I. Summary of Progress

A comprehensive series of runs involving a variety of electrodermal and other physiological measures has been completed on a population of 26 subjects under a variety of task conditions and contrived psychological "sets" to assess the relative sensitivity and reliability of various electrodermal measures, including the recovery limb time constant. Assessment of impulsivity and anxiety by psychological tests as well as a psychomotor test of inhibition have been obtained on the subjects. Data analysis is still in progress, but some preliminary conclusions have already been drawn and are reported here as an interim progress note. Runs on a separate population of twenty subjects under a different set of stimulus conditions have been used to examine the dependence of recovery limb time constant upon base conductance level and response amplitude. The initial study of the vascular component in the skin potential response has been completed. Development of the automatic measurement of recovery limb time constant has progressed to the point at which a system is now available, using first derivatives, which overcome many of the difficulties of the earlier approach in which second derivatives were employed. The new system has been used to print out the time constants for 22 subjects whose data had been stored on magnetic tape. These data are now being subjected to statistical evaluation.

II. Study of Characteristics of Recovery Limb in Relation to Other Electrodermal Measures

a. Dependence of Recovery Limb Time Constant on Base Level.

To determine whether the apparent relation of recovery limb to nature of the stimulus condition was to be explained by differences in base resistance level, comparisons were made between base level and recovery limb time constant for 21 subjects in two conditions, each of which caused activation and consequent decrease in base resistance, but with different degrees of goal oriented task demands.

Means for the two situations were as follows:

Condition	Backward Counting (by sevens)	Cold Pressor
Average time constant		
(scale units)	17.1	21.7
Average base resistance		
level	29.5 K	27.6 K

These data indicate that despite the fact that the cold pressor task was, if anything, slightly more activating (difference in level not statistically significant) the time constants were significantly different ($p < .01$, paired comparison), the difference is therefore not attributable to difference in base level.

It is to be expected, however, that subjects who show greater activation for performance of a task might show a reflection of this mobilization both in base level and in recovery limb time constant. Accordingly the correlation between base conductance and time constant was determined for this same group of subjects during the backward counting task, and it showed a significant relationship ($r = -.49$, $p < .05$). For the cold pressor situation where the activation is presumed to be of a different quality, the correlation was considerably less ($r = -.23$, N.S.)

b. Dependence of Recovery Limb Time Constant on Response Amplitude

Although the time constant of an exponential decay should, if properly measured, be independent of amplitude of the curve, there are many conceivable reasons for suspecting that such may not be the case for the electrodermal response. Accordingly for each of 12 subjects, time constants were compared with peak amplitudes (conductance change) for 30 sequential responses taken across four experimental conditions (rest, perceptual task, cognitive task, perceptual-motor task). The Pearson's correlations are shown below:

Subject	Pearson's r	Subjects	Pearson's r
1	.29	7	-.04
2	-.29	8	.14
3	-.06	9	-.04
4	.43	10	.03
5	-.25	11	-.06
6	.15	12	.00

The independence of these two measures is well demonstrated. Some negative correlations might be expected because demanding tasks could produce higher responses and also, because of the nature of the activation, shorter time constants. For most of these subjects, however, such was clearly not the case.

c. Dependence of Recovery Limb Time Constant on Quality of Task

A study was undertaken to answer two questions.

1) Does the recovery limb vary as a function of the perceptual, cognitive,

or motor aspects of a task.

2) If it does so, how does its specificity and sensitivity compare with those of more conventional methods.

A. Method

Twenty-six subjects were used in an experiment in which three tasks were performed, along with associated rest periods. In order to exclude the variance known to be due to the operator's mode of instruction and his relation to the subject, the tasks were programmed on video tape.

1. Cognitive

Each of a series of 12 Ravens Matrices Problems was presented for 30 seconds followed by a 15 second rest period. The subject was to choose the pattern which properly completed the matrix and was to report only after the given problem disappeared from the screen. Responses were chosen only from the period in which he was solving the problem. Obviously, contaminants such as visual perception, frustration, etc., were present, but it was hoped that the group result as a whole would be heavily weighted by the cognitive performance factor.

2. Perceptual

A fixed pattern remained on the screen for three minutes. At random intervals during this period, it would disappear, momentarily (40 msec) and for a total of 18 times. The subject was to continuously observe the pattern and after the end of this task, upon command, report the number of disappearances. All useable responses during the observation period were analyzed.

3. Reaction Time

A series of five reaction time trials was used, each having a warning signal and a 10 second foreperiod. Measures were taken at the time of the reaction key press.

4. Other Measures

a) Behavioral. In addition to the above, two psychological tests were administered to these subjects, the Barrett Impulsivity Scale and the Spielberger Trait Anxiety Scale. A behavioral test of motor inhibition task was also administered. In this task, ~~devised by this investigator,~~ the subject is told to turn a knob through 180 degrees, continuously, but as slowly as he can. Inhibition is assessed by the total time taken and by the degree to which rate is accelerated as the task progresses.

b) Physiological. In addition to the skin conductance measure, skin potential, cardiotachometer recording, respiration (mechanical pneumograph only) and frank perspiration were measured. The last measure was obtained by a modification of the photoelectric prism method previously described. The device has been improved to eliminate vasomotor artifacts and to allow use of a lightweight unit secured to the finger tip.

5.

