DOCUMENT RESUME

ED 051 539	24	CG 006 487

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TITLE	The Identification of Individual Differences in the Strength of the Nervous System. Report from the Project on Motivation and Individual Differences in Learning and Retention.
INSTITUTION	Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
REPORT NO	TR-162
BUREAU NO	BR-5-0216
PUB DATE	Apr 71
CONTRACT	OEC-5-10-154
NOTE	27p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Arousal Patterns, Auditory Discrimination, *Aural Stimuli, *Sensory Experience, Stimuli, *Stimulus Behavior, *Stress Variables, Visual Discrimination, *Visual Stimuli

ABSTRACT

This study investigates the hypotheses set forth by Russian researchers that there may be identified a pervasive characteristic of the central nervous system labeled as "strength". Ten of the 12 measures used were direct replications of representative strength measures derived from the Russian work. Two additional measures were included to test the possible relationship between strength and "arousal". Thirty-three graduate students were measured for Absolute Visual Threshold, Auditory Threshold, 2-Flash Threshold and Reaction Time, with the remaining variables derived by systematically varying experimental conditions. A factor analysis provided no clear-cut support for a dimension of strength although a number of less pervasive factors were obtained. The discussion centers around methodological issues and an apparent dimension of arousal. (Author/TL)

THE IDENTIFICATION OF INDIVIDUAL DIFFERENCES IN THE STRENGTH OF THE NERVOUS SYSTEM

CENTER FOR
COGNITIVE LEARNING

ED051539

Technical Report No. 162

THE IDENTIFICATION OF INDIVIDUAL DIFFERENCES IN STRENGTH OF THE NERVOUS SYSTEM

By Herbert H. Severson and Frank H. Farley

Report from the Project on Motivation and Individual Differences in Learning and Retention

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Madison, Wisconsin

April 1971

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the Office of Education and no official endorsement by the Office of Education should be inferred.

Center No. C-03 / Contract OE 5-10-154

STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Motivation and Individual Differences in Learning and Retention Project from Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Learning and Memory Project has the long-term goal of developing a theory of individual differences and motivation. The intermediate objective is to generate new knowledge of the learning and memory processes, particularly their developmental relationship to individual differences and to motivation.

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ABSTRACT

This study attempted to investigate the hypotheses set forth by Russian researchers that there may be identified a pervasive characteristic of the central nervous system labeled as "strength." Ten of the 12 measures used in the study were direct replications of representative strength measures derived from the Russian work. Two additional measures were included to test the possible relationship between strength and "arousal."

The study employed 33 graduate students as *Ss*. The measures used included Absolute Visual Threshold, Auditory Threshold, 2-Flash Threshold, and Reaction Time, with the remaining variables derived by systematically varying experimental conditions.

A factor analysis provided no clear-cut support for a dimension of strength although a number of less pervasive factors were obtained. Discriminate function and regression analyses supported this general conclusion. The discussion centered around methodological issues and an apparent dimension of arousal.

I

INTRODUCTION

Research on individual differences (IDs) by Russian psychologists has differed in some major respects from the approach undertaken by most Western investigators. The latter have typically been concerned with such ID variables as intelligence, ability, and personality. These variables have usually been measured through more or less standard psychometric procedures such as paper-and-pencil tests, self-report inventories, and projective techniques. Occasionally objective behavioral or apparatus measures are taken or physiological indices recorded. The paper-and-pencil paradigm predominates, however, with scores on these tests usually being correlated with scores on other tests, or with measures of learning, perception, and so on. Where human learning is concerned, to consider one specific area of research, distinctions have been made between extrinsic and intrinsic IDs (Jensen, 1967). The former were considered to be sources of ID variance external to the learning process or those subject variables which operationally bear no resemblance to the learning process as we generally think of it. This classification in which subject attitudes and personality characteristics are found may influence an individual's performance on a learning task. Intrinsic IDs were seen as sources of ID variance internal or intrinsic to the learning process. These IDs were inherent in learning and did not exist independent of the learning phenomenon. This consisted of intersubject variability in the learning process itself. Examples of intrinsic IDs were a subject's susceptibility to interference in proactive and retroactive interference paradigms. In both cases, IDs are considered to contribute to learning.

