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ABSTRACT

A study attempted to determine the usefulness of skin resistance and other physiological measures as indicators of a simple cognitive skill such as the immediate recall of digits. Subjects were placed in a sound attenuated chamber and wired for heart rate and skin resistance recordings. The task involved immediate recall of a 10, alternative digit sequence and a two digit alternative sequence. Results indicated no statistically significant relationship between physiological measures of alertness (skin conductance and heart rate) and a simple cognitive task (digit recall). Further experimentation is required to resolve ambiguity of results; in particular, a design is needed in which task difficulty and task duration are systematically varied over several points over a wide range.
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PSYCHOLOGICAL INDICES OF A SIMPLE COGNITIVE TASK

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NAVTRAEQUIPCEN Task No. 7885-23

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PHYSIOLOGICAL INDICES OF A SIMPLE COGNITIVE TASK. FINAL REPORT

ABSTRACT

The purpose of the study was to determine the usefulness of skin resistance and other physiological measures as indicators of a simple cognitive ability such as the immediate recall of digits. Subjects were placed in a sound attenuated chamber and wired for heart rate and skin resistance recordings. The task involved immediate recall of a 10 alternative digit sequence and a two digit alternative sequence. Results indicated no statistically significant relationship between physiological measures of alertness (skin conductance and heart rate) and a simple cognitive task (digit recall). Further experimentation is required to resolve ambiguity of results; in particular, a design is needed in which task difficulty and task duration are systematically varied over several points over a wide range.

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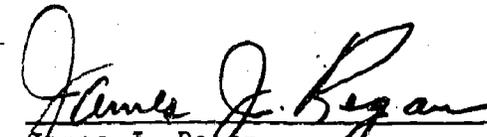
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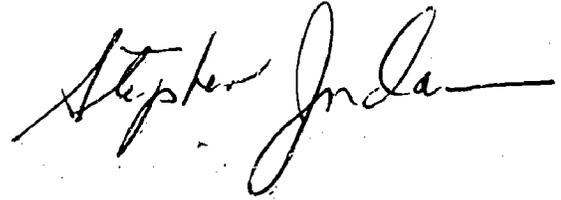
Dr. H. H. WOLFF
Technical Director

FOREWORD

The overall objective of Project 7885-23, Levels of Alertness and Military Proficiency, was to investigate the feasibility of enhancing operator performance by providing the operator with a more sensitive and accurate index than he usually gets on his own capacity to perform complex tasks as revealed by physiological measures.

In this experiment the value of heart rate and skin conductance as indices of performance were investigated experimentally.

STEPHEN JORDAN, Ph.D.
Project Psychologist

A handwritten signature in cursive script that reads "Stephen Jordan". The signature is written in dark ink and is positioned below the typed name and title.

INTRODUCTION

A positive relationship between the reaction time of a human and the resistance of his skin to the flow of electricity (skin resistance) has been well established by psychophysicologists. The purpose of this study is to determine the usefulness of skin resistance and other physiological measures as indicators of simple cognitive ability, such as the immediate recall of digits. In addition to simplicity, this particular task was chosen for study because it is devoid of any obvious motor component which in itself is known to vary with skin resistance.

EXPERIMENT

Method

Subjects. The 20 subjects (Ss) were paid male volunteers from a local university. Their ages varied from 18-27. Ss with suspected or actual heart or hearing impairments were excluded. Each S was tested for one one-hour session.

Experimental Design

Instructions. The Ss sat in a comfortable recliner in a sound attenuated chamber, and were given the following instructions through an intercom: "Right after I say, ready, I will read a list of numbers which you will repeat to me as soon as I finish reading them. A new list of numbers will be read every 30 seconds. Any questions?"

Procedure

Prior to entry into the sound attenuated chamber each subject was wired for heart rate and skin resistance recordings. Heart signals, which were fed to an Offner A. C. Coupler, type 9806A, were sensed with a pair of Telectrodes filled with Beckman electrode jelly. The Telectrodes were placed at forearm locations. Skin resistance electrodes were clamped to the palm of each hand. These electrodes, which were connected to an Offner Skin Resistance Coupler, Type 9892A, were two cm. diameter zinc plates mounted in plastic cups filled with zinc sulfate paste. After the Ss was comfortably seated in the sound attenuated chamber, and the electrodes were connected to the Offner-type R Dynagraph, the equipment was adjusted to obtain satisfactory readings.