During ~~the above runs,~~ tests were run on 24 of the subjects to determine the sensitivity of the recovery limb time constant for detecting subtle changes of emotional set. test was adopted for this purpose and was used under three different demand situations. The use of video tape was again helpful in reducing differences in operator effect. The subject was presented four letters and asked to choose one and write it down, to be turned in after the task was over. He was then presented a screen in which these four letters appeared in a new order, the group being preceded by three other letters and followed by three more. An arrow appeared and pointed to the first letter where it paused for 15 seconds. It then moved on to the next in the sequence and again paused for 15 seconds, etc. The subject knew in advance that this would happen in regular sequence. In the first such test, the subject was to simply observe this sequence without any verbal report. In the second test, the identical sequence

In a third series run on 13 of these 24 subjects, the subject was told that he would earn an extra dollar if he managed to successfully

An entirely new series and new

were used. At the end of the previous two tests he had been told the operator's conclusion as to which of the letters was

This time his "set" had been altered by his knowledge of the operator's previous success and by the added incentive

Again he was to respond "no" to each letter.

B. Results to Date

Analysis of these data is still in process, but some early results may be presented. Follow-up progress reports will be made as calculations are completed.

1. Data Handling

The tapes were made primarily so that analysis of these records could be made after further development of electronic techniques for calculation of the time constant. This development went on as a parallel effort during completion of the above series of runs and has since been completed. The tapes have been run off and the printed out by use of first derivative processing. Means and standard deviations of responses for each subject under each task condition are being calculated in preparation for t-tests of differences between conditions. To date calculations on 12 of the 26 subjects have been completed.

2. Comparison Between Conditions

No comparisons across subjects can be made until all means and standard deviations have been calculated, but intra-individual comparisons between tasks have been made for those subjects completed. Of 32 possible comparisons, only 3 reached significance; 5 approached significance. In 10 of the 11 subjects who showed reaction time responses, the time constant for this task was the shortest of the three tasks. No consistent difference appears between the cognitive and perceptual tasks for that part of the population completed.

3.

Using the the operator correctly identified the concealed letter in the first series for 18 of the 24 subjects. Moreover, when the subject was motivated to by monetary reward, the operator identified it correctly in 10 of the 13 cases. In 5 instances, the operator had failed to identify the letter in the first series, but when monetary reward was added he correctly identified the new letter for 4 of these 5 subjects. The comparison of

It is noteworthy that in some instances in which skin conductance activity gave ambiguous results, the optical sweat recording showed a dramatic differentiation.

4. Psychological and Psychomotor Tests

These tests will later be used as a basis for sorting the population into different types of physiological responders. To date, the individual impulsivity ratings on the Barrett Scale have been compared with the time taken for 180 degree knob rotation. The correlation was unpredictably a positive one for the 26 subjects ($r = .37$, $p < .05$), i.e., individuals judged more impulsive by the Barrett Scale took longer to rotate the knob, indicating that the type of inhibition measured by the two tasks is different. The Barrett Scale was also demonstrated to give ratings which were independent of the Spielberger Anxiety ratings. Later calculations will examine the interaction of these scale ratings and physiological findings.

III. Study of a Possible Vascular Component in the Skin Potential Response

This study, involving the effect of arteriol or venous cuffs upon skin potential, has been completed on a total population of 24 subjects. Results are highly significant and show that the shift in potential can be more easily demonstrated upon deflation than upon inflation of the cuff, and that the polarity of this post-deflation response differs according to the type of pressure cuff used. For venous (engorging) cuffs ($p = 60$ mm Hg) the response positive. For arteriol (occlusive) cuffs ($p = 180$ mm Hg) the post-deflation response is negative. The conclusion that these represent vasomotor adjustments is supported by a follow-up pilot study on the local potential responses reported earlier. It had been concluded that the slow component of this positive response to stretch is of vascular origin. If so, it should be demonstrable even when the epidermis is penetrated. Microelectrodes were pushed through the epidermis until the negative potential fell precipitously indicating penetration of the dermis. After allowing time for stabilization, increase of pressure on the electrode causes a potential variation. These experiments must be refined to eliminate the possibility of the "responses" being only a reflection of variations in tip potential or sweat gland activity. If valid they will offer strong support for a vascular component in the skin potential response.

IV. Development of Automatic System

Comparison of values for recovery limb time constant obtained by template matching with those obtained by the use of first derivatives indicated the interchangeability of these two methods. The principle involved in the first derivative method is that the absolute steepness of the recovery limb is a measure of its time constant for responses of equal amplitude. Responses of higher amplitude having the same time constant will have a greater absolute steepness to the recovery limb. Hence the absolute slope of the recovery limb can be used as a measure of time constant if a correction for amplitude is made. In practice the simplest correction is to divide the amplitude of the peak slope (first derivative) of the ascending limb by that of the recovery limb. This ratio, plotted against the template readings, gives a good linear relationship.

To accomplish this electronically, the derivatives are obtained by R-C differentiation and the output stored on capacitors with diode input so that peak values are obtained. Gating circuits are used to allow computation only after both peaks have been stored and only if the time elapsing between successive waves is long enough to allow the recovery limb to reach its peak. If the contingencies are met, a command signal feeds the two stored voltages into two voltage to frequency converters, and from there to a counter having an input for obtaining the ratio of two frequencies. The output is printed out upon command and the system reset. At the same time as the above occurs, the value of the peak first derivative of the ascending limb which is proportional to response amplitude is printed out after measurement by a separate counter. Thus the response amplitude and recovery limb time constant are measured in a single operation. It is presumed, however, that most facilities will not have the luxury of two parallel voltage-to-frequency converters and counters and, therefore, an analog division circuit is being tested. In this system the two voltages to be divided are fed into a diode division circuit and the quotient, as a voltage level is fed into an A-D conversion and printing unit. This circuit is very simple, and as an alternative the output (proportional to time constant) can be written out on an ordinary analog recorder. The system then approaches practical utility.