stimulus to a particular subject at a particular time. Evaluating the emotional meaning or affect value of a stimulus or class of stimuli, implies either considerable information in depth, as may be accrued in longitudinal psychotherapy, or a manipulation of the experimental environment which insures reasonably constant meaning of a given stimulus across a group of individuals. It is this latter manipulation that is undertaken in the polygraph study in that every effort is made to force the subjects to cathect or emotionally charge, the significant aspects of a simulated crime. The large monetary reward for successful deception is a further attempt to insure relatively high and standardized cathexis to the events and objects within the simulated felony.

It is important to note that we do not see the detection of the guilty or the guilty knowledge subjects as dependent on the psychophysiological measurement of the highly abstract and relatively diffuse affect-emotional state of "guilt" or "guilty feelings". We make no effort to induce "guilt" in the subjects, but rather our attempt is to insure emotional charge or affect bonding to specific symbols of events which occurred in an actual situation. The psychophysiological response is a physiological reflection of the affect unit which is bonded to the symbol. The symbol in the stimulus field of the polygraph interrogation is of course the key word or words verbalized by the examiner in the pertinent questions.

The following design may be critized on the basis that a simulated role can never approximate the emotional involvement of real life. We have substituted the crime of armed robbery for an earlier experimental crime of

murder on the argument that far more elements of armed robbery can be physically acted out (it is assumed that actually accomplishing a physical act which requires physiological work may be expected to cathect the act), and also in the belief that the average young American male is more likely to have experienced fantasies of stealing money than fantasies of murdering a beautiful young woman. We have attempted to make the simulated crime as ego-syntonic and as compatible with expected values as possible. Despite the fact that the crime is not "real life", the felony interrogation paradigm offers the tremendous experimental advantage that the facts of guilt, guilty knowledge and innocence are known; also, the knowledge and actual experience of the subjects are titrated in that the innocent subject knows very few specific facts of the crime - only such facts as he might have read in the newspaper - while the guilty knowledge and guilty subjects share a moderate number of facts, but no subject knows all the facts about all roles.

Finally, it should be noted that the experience of this crime as reported by our subjects seems to approximate real life if subjective reports of anxiety and emotional involvement can be accepted as indications.

B. Polygraph Study Design

1. Subject Selection and Briefing

Three subjects per run are recruited from a paid volunteer population. The subjects are students in a university, dental school or medical school. Each subject, upon entering the testing room individually, is asked if he knows the meaning of the words Polygraph Test. The usual response given by the subject is in the form of a question, e.g., "Do you mean the Lie Detector"? If the subject doesn't understand the meaning of the polygraph test the words lie detector are used by the individual conducting the briefing session as a simple explanation. All subjects are asked to sign a release form in which the subject's voluntary participation and responsibility are explicitly stated as follows:

HOUSTON STATE PSYCHIATRIC INSTITUTE

PSYCHOPHYSIOLOGY DIVISION

I hereby state that I am over 18 years of age, and that I have volunteered to be a subject in research on stimulus field presentation to be conducted at Houston State Psychiatric Institute and Baylor University College of Medicine over a period of two days.

I understand that a polygraph test will be given as part of the study, but that the material covered will be limited to the usual identifying data and the experiences in these laboratories.

I also understand that a series of psychological tests will be given, the purpose of which is to relate such test results to my role in the experiment and to the results of the polygraph test.

_____ Subject

Witness

_____

Address

The subjects are assigned roles and briefed in their respective roles as innocent, guilty knowledge and guilty by casting a die for each subject. On the cast of the die all 1's and 2's are guilty, all 3's and 4's are guilty knowledge and all 5's and 6's are innocent. Subjects assigned the same role are briefed independently and carry out their assignments independently; if all 3 subjects are assigned the role of guilty, 3 independent crimes are committed on that day.

Instructions to the Innocent Subject - The purpose of this study is to undertake an investigation into lie detection techniques.

You have been chosen as the innocent subject and when participating in the polygraph test you will answer all of the questions with the truth.

The interrogation study will last most of tomorrow afternoon. You will be paid $10.00 for your participation, and should the examiner identify you as the innocent subject you will receive part or all of the stolen money as a bonus; the bonus will be divided among those subjects designated as innocent by the polygraph examiner. It is obviously to your advantage for you to be unfamiliar with all of the facts of the crime - do not discuss any of the details of this experiment with the other subjects prior to the polygraph test.