For one-half of the test population the digit recall task began with 60 trials of a 10 alternative digit sequence and ended with 60 trials of a two digit alternative sequence with a five minute rest period between. The order was reversed for the other Ss. In the 10 alternative digit sequence each digit was randomly selected from numbers zero through nine. In the two digit alternative sequence the random selection was from numbers one or two.

The easier two digit alternative digit recall task was included to determine if task difficulty was a relevant factor. The length of the digit sequence given to the S varied as a function of S's performance. If S correctly repeated a given sequence, it was increased by one digit on the next trial. At the start of each block of 60 trials the digit sequence length was set at three. The rate of presentation of the spoken digits was two per second. A new digit sequence was presented every 30 seconds.

Every effort was made to maintain the Ss in monotonous environment. The inside walls of the soundproofed room were without decoration and aside from the digits spoken by the experimenter and S's response, no other communication was encouraged. The length of each block of trials (30 minutes of uninterrupted testing) was designed to produce fatigue and boredom in the subject, i.e., the aim being to produce sizeable changes in physiological responses and perhaps consequently performance decrement. It was thought that if a relationship between performance and physiological measures existed it would be more readily revealed if changes in physiological response were facilitated by the environmental conditions.

RESULTS

To facilitate statistical analysis the experimental data was grouped into thirds as a function of trials. Analysis of variance was performed using the raw scores from heart rate and digit recall performance and the transformed skin resistance scores. The transformation took the form of

$$\frac{1}{\text{skin resistance in K ohms}} \times 1000 = \text{Microsiemens}$$

A statistically significant decrease in skin conductance ($F = 7.2$, $P = < .01$) as a function of test duration is in evidence for the ten alternative digit recall (see figure 1). There is also a statistically significant ($F = 4.9$, $P = < .05$) lowering of heart rate over time for the ten alternative digital recall (see figure 2). Taken together these physiological measures tend to suggest a decrease in S's level of alertness with time in the test situation. The physiological data for the two alternative digit recall shows the same downward trend in skin conductance (see figure 3) and heart rate (see figure 4) but statistical significance is not achieved for either (an $F = 2.1$, $P = > .05$ for skin conductance and an $F = 2.4$, $P = > .05$ for heart rate).

Contrary to expectation the performance on the digit recall tasks do not fall off with time. The slight downward trend for the 10 digit alternative which is depicted in figure 5 is not statistically significant ($F = .23$, $P = > .05$). In addition, no statistically significant performance decrement ($F = 2.1$, $P = > .05$) occurs over time with the two alternative digit recall (see figure 6). Thus in spite of a marked reduction in subject alertness as measured by heart rate and skin conductance, there is not significant fall-off in the number of digits recalled. It is interesting to note that from a subjective viewpoint the subjects did indeed appear extremely fatigued or bored by the end of the session.

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Cognitive ability
Recall tasks
Performance measurements
Alertness