Jensen stated that in his review of more than 40 factor analytic studies of IDs in learning he had found little that would provide even a rough outline for a taxonomy of IDs (Jensen, 1967). One approach to clarifying the situation was his aforementioned dichotomy of extrinsic-intrinsic IDs. Related to this is his distinction between the phenotypes and genotypes of learning. Phenotypes were described in terms of task characteristics or the location of a learning task in Jensen's 3-dimensional cube which he used to graphically illustrate classes of variables in a learning situation. The three dimensions or classes of variables used by Jensen were (1) Types of learning (rote learning, motor learning, etc.), (2) Procedures (pacing, distribution of practice, etc.), and (3) Content and Modality (verbal, numerical, etc.). The genotypes are the underlying factors or basic processes which cause the patterns of intercorrelations among the phenotypes.

Jensen, following his belief that the largest source of variance in learning is connected with procedural variables, hypothesized that by systematically including this variance in factor analyses of learning data, one would discover the most basic and pervasive genotypes of IDs (Jensen, 1967). An earlier study found what appeared to be a common genotype underlying memory span, serial rote learning, and performance on the Stroop color-word test, particularly the speed at which a subject could read the names of the colors (Jensen, 1964). Zeaman and Kaufman (1955) also did a similar study of IDs using a motor learning task. The study was carried out along Hullian lines with genotypes for habit, strength, drive, reactive and conditioned inhibition, and so on.

The Russian researchers, following the impetus of Pavlov, have drawn a similar dichotomy, and although the labels differ, the parallel is striking. A paper by Kupalov (1954, pp. 5–6) pointed out that the concept "an animal's type of nervous system" can be interpreted in two ways: From the constitutional point of view, a type is a specific complex of the basic properties of the nervous processes, excitatory and inhibitory. Seen at the level of higher nervous activity, a type is a characteristic pattern of an animal's behavior. The word "type," then, is used in the literature on higher nervous activity in two senses: (1) type as a characteristic pattern of animal or human behavior; (2) type as a complex of the basic properties of the nervous system. According to Gray (1964) "a failure to distinguish between these senses confuses the types of higher nervous activity in a way which is particularly harmful to the psychology, as well as the physiology, of human higher nervous activity" [p. 3]. Unfortunately, in the works of a number of physiologists this distinction has not been made. Kupalov, cited earlier, has made a valuable contribution in pointing out the need for a clear distinction between the two senses of the word "type."

In the theory of arousal and human higher nervous activity the expressions "type of nervous system" and "type of higher nervous activity" as scientific terms can, for the present, have only the second of the two meanings cited above. Pavlov dealt with this problem by defining these terms as "these or other complexes of the basic properties of the nervous system" (1955).

Pavlov considered that there are three such basic properties of strength, mobility, and equilibrium, each of which are composed of two opposing processes, excitation-inhibition. His personality theory held that nervous system activity and, hence, personality varies along these dimensions.

The relationship between Jensen's extrinsic and intrinsic IDs, or the phenotype and genotype, as well as between the two "types" discussed above, is not a simple one. On the one hand, it is possible that some specific complex of properties of the nervous system may be reflected in certain typical patterns of behavior such as psychiatric diagnostic classifications of personality. On the other hand, it may be that in order to make a scientific analysis of typical behavior patterns we need to study "types" as complexes of properties of the nervous system. Typical patterns of behavior and types as complexes of properties cannot simply be superimposed one on the other. Gray points out that this highly important fact has only gradually become apparent and its full significance for psychology is yet to be realized.

Individual differences between dogs attracted attention from the earliest years of research on conditioned reflexes. These were at first based upon the description of the dog, both in the experimental stand and out; and, only later, did the IDs in salivary-conditioned responses attract attention. In general, the historical development of Pavlovian theory of types of nervous system follows that the determination of type at first was mainly based on the general picture of behavior but there has been a gradual transition from this approach to a reliance on strictly experimental indices of specific properties of the nervous processes (Gray, 1964).

It is important to note that during the earliest period of research on conditioned reflexes, the concept of "type" of dog made its first appearance at the same time as the first hypothesis as to the property of the nervous system, which could serve as a basis for a classification system of type. Teplov (1964) considered that the basis of this principle in Pavlov's doctrine of types tied in the discovery of those properties of the nervous system on which classification of types can be produced. Teplov regarded it as essential therefore, to proceed from "properties" to "types" and not the reverse.