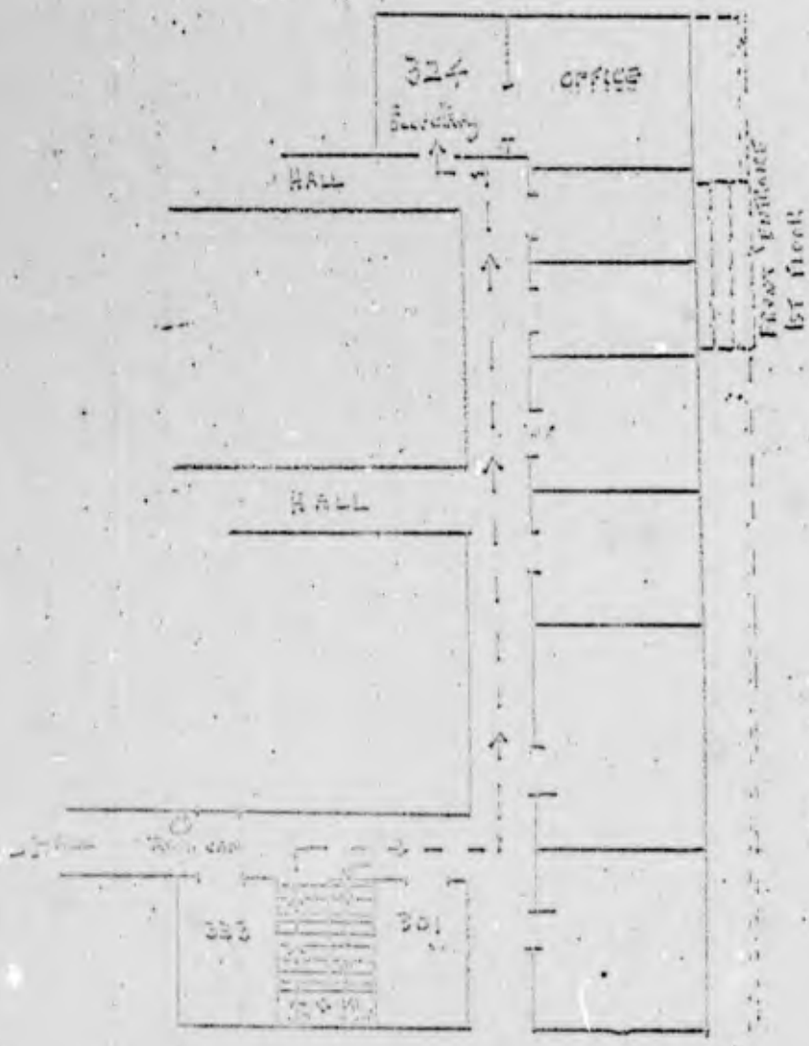
You are now to leave and return to this building tomorrow, reporting to room 06D at 1:00 P.M.

Instructions to Guilty Knowledge Subject - The purpose of this study is to undertake an investigation into lie detection techniques. We are therefore simulating a crime in which you have been chosen to have guilty knowledge of the crime about to take place; you are not to discuss any of the facts of this crime or to communicate any of the details to anyone, including the other two subjects, until this experiment is completed. You are asked not to discuss the experiment with any of your friends until the full series has been completed - approximately one year.

Your knowledge of the crime will be limited. You will know that the crime was an armed robbery committed at gunpoint and that the robbery took place at Houston State Psychiatric Institute. In addition to this knowledge you will copy and study a floor plan outlining the path that the robber will take. You are asked to have your copy of the floor plan concealed on your person during the entire polygraph testing period (c.f. copy of floor plan illustrated in Figure 10).

You should be aware that this prior knowledge of a crime about to be committed makes you an accessory before the fact unless you report your knowledge to the proper authorities. This prior knowledge, which could help prevent the crime, makes you legally responsible - you will not report this to any authorities.

Tomorrow you will return to this building and report to room 06D at 1:00 P.M.. The interrogation study will last most of tomorrow afternoon. You will be paid at the rate of $10.00 for your participation, but should the examiner misidentify you as the innocent subject, you will receive part or all of the stolen money as a bonus; the bonus will be divided among only those subjects designated as innocent by the polygraph examiner.



SECOND FLOOR PLAN

When taking the polygraph tests you must remember to lie about all matters pertaining to the guilty knowledge you have and do not reveal information pertinent to the crime to the examiner at any time - the tests begin as you walk through the door of the examination room. Cooperate with the examiner only in the polygraph test procedures - do not reveal information that might help him determine your guilty knowledge.

Instructions to the Guilty Subject - The purpose of this study is to undertake an investigation into lie detection techniques. We are therefore simulating a crime in which you have been chosen to commit an armed robbery at gunpoint in the Houston State Psychiatric Institute. You will be accompanied out of this building into the Houston State Psychiatric Institute, and to the corridor leading to the office where you will commit the robbery. This is the gun you will use; this is the paper sack in which you will hide the gun.