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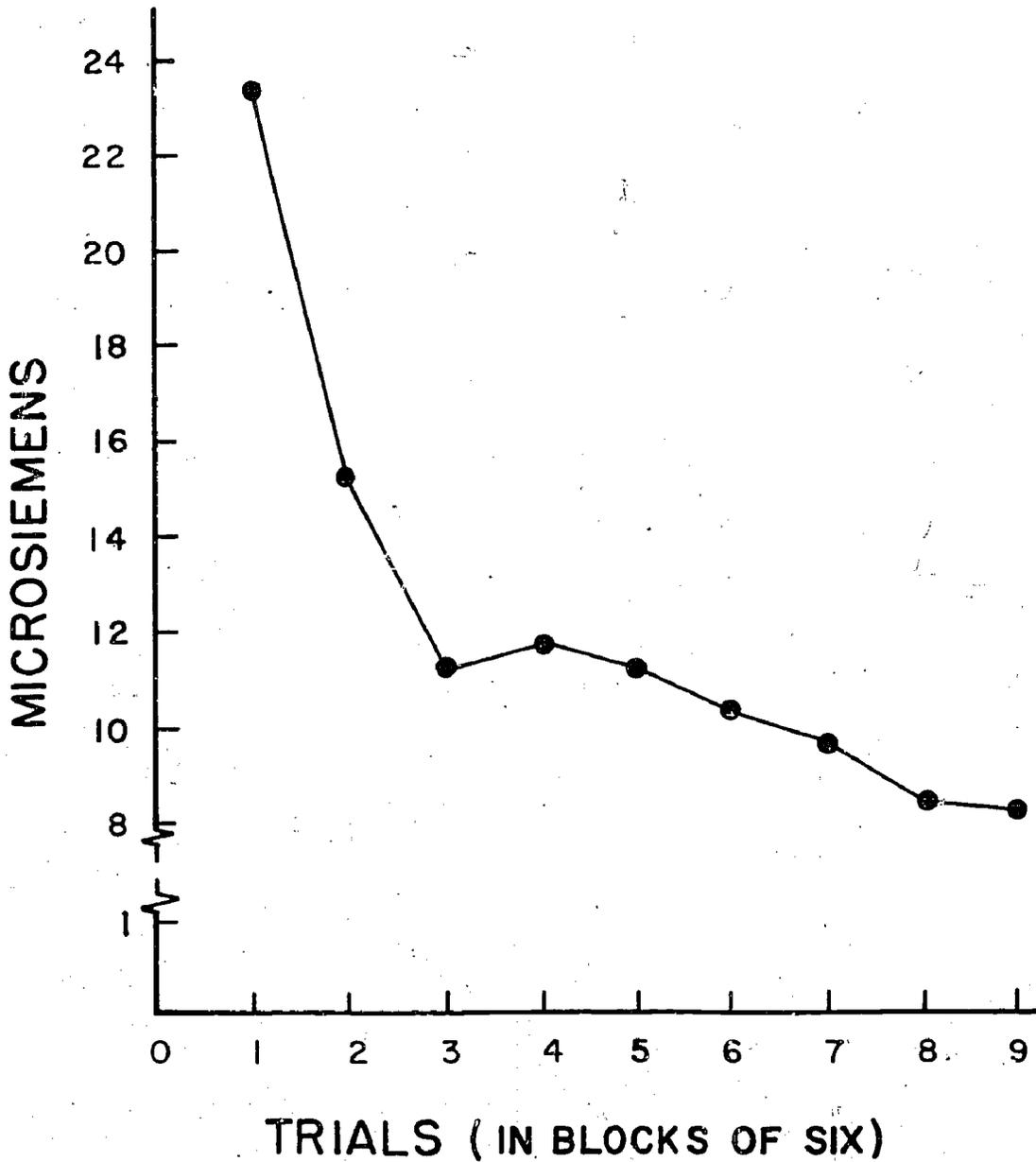


Figure 1. Skin conductance as a function of the number of ten alternative digit recall trials.