Theoretically, a nervous system could be described by the degree of strength or weakness of the excitatory processes and the inhibitory processes. It could also have a mobile or inert excitatory process and mobile or inert inhibitory process, as well as a state of equilibrium between excitatory and inhibitory processes, or disequilibrium with predominance of inhibition. Pavlov's work on "personality" was restricted to dogs but since Pavlov's time a major body of personality research on humans has developed which has been directly relevant to the notion of "strength" of nervous activity.

Teplov represents a major Russian approach to the study of IDs of the properties of higher nervous system activity. He has attempted to study the three Pavlovian dimensions of "strength," "equilibrium" and "balance" of cortical excitation-inhibition in human subjects through the measurement of sensory and intersensory phenomena such as absolute visual threshold (AVT), the effect on AVT of repeated peripheral stimulation, the effect on AVT of repeated high intensity stimulation, the effect on absolute auditory threshold (AAT) of visual stimulation, and so on.

Working at the Institute of Psychology in Moscow, Teplov has, with his students, advanced a body of data and theory supposedly substantiating a dimension of strength and in a preliminary fashion has attempted to relate this dimension to learning and problem-solving. Teplov's experiments have suggested that strength is a major dimension along which individuals vary. However, he diverges from Pavlov's notion of strength which referred to the strength of both the excitatory process and the inhibitory process, by concerning himself with the strength of the excitatory process only. "Strength of the excitatory process" was originally defined by Pavlov (1955) as the "working capacity of the cerebral cells." Without going into the details of Teplov's own theorizing here, we might note his (Teplov, 1959) reference to "working capacity," and hence strength, as "the capacity to endure stimulation which is extreme in its *duration* and *intensity*." Strength is operationally defined by various "thresholds" which measure the "limit of working capacity." It may be generally stated from Teplov's theory that with any threshold of neural activity which is reached by increasing the intensity of stimulation, the weaker the nervous system, the lower the stimulus intensity at which this threshold is reached. Two "thresholds" with which Teplov has worked extensively are the so-called "threshold of transmarginal inhibition," and the absolute sensory threshold (visual and auditory). The first of these is based on classical conditioning studies showing that the magnitude of a conditioned reflex increases with the intensity of the conditioned stimulus up to a limiting value of this intensity (the "threshold of transmarginal inhibition") beyond which further increases in stimulus intensity lead to a decrease in the magnitude of the conditioned response [due theoretically to the action of "transmarginal" or "protective" inhibition which is thought to protect the cell from possible damage in the event of continued response to stimulation]. The greater the stimulus intensity at which the magnitude of the conditioned response begins to diminish, i.e., the higher the "threshold of transmarginal inhibition," the greater is the "working capacity" and therefore the strength of the nervous system. Teplov has conducted a number of studies into transmarginal inhibition, using primarily a conditioned photochemical reflex in which the unconditioned response is a decrease in visual sensitivity produced by brief exposure to an intense light source. An auditory stimulus, if immediately coupled with exposure to the light, may come to evoke a conditioned rise in threshold. Teplov claims that all standard classical conditioning phenomena can be demonstrated with this method.

The second threshold referred to above as the absolute sensory threshold is studied on the basis of Pavlov's notion that the working capacity of the cortical cell is thought to be a function of the ease and speed with which a hypothetical "excitatory substance" present in the cells is functionally destroyed during the process of excitation. The more easily and rapidly it is destroyed, the lower the working capacity; that is, the weaker the nervous system. Equally, the more easily and rapidly it is destroyed, the more sensitive or reactive the nervous system is to stimulation. From the foregoing considerations one might predict a negative correlation between strength and sensitivity, and indeed, Teplov has confirmed this prediction using as measures of sensitivity the absolute visual and auditory thresholds. The strong nervous system would then have a high threshold and the weak nervous system would be indicated by a low threshold, since sensitivity is the inverse of the threshold. The dimensions of strength and sensitivity may therefore be united in the single dimension of "reactivity"; one end of this dimension is strength plus low sensitivity, the other is weakness plus high sensitivity.

Teplov and his associates have, until recently, approached the confirmation of the strength dimension by using measures which differentiate between extreme groups as defined by some known criterion. In addition to the above, they have tried to employ a number of other measures of the strength dimension and in doing so recognized that this is a problem most satisfactorily handled by factor analysis of a large number of measures. Two such studies have appeared, and they represent some of the very few Russian reports to have employed factor analysis as a statistical method.