You must go through the secretary's office to get to your victim. Once outside the secretary's office you will enter the office and roughly order her out of her chair at gunpoint. You will force her to go before you into the inner office, order her to sit down and be quiet. Within the inner office you will find a distinguished gentleman sitting behind the desk. You will order him to stand up, turn around and place his hands against the wall. When he has his hands against the wall you will reach into the inside pocket of his jacket and extract his wallet. In the wallet you will find $30.00 in bills which you will steal and put into your own pocket, throwing the wallet onto the desk. You will then retrace your steps along the corridor. Outside room 333 you will find a trash can into which you will drop the gun concealed in the paper sack. You will then go on your way with the $30.00. You are asked to have the $30.00 concealed on your person during the entire polygraph testing period.

Tomorrow you will return to this building and report to room 06D at 1:00 P.M. The interrogation will last most of tomorrow afternoon. You will be paid $10.00 for your participation, but should the examiner misidentify you as the innocent subject, you will receive part or all of the stolen money as a bonus; the bonus will be divided among only those subjects designated as innocent by the polygraph examiner.

When taking the polygraph tests you must remember to lie about all matters pertaining to your guilt; and do not reveal information pertinent to the crime to the examiner at any time - the tests begin as you walk through the door of the examination room. Cooperate with the examiner only in matters of the polygraph test procedures - do not reveal any information that might help him determine your guilt.

Preparation - On the day of the test the subjects are prepared with all necessary electrodes. They are not permitted to see or speak to each other and after preparation the first is escorted to the interrogation room and all electrodes connected to the polygraph and other transducers. A two minute control recording is made with the subject alone in the room and resting with his eyes closed. After the control run is over the interrogator enters the room, introduces himself to the subject and begins the pre-test.

After the pre-test, the examiner begins the questions to which the subject has been instructed to answer yes or no according to the instructions given during the previous days briefing.

2. Test Questions Employed in Polygraph Examination

1) Are you sitting down now?
2) Are you going to cooperate and answer all of my questions with the truth?
3) Do you ever drink water?
4) Are you the one who only knew about the robbery and did not report it?
5) Are you in Houston now?
6) Are you the one who robbed the doctor at gun point?
7) Are you in the State of Texas now?
8) Are you the one who hid the pistol in the trash can?
9) Are you the one who stood lookout for the robber?
10) Are you the one who is hiding a copy of the floor plan of the robbery?
11) Are you the one who drove the get-away car?
12) Are you hiding the doctor's money on you now?
13) Have you ever gone to a movie?
14) Have you ever intentionally lied to anyone?
15) Have you ever smoked a cigarette?
16) Have you ever stolen anything in your life?
22) Have you lied to me since you have been in this room?

Rationale of Polygraph Questions

Question No.1

This question exemplifies the format of the majority of questions, most beginning with "Are you", in order to decrease the probability of a psychophysiological response to unexpected syntax. The exceptions to this format will be explained under the appropriate questions number. "Are you" was selected as the general format in order to emphasize the present tense and to attempt to focus the question in direct confrontation (a frequently utilized psychotherapeutic technique) of the subject as an individual in interpersonal interaction. In this first question the substance of the question about the subject "sitting down" is so trivial as to make it painfully apparent that this is not a "relevant" question. While this question is obviously bland and innocuous, it may be expected to consistently elicit psychophysiological arousal simply because it is the first question of the series and therefore carries a high probability of a "startle" response from the novelty effect.

Question No. 2

At one point in the design this single question was structured as two different questions. The present sentence attempts to combine the two concepts of "cooperation" in general and the specific cooperation of "answer all of my questions with the truth". The instructions to both the guilty and guilty knowledge subject strongly demand only limited cooperation and lying on all pertinent questions; thus, this question should be relevant to both the guilty and guilty knowledge subject and a psychophysiological arousal response is expected in relation to the question. This question is included in the category of novelty effect for the innocent subject because, although it is the second question in the series, it is the first of the non-trivial irrelevant questions which apply to the ongoing experimental procedure.

Question No. 3

This is another irrelevant question of trivial nature similar to question No. 1 but is the first of the questions included in the irrelevant category based on the assumption that the subjects will have largely accomodated to the novelty effect by the third question.

Question No. 4

This question is designed to be relevant primarily for the guilty knowledge subject but the possibility exists that it may be interpreted by some guilty subjects as relevant to their role. Since the innocent subject has no knowledge of the crime to be committed, for him this question becomes essentially a "guilt complex" question; that is, it is not as trivial and as obviously irrelevant as "do you ever drink water?" but, for the innocent, describes a hypothetical criminal act which in itself may elicit more psychophysiological response than questions of the irrelevant category.

Question No. 5

This question is irrelevant for all subjects.

Question No. 6

This question should be relevant for the guilty subject and should act as a guilt complex question for the guilty knowledge and innocent subject.

Question No. 7

This question is irrelevant for all subjects.

Question No. 8

This question should be relevant for the guilty subject and a guilt complex question for guilty knowledge and innocent subjects.

Question No. 9

This question should be guilt complex for all subjects since it pertains to a hypothetical criminal act which did not actually take place in the simulated crime.

Question No. 10

This question should be relevant only to the guilty knowledge subject and should act as a guilt complex question for the guilty and innocent subjects. Unfortunately, the experimental results suggest that the word "hiding" tends to elicit an arousal response in both the guilty and guilty knowledge subject unrelated to the remaining portion of the sentence pertaining to a copy of the floor plan. If the word "hiding" elicits arousal in the guilty subject (because his principal task in the role of guilty is "hiding" information), we may expect question 10 to occasionally fall into the relevant category for the guilty subject.

Question No. 11

This is a guilt complex question for all subjects because it did not occur in the simulated crime.

Question No. 12

This question is relevant to the guilty subject and a guilt complex question for the guilty knowledge and innocent. Here again, the experimental results may be somewhat confonded by the word"hiding" following the argument of question 10. It will be noted that this is a considerably shorter question than question 10 and breaks the thythn of the previous question format by deleting the phrase "the one who is". This re-phrasing may increase the impact of this question which already contains the element "money", presumably highly catchected as a central sign of the simulated crime, and the elements "on you now" which directly confront the body image of the subject in the context of the present situation. Taken together, these elements and factors would predict relatively intense psychophysiological arousal to this question.

Question No. 13

This is an irrelevant question for all subjects but the tense has been changed from the present to the past "have you" in order to emphasize the different nature of the last four questions and to generalize the questions by broadening the time base to all of the subject's past experience.

Question No. 14

This is a control question for all subjects on the assumption that all subjects have at some time intentionally lied to someone. The purpose

of the control question is to elicit a more or less "standard" response from each individual subject; the level of confidence that a response to a relevant question is significant is increased if that level of response is greater than the response to a control question. It is also expected that the level of psychophysiological response to the control questions will be approximately the same as the level of response to the novelty effect questions. It is thus anticipated that for the guilty and guilty knowledge subjects, questions 1, 14 and 16 may be combined in one category and for the innocent subject responses to questions 1,2,14 and 16 may be combined.

Question No. 15

This is an irrelevant question for all subjects.

Question No 16

This is a control question for all subjects on the assumption that almost everyone has stolen something in their life time.

Question No. 22

This is an optional question and usually employed to elicit a guilt complex response presumably greater in those that are involved that those who are innocent.

QUESTION CATEGORIES FOR DISCRIMINANT FUNCTION, POLYGRAPH STUDY

	Categories	Question Nos.	
Guilty	NE + C	1, 14, 16	(6)
	IR	3,5,7,13,15	(10)
	R_1	2,(4*,10*)	(6)
	R_2	6, 8,(12*),2	(6)
	GC	9, 11	(4)
Guilty Knowledge	NE + C	1, 14, 16	(6)
	IR	3,5,7,13,15	(10)
	R_1	2,(4*,10*)	(6)
	R_2	6, 8,(12*),2	(6)
	GC	9, 11	(4)
Innocent	NE + C	1, 14, 16	(6)
	IR	3,5,7,13,15	(10)
	R_1	2,(4*,10*)	(6)
	R_2	6, 8,(12*),2	(6)
	GC	9, 11	(4)

NE + C: Novelty effect and control
IR: Irrelevant
R_1: Relevant for guilty knowledge subject
R_2: Relevant for guilty subject
GC: Guilt complex for all subjects

* The starred questions in parenthesis are ambiguous as explained in the text and while they are to be treated initially in their assigned categories, it is expected that they may confound the results somewhat. The question categories are listed in the rank order of the expected level of psychophysiological response. It is of course expected that the questions in the relevant category will elicit greater psychophysiological arousal than the questions in the irrelevant category.

C. Measures and Physical Situation

1. Direct interrogation situation: Subject and examiner in interrogation room.

a. Measures recorded: Keeler instrumentation Model 6308 Polygraph (modified - fed from Baylor basal recording), also recorded on analog magnetic tape.

1) Blood pressure
2) Respiration
3) GSR
4) One second time marker
5) Five second on-off light

b. "Field" Conditions

1) Subject introduction to test and attachment of Keeler GSR and respiration transducer.

2) All Baylor transducers connected with subject chair toward mirror and TV camera.

3) Pre-test interview is conducted by examiner and the content and order of question are explained to the subject. The examiner is encouraged to ask questions of the subject spontaneously and to probe any areas which seem indicated in order to elicit information which might aid the examiner's decision. The pre-test interview is paced in such a way as to allow a reasonable response time to the questions being explained. An attempt is made to standardize the order and content of the majority of the questions presented during the pre-test. From the psychophysiological point of view, the pre-test interview is a special interrogation situation in which the subject is not usually aware that he is being interrogated and not aware that his psychophysiological responses are being continuously recorded. Presumably the subjects have a somewhat different emotional set toward this "non-test" portion of the run than they have toward the Keeler portion when the test has obviously begun. It should be of special interest to determine how effective the pre-test portion of the interview can be in determining the guilt or innocence of the subjects as compared to the Keeler run itself. Preliminary evidence suggest that guilty and guilty knowledge subjects sometimes respond to relevant questions on the pre-test portion of the run but do not respond to the same questions on the Keeler portion. If this turns out to be true in a significant number of the subjects, we may be able to demonstrate that crucial information is being lost in the standard Keeler run when measures are not continuously recorded during the total interview situation. At the very least the psychophysiological responses obtained during the pre-test interview should be of use in determining baseline values for a given subject and perhaps of use in developing a conversion factor for the psychophysiological responses of the Keeler run itself.

a. Questions fall in three major classes of stimuli

1) irrelevant

2) Relevant
3) Control

(b) Questions presented in order of matched pairs: irrevelant, relevant, irrelevant, etc.

4) A Keeler test is conducted of two to three minutes; subject instructed to verbalize yes-no answers to questions but to keep eyes closed, face forward and relax. Questions in the first test are standardized and remain constant across all subjects.

5) Period of inquiry is conducted at the option of the examiner; the examiner may ask the subject to elaborate on his yes-no answers to any questions or the examiner may inquire into areas related to the crime. At the examiners discretion the subject may be told of his Keeler responses and asked what associations he had to a particular question which might explain his Keeler responses.

6) A second Keeler test is conducted under the same conditions as the first and a period of enquiry may follow if indicated.

7) At the examiner's discretion, a third Keeler test may be conducted. During this run the examiner may use any or all of the questions and in any order he choses. This completes a run.

8) Video tape-audio and video tapes record each session for subsequent evaluation of non-verbal and interpersonal interaction stimulus fields.

c. Task of Examiner

1) Mark question number and end of question on paper record.

2) Note significant changes or resetting in all measures.

3) Mark identification of subject, run number, etc., on all records.

4) Render final decision of guilty, guilty knowledge and innocence after each subject has been run.

5) In the following week, examiner completes standard evaluation forms for polygraph coding before the next experiment. The examiner uses "standard codes for significant polygraph patterns" (See following section) when completing forms. Detailed, personal debriefing of the examiner on reactions and responses of all subjects has been dicontinued; examiner now notes a significant reactions and responses of subjects as part of the standard coding procedure.

2. Remote Interrogation Situation: Subject and examiner in interrogation room, second or "remote" examiner in observation room. Subject may be viewed by remote examiner and observers both through the viewing mirror and on the closed circuit t.v. monitor. While the current design calls for the Keeler examiner to be in the room with the subject during all runs, the remote station offers the capability of literally remote interrogation in which the subject need never see the examiner.

a. Measures recorded: In addition to the recording of Keeler measures as listed, the Baylor measures are continuously recorded from the time the subject enters the room and is connected to the time he leaves the room. Such continuous recording offers the advantage of allowing the study of psychophysiological responses during the pre-test interview and during the period of inquiry between Keeler runs.

1) Subject GSR with 8-second time constant recorded on Rectiwriter pen in remote station, recorded on Rectiwriter pen, Offner Dynagraph and Analog magnetic tap recorder in basement.

2) Finger plethysmogram - light transducer. Recorded on Grass polygraph in basement and also a long time constant recording on the Offner Dynagraph.

3) Respiration - modified Keeler with light transducer for voltage output without Keeler pen. Recorded in the same way as the GSR. This measure is recorded on an Offner Dynagraph.

4) Keeler cuff - A light transducer mechanically attached to the Keeler system allows recording of this Keeler measure; this measure is recorded in the same way as the GSR and is recorded on an offner Dynagraph.

5) Single channel EEG vertex-occipital midline placement. This measure is recorded on the Grass polygraph and Analog magnetic tape recorder.

6) Examiner 8-second time constant GSR. This measure is recorded on an Offner Dynagraph.

7) Voice pen - One channel of the Grass polygraph is used to record the verbalizations from the subject room. The pen pattern associated with a particular word can generally be identified and should allow correlation of psychophysiological responses with particular words, with excellent time resolution; the Grass record is run at 60 millimeters a second.

8) One second time code. This time code is recorded on all records and Analog magnetic tape so that each record is synchronized with every other record.

9) Five-second on-off light. This is not recorded.

10) Event marker. The event marker is recorded in the same way as the GSR.

b. Field conditions

The protocol for the examination is of course exactly the same as in the direct interrogation situation since in the current design the Keeler examination is the only stimulus field employed. Future work will include study of remote interrogation, interrogation by visual slides and remote group interrogation.

c. Task of remote examiner

1) Mark question number and end of question on paper record.

2) Mark identification of subject, run number, etc., on all records.

3) Render final decision of guilty, guilty knowledge and innocence after each subject has been run.

4) Event marker is used to identify the beginning and end of questions.

APPENDIX A

Final Report, 1 July 1965 - 30 June 1966

PSYCHOPHYSIOLOGICAL CORRELATES OF HUMAN INFORMATION PROCESSING UNDER ALTERED STATES OF CONSCIOUSNESS

for

Air Force Office of Scientific Research

Washington, D. C.

Under Grant AF-AFOSR-727-65

by

Robert Roessler, M. D.

and

Neil R. Burch, M. D.

Biophysical Research Division

Houston State Psychiatric Institute

and

Department of Psychiatry
Baylor University College of Medicine

Houston, Texas

March, 1966

INTERIM REPORT

In the interval since the September, 1965 Annual Report, work has continued in the following areas:

1. Preparation and presentation of a scientific paper to the October, 1965 meeting of the Society for Psychophysiological Research,

2. Preparation of an expanded version of this scientific paper for publication in the journal Psychophysiology,

3. Further analyses of the GSR data obtained in the study summarized in the 1965 Annual Report,

4. Correlational analyses of various psychological scales with the academic performance of the subjects tested in the aforementioned study,

5. Continued hand-scoring and card punching of the heart rate, pulse wave amplitude and finger volume variables,

6. Analysis of the EEG data, directed toward defining discrete levels of consciousness,

7. Exploratory studies of the physiological responses to complex visual stimulus fields, simulated interrogation and drugs, and,

8. Further development of instrumentation for the automatic analysis of physiological variables.

The work in each of these areas is elaborated below.

1. and 2. Scientific paper

The paper which reported the results of the GSR analysis was submitted to Psychophysiology for publication. It was accepted for publication but the editor suggested that consideration be given to further analyses suggested by two editorial consultants. One of the consultants expressed an interest in the basal resistance values of the subjects and the relationship, if any, of these values to GSR amplitude. He suggested that co-variance corrections might result in a change in the results where group comparisons had been made, especially the alert vs drowsy comparisons. The other editorial consultant questioned whether appropriate error terms had been used in the analyses of variance and suggested that analysis of variance for repeated measures was more appropriate. These questions not only seemed relevant to us but had already occurred to us, so we had already initiated further analyses of the GSR data directed toward answering these questions. We therefore decided to delay publication until the results of these further analyses were available. They are now available and are being incorporated in a revised report.

3. Further analyses of GSR data

The basal skin resistance of high ego strength vs low ego strength subjects and alert vs drowsy subjects were compared by t-tests. It was found that, in most of the comparisons, there was a significant

difference. In general, low ego-strength subjects had higher mean resistances (i.e. lower conductances) than high ego-strength subjects. Similarly, drowsy subjects, in most comparisons, had higher mean resistance levels than did alert subjects. The direction of these differences was opposite to that which might have been predicted in the case of the high vs low ego-strength subjects if the "law of initial values" was operating. A co-variance correction would then serve to accentuate, rather than diminish, group differences. Nontheless, it did seem desirable to re-analyze the data with co-variance analyses, adjusting the GSR scores for differences in basal resistance. Such analyses also seemed particularly desirable from the standpoint of the sponsor. The commercial instruments ordinarily employed in field applications do not provide a basis for taking into account the effects of differing base-line values, at least insofar as the possibility of making a systematic correction for such differences is concerned.

Co-variance analyses parallel to the analyses which had been previously computed and reported in the annual report were therefore carried out. In every instance, the previously reported group differences not only continued to be significant, but, as we predicted, the size of the differences were accentuated when scores were adjusted for difference in basal resistance.

The relationship between basal resistance values and GSR amplitude was examined further in several ways. The regression coefficients computed in the analysis of co-variance revealed that the relationship between basal skin resistance and GSR amplitude was a very slight one, so small that it may safely be ignored in field applications. The range of basal skin resistance in this study was from 10,000 ohms to 140,000 ohms, certainly a very wide range and one probably not exceeded in field applications.

However, since the regression coefficients were based on group data, it seemed possible that an examination of BSR vs GSR relationships in individual subjects might reveal a greater relationship in some subjects than in others. A number of correlational analyses were therefore carried out to examine this possibility. Product-moment correlations between initial resistance levels and GSR amplitude, between GSR amplitude and resistance levels following stimulation, and between initial resistance and resistance following stimulation were computed for individual subjects within and across the four runs, within each stimulus modality (light and sound) and in relation to stimulus intensity. The number of these correlations reaching significant levels did not exceed chance and were normally distributed, with the largest number of values approaching 0. The conclusion that these relationships may be safely ignored in field applications was therefore further strengthened.

The suggestion that we may have employed an incorrect error term in our analyses of variance was discussed intensively with several statistical consultants. They differed among themselves but, after further study, we concluded that it would be disrable to employ analyses for repeated measures. No computer program was available for this form of analysis and our programmer is currently writing such a program. Since it is a complicated one, a considerable amount of time has been devoted to this effort. When the program is available, the data will

be reanalyzed. It appears probable that, like the co-variance analysis, this will not effect the significance of the results already reported in the Annual Report.

4. Academic Performance Correlations

One of the questions included in the design of this study was whether it would be possible to define a relationship between academic performance on the one hand and GSR responsivity, ego strength and various psychological test scales. (It will be recalled that GSR amplitude was not greater during the testing under the presumed stress of anticipating examinations.) Since the only available academic performance criterion was the class rank of the subjects, the medical student subjects and dental student subjects were examined separately in this analysis. The statistic employed was the non-parametric statistic "tau", a "distribution-free" correlation coefficient. Ego strength, the Need Achievement score, the full-score WAIS, the Intellectual Efficiency score from the California Personality Inventory and the Debilitating Anxiety score from the Alpert-Haber Index were correlated with class rank. None of these correlations reached significant levels, not even the WAIS intelligence measure. Mean GSR amplitude was also correlated with class rank and found to be non-significant. None of the analyses thus far, therefore, show a relationship to performance.

5. Scoring and key punching of other physiological variables

As we noted in the Annual Report, the pulse-wave measure for the first run was being scored for 11 parameters on the Oskar-K, a semi-automatic scoring and key punching machine. Since this scoring was extremely time-consuming we decided to score only pulse wave amplitude in the remaining runs. Even this reduced amount of hand-scoring has consumed many hours but it is now complete and key punched. As soon as the program for the analysis of variance for repeated measures is available, that data will be analyzed by analyses parallel to those employed for the GSR analysis.

The EKG data has also been hand-scored and key punched, it too consuming laborious hours. Like the pulse wave amplitude measure, amplitude will be analyzed when the analysis of variance for repeated measures program is available. Hand scoring of finger volume, (the long time-constant A-C coupled measure) is proceeding currently.

6. Numerical definition of level of consciousness

In our Annual Report of September, 1965, we noted that a discriminant function analysis of the EEG data was being carried out on the 33 parameters derived from the period analysis of the electroencephalogram. The initial analysis was one which attempted to discriminate among the various intensities of stimulation and by various levels of consciousness defined by clinical interpretation. The latter were based upon categorizations of data obtained from a previous experiment on sleep deprivation effects. This first effort yielded too few discrete levels. The next

attempt, which extended the permissible limits with each of the 33 period analysis parameters, yielded over 100 discrete levels of consciousness, a number too large to employ in practical applications.

The next step was the exploration of a "tri-modal" criterion. In this approach, the computer was programmed to select the bands of maximal activity in each of the major, intermediate and minor periods and these results were then correlated with clinical interpretation of levels of consciousness.

7. Pilot studies

Pilot work has been carried out preparatory to experiments in three areas. The first of these was a comparison of the data obtained with a commercial polygraph to that obtained with the automatic analysis instrumentation under a simulated interrogation design.

a. Comparison of commercial polygraph to automatic analysis

Introduction: This exploratory study was designed to investigate standard interrogation techniques and to determine to what degree they might be utilized in the study of small group interaction and to what extent they might be enhanced by recent developments in computer analysis. In this study we received the technical assistance and consultation of Mr. Charles Neal, polygraph expert, attached to the Texas Department of Public Safety.

Subjects: Eight male subjects between the ages of 18 and 30 were tested, using both polygraph recordings and concurrent physiological measures of the GSR and EEG which were processed by period analysis techniques.

Instrumentation: The instrumentation used in these preliminary studies was:

1. A Keeler Polygraph

This is a commercially available instrument designed to measure blood pressure, respiration and the galvanic skin response. The blood pressure is obtained by a cuff, inflated at intervals as required by the interrogator and recorded on a built-in pen writer. The GSR is obtained from finger electrodes or palmar electrodes and the respiration from a flexible convoluted tube. These measures are also recorded on the built-in pen writer. The resulting graphs are interpreted by the interrogator.

2. Special purpose analysis

Concurrent recordings were made on all subjects of the GSR and electroencephalogram, both analyzed by special purpose computers and interpreted by technicians trained in this field.

The EEG electrodes were silver/silver-chloride discs 2 sq. cm. in area and applied with electroyte to the left parietal-occipital sites conventional to encephalography. An Offner Dynagraph supplied the write-out and the information was further processed through a special purpose computer for period analysis and its output typewritten on an IBM Selectric typewriter. Friden paper punched tape supplied the means for permanent storage for future computer analysis. The GSR was also recorded on both subject and interrogator during each session and amplified through a Biophysical Research Instruments Amplifier and written out side by side on a pen writer. The information was further processed through GSR analysis to an IBM Selectric typewriter for digital print out and a Friden punched paper tape for further computer processing.

Preparation technique: Each subject, on arrival at the laboratory, was first prepared for the physiological measures. He was then given a glossy picture of an attractive girl, who was conventionally called Mary, and told that he was to kill her with one of the several weapons provided for this purpose. The instructions requested a full emotional investment in the act and real mutilation of the picture. The weapons included:

1. Hammer
2. Knife
3. Rope
4. Tub of water
5. Ice pick
6. Wire
7. Scissors
8. Gun

The "murder" weapons varied randomly throughout the series.

A fictitious story, maintained for all subjects, was invented to give reasonable purpose for the "slaying". The subject was then left alone to commit the deed and then taken to the subject room where he was attached to the polygraph and the analysis system and the interrogator began the inquiry.

The inquiry: Preliminary to the inquiry, the subjects were instructed to answer all questions about the "murder" with a denial. The interrogator then proceeded to ask such questions as:

"Did you cut Mary with a knife?"
"Did you choke Mary with a rope?"

Questioning continued until all available weapons had been mentioned. These questions were always put in the same order. After the session the interrogator would unplug his connection and retire from the subject room to confer with other technicians on the results and interpretation. He would then return and reconnect his own GSR and a second session would commence.

Two or three such interrogation sessions were made on each subject depending upon the degree of confidence the interrogator had for his assessment. In some cases a reward was offered to the subject if he succeeded in deceiving his interrogator.

Later in the study the "sentence" type inquiry was abandoned for a "single word" inquiry in which the weapons were mentioned by name in a sequential order. If the order was changed the subject was informed beforehand.

Results: Several problems were defined which will need to be taken into account in the design of an experiment in this area. One of these was a problem relating to the instrumentation. The resistances of the commercial polygraph, on the one hand, and period analysis instrumentation on the other, diverged to such a degree that there was frequent obliteration of the commercial polygraph record. Another source of instrumentation artifact arose when the interrogator grounded himself on the polygraph case and elaborate precautions were required to eliminate this.

The interrogator was asked to base his decisions exclusively upon the physiological responses. When he attempted to do so, frequent errors in "detection" resulted. It is evident that great care will be needed in designing experiments in this area in order to separate cues based upon the interrogator's observation of the subject from the information provided by the physiological data itself.

Marked anticipatory responses were encountered in the physiological data. This resulted frequently in the interrogator selecting the "weapon" named immediately prior to the actual weapon selected by the subject.

b. High information stimulus fields

In another pilot exploration, GSR data were obtained in more and more complex stimuli situations. A group of 3 subjects were each isolated in booths in the group observation room and required to give their percepts to Rorschach Ink Blots flashed on the screen. These individual responses will be evaluated according to various scoring systems for Rorschach interpretation, and an attempt made to correlate GSR responsiveness with ego strength barrier score, etc.

Continuing with the second part of the experiment, the 3 subjects entered a still more complex stimuli field when, at the end of their individual Rorschach, they reviewed each Rorschach stimuli and as a group selected one response, attempting to fit their response to a vague category that will earn a reward for the entire group. As this work progresses, video and audio recordings will be made of these interactions, allowing a variety of group-process interpretations to be attempted - not limiting the study to immediate formulations of group process as is accepted in the classical Bayles system.

This pilot run was made for feasibility only - the on-line GSR automatic analysis for 3 traces was not yet available, so that the entire 2 hours 15 minute run has been hand reduced. Audio and video systems required alteration for retaining full impact. The experiment provided an excellent stimulus to GSR responsivity.

After norms for the subjects in the foregoing are established, pilot work on the effect of drugs on the GSR responsivity is planned.

This work is being conducted by Dr. Theodore Greiner, whose participation in this phase of the research was planned in the original proposal.