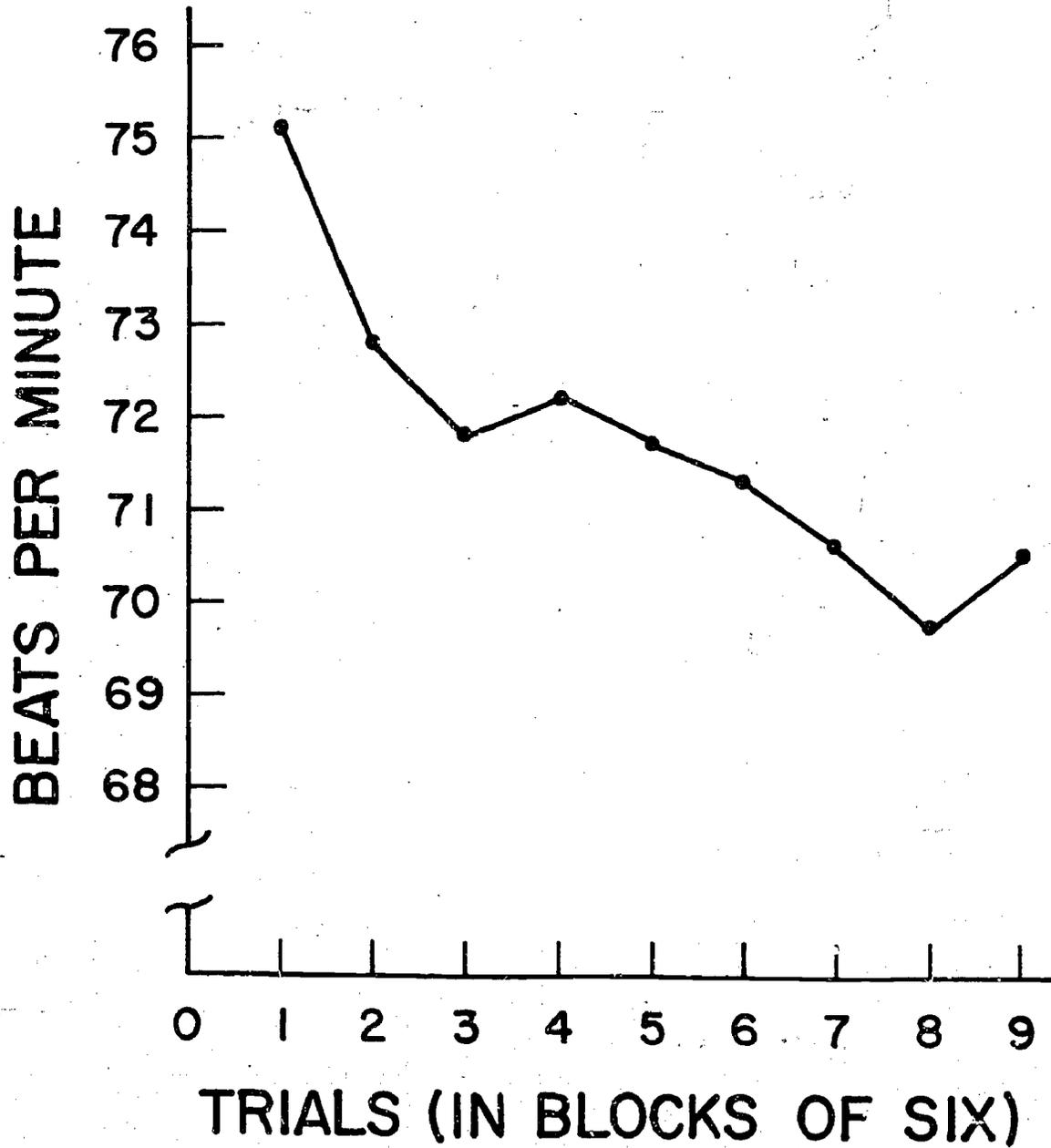


Figure 2. Heart rate as a function of the number of ten alternative digit recall trials.