The first and most comprehensive factor analysis was that done by Rozhdestvenskaya, *et al.* (1960), which detailed a Thurstone-type factor analysis of 21 putative measures of strength, using 38 subjects. Following rotation it was found that the factor accounting for the greatest proportion of the variance was a well-defined factor of "strength." Thirteen measures had loadings of .40 or greater on this factor. Five variables had loadings of .70 or greater. The single variable with the highest loading was absolute visual threshold, which would seem on the basis of this analysis to constitute the best measure of strength. The Rozhdestvenskaya, *et al.*, study is one of the most important yet reported on the dimension of strength. It demonstrated that such a dimension could be established on the basis of the various measures of strength, each of which had been developed independently.

A second factor analysis is that of Nebylitsyn (1963) in which the principle concern was finding intercorrelated measures of equilibrium and the relationship of these measures to measures of strength. Most of the measures of equilibrium were derived from Pavlov's theory that subjects with predominant excitatory processes condition quickly but extinguish slowly and have difficulty in not responding to the negative stimulus in discrimination learning situations (Lynn, 1966). The study had an N of 22 subjects. This factor analysis is important to the present study only to the extent that it indicated the equilibrium and strength dimensions to be substantially independent (Lynn, 1966).

The present account is insufficient to communicate fully the very extensive and ingenious research that has been accomplished in Teplov's laboratory on the dimension of strength of the nervous system. The careful working-out of the measures of strength and the subsequent clearly defined factor of strength in the Rozhdestvenskaya, *et al.* factor analysis represents major contributions to the study of individual differences. Some of the physiological implications of the Pavlovian theory on which the dimension of strength is based would be unacceptable to many Western investigators but if the theory of strength is viewed purely as a behavioral theory, and evaluated on the basis of the behavioral operations and data, then the dimension of strength remains an intriguing one. Since identifying consistent individual differences in "strength" across the wide variety of tasks and procedures he has employed, Teplov has tried to identify the broad psychological characteristics that are associated with this dimension. Strength is said to go together with ability to withstand prolonged tension and to recover quickly from fatigue, as well as the capacity to handle complex materials perceptually and intellectually. Weakness is said to go together with lack of initiative and perseverance, lack of capacity for intellectual work, and inability to concentrate.

Western research that appears to be related to Teplov's dimension of strength is represented in some studies of physiological arousal or activation (Gray, 1964) and in some of the work of Eysenck on extraverted and introverted patterns of behavior (Eysenck, 1967). Gray (1964) has attempted a reinterpretation of the notion of weak and strong nervous systems in terms of levels of arousal and has suggested that the strange terminology of the Russians may make some degree of sense when so re-interpreted. However, despite Gray's speculations, the research to be reported and that by Mangan (1967) represent the only published attempts by Western researchers working with human *S*s to undertake the study of this, either in terms of its identification or ability to account for learning or problem-solving behavior or its relationship to other personality factors. Additionally, no scientists have attempted to relate the Teplovian notions empirically to current Western conceptions of arousal or activation.

The present research is the first Western attempt at a representative replication of a number of Teplov's measures (Farley, 1967).

The primary objective of the present study was to determine whether a "strength" dimension could be established utilizing tasks reported by the Russians as putative measures of such a dimension. This study attempts to put together, in one experiment, strength measures from a number of Russian reports, including five measures reported in the Rozhdestvenskaya, *et al.*, factor analytic study. Also included in this study were five other measures used by the Russians but not included in the factor analysis. Additionally, two indices of cortical activation were included, bringing the total number of measures included to this study to 12.

The 10 measures replicated from Russian reports are basically measures of visual and auditory threshold under a number of standard conditions. The methodology and statistical treatments used in obtaining these measures is complex and a full description of the measures follows in the Method section. A very brief description of the measures is given here to provide the reader with an idea of how the measures were derived. Briefly, the 10 measures were as follows:

(a) *Absolute Visual Threshold* (AVT)
This measure was taken using a standard adaptometer following a 45-minute dark adaptation period. A modified method of limits was used and presentation was binocular. Factor analysts studied cited earlier showed this measure had the highest loading (.76) on the strength dimension.

(b) *Exhaustion Method* (Visual Threshold)
This method employed a peripheral light source at an angular distance below the primary fixation point of the adaptometer.

This peripheral light could be varied in intensity from 10 to 100 times a subject's threshold. The exhaustion method compared standard AVT before and after a number of repetitious trials in which the peripheral light was at a high intensity. This measure