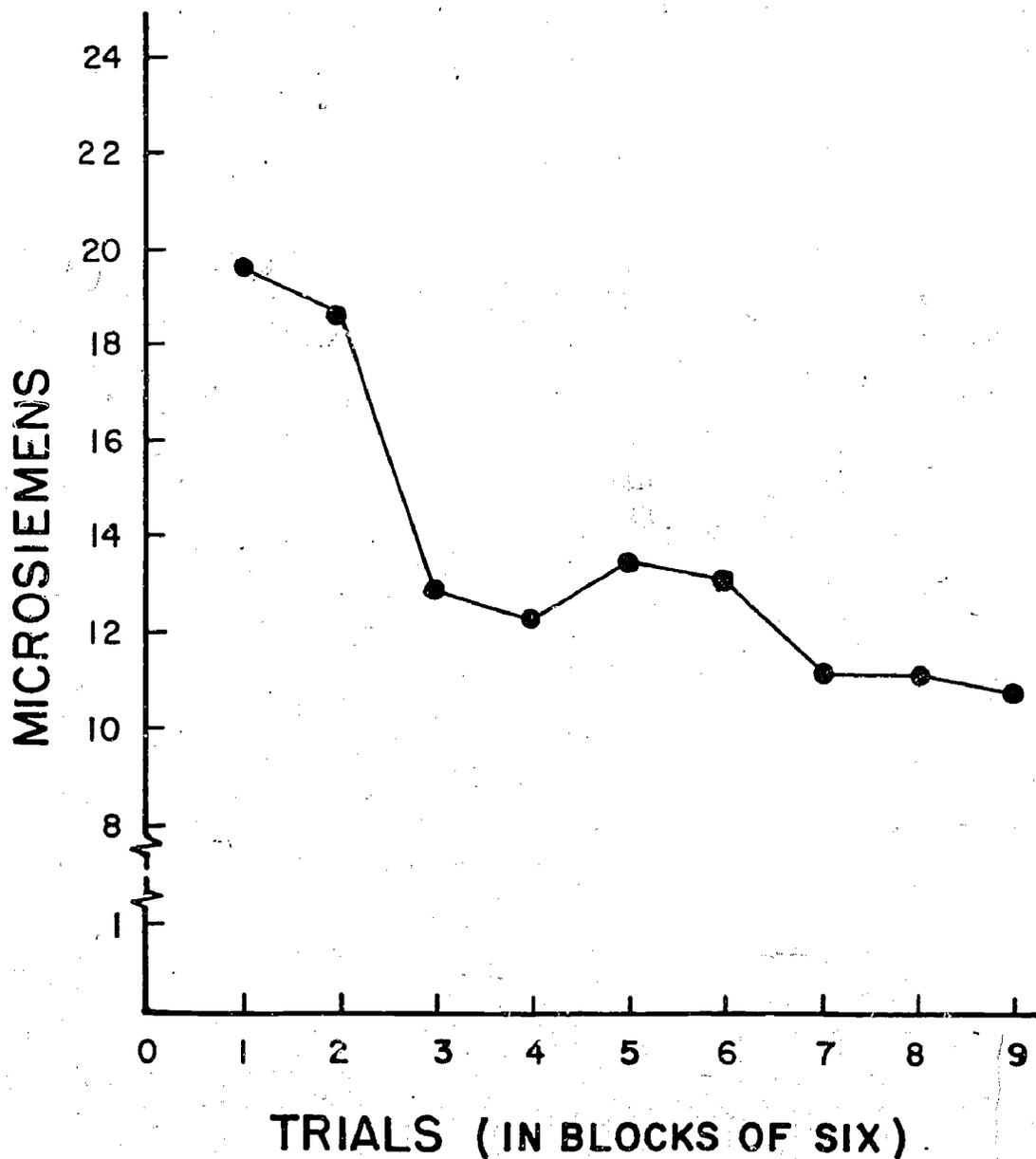


Figure 3. Skin conductance as a function of the number of two alternative digit recall trials.

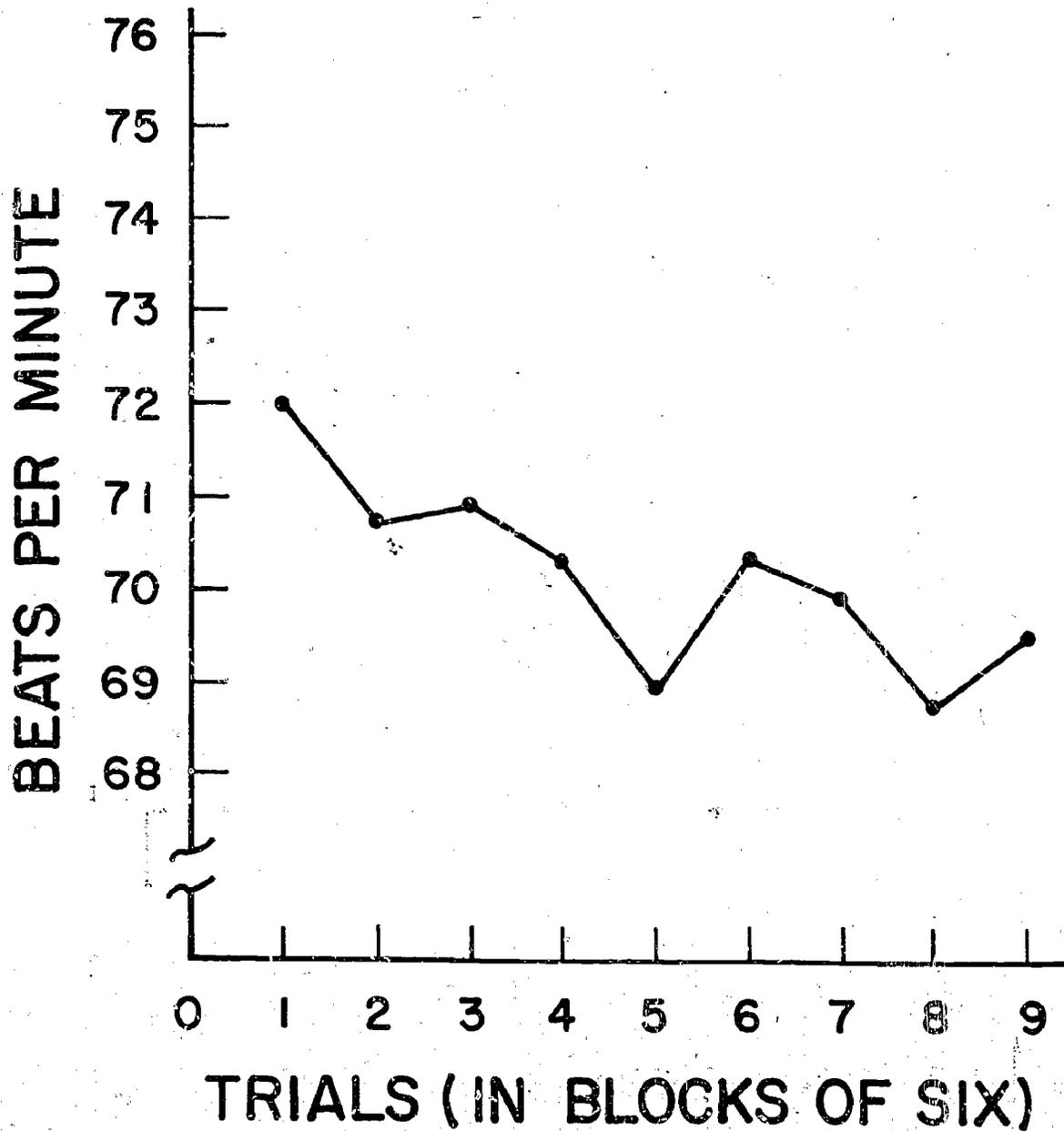


Figure 4. Heart rate as a function of the number of two alternative digit recall trials.

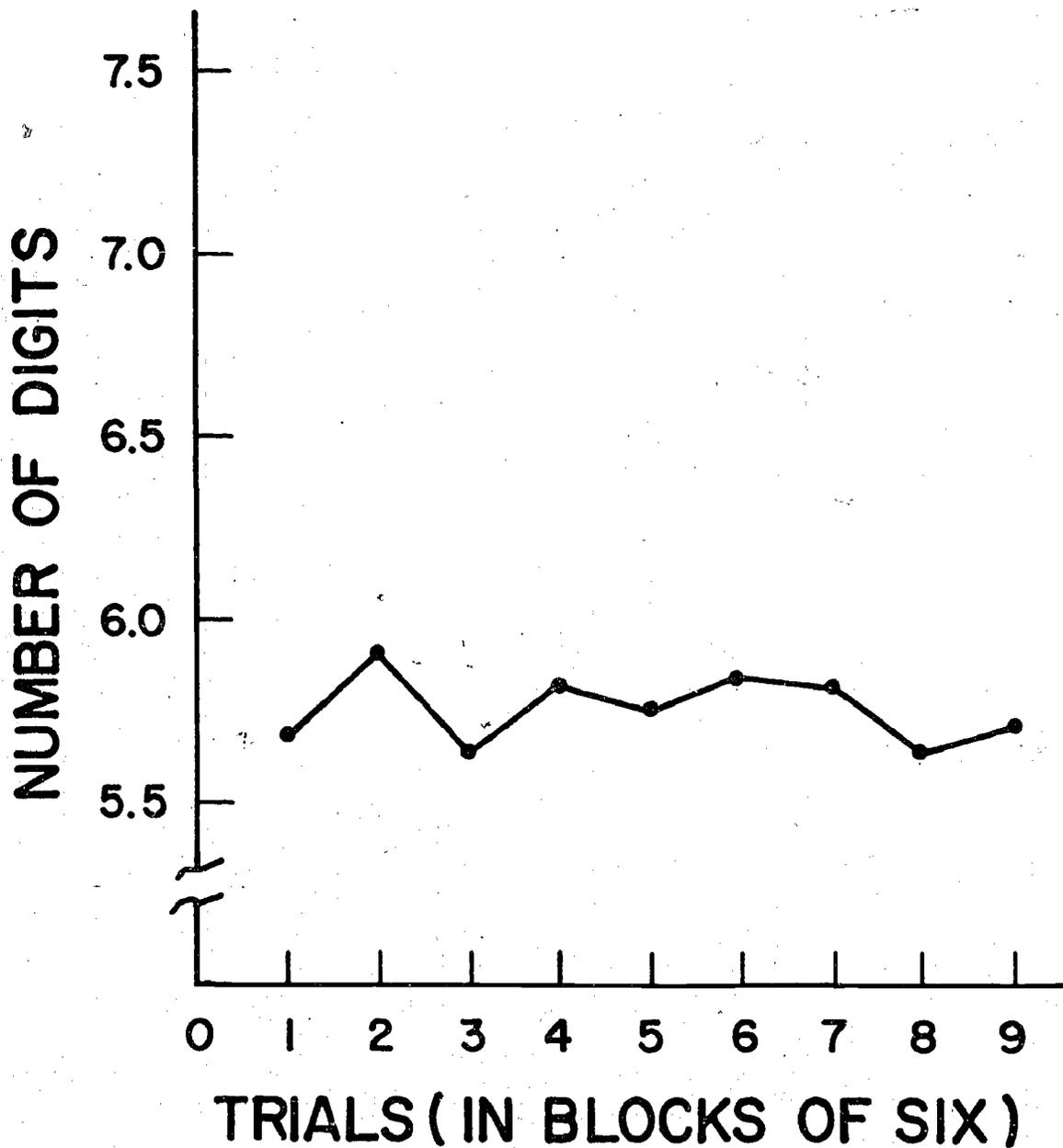


Figure 5. Ten alternative digit recall as a function of the number of trials.

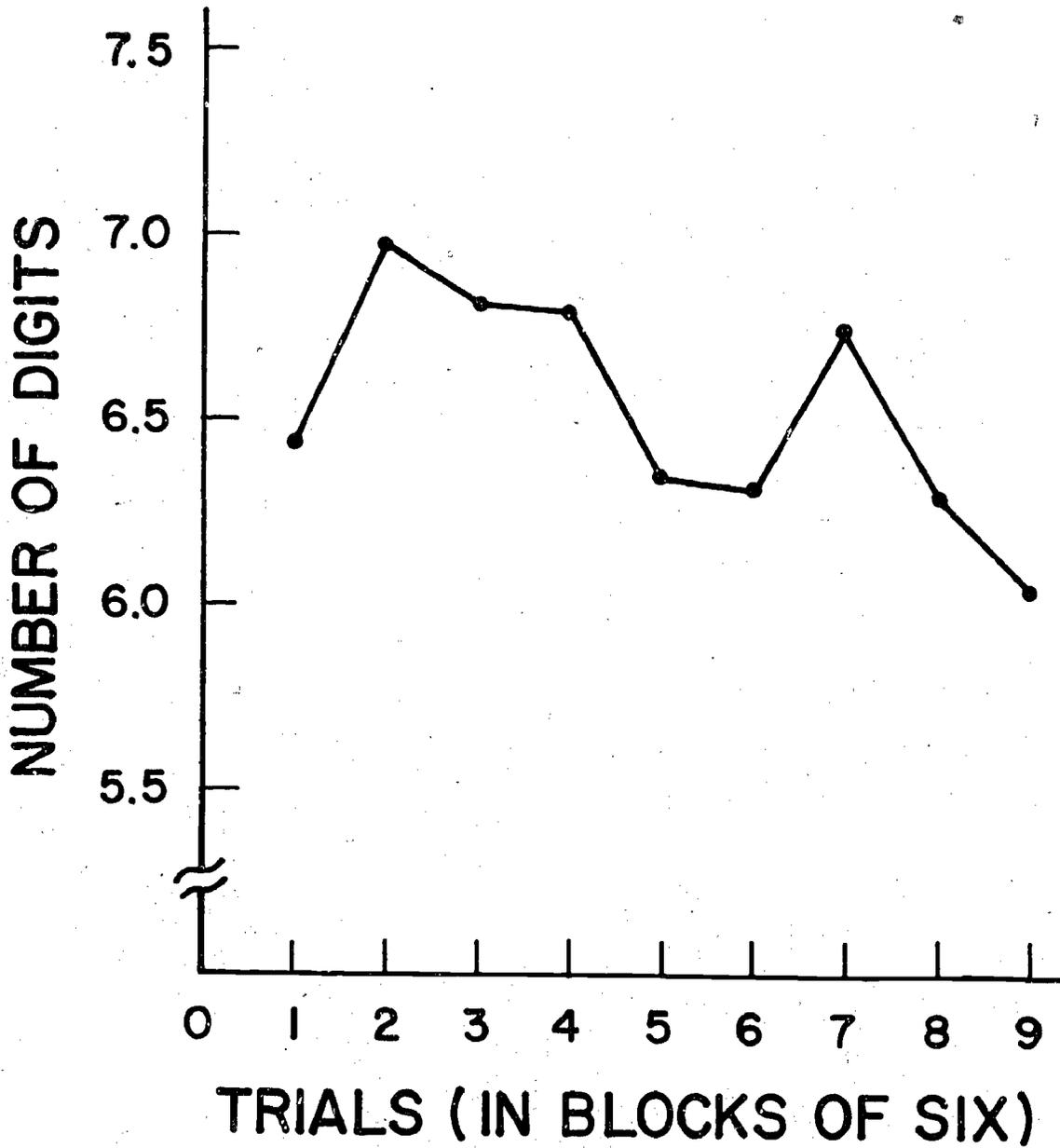


Figure 6. Two alternative digit recall as a function of the number of test trials.

The absence of a relationship between physiological indices of alertness, i.e., skin conductance and heart rate, and a simple recall task such as a digit recall as found in this experiment, does not necessarily mean that they are unrelated. It may be that the Ss were not sufficiently fatigued or bored to fall off in their performance. Perhaps an extreme fatigue state such as is experienced with extended sleep deprivation is required to demonstrably affect the short term store and recall capacity of a human. On the other hand it may be that measures of skin resistance or heart beat are unrelated to the simple cognitive activity under investigation. A third explanation of the result is that simple cognitive functions are unaffected by the level of alertness or awareness of the operation. Wartime stories of radio operators transcribing messages while they were asleep or in a state of semi-consciousness seem to be in line with this interpretation.

Further experimentation is required to resolve the ambiguity which surrounds the present results. In particular, a design is needed in which task difficulty and task duration are systematically varied over several points over a wide range.

SUMMARY

No statistically significant relationship was found between physiological measures of alertness, namely, skin conductance and heart rate, and a simple cognitive task, namely, digit recall.

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13. ABSTRACT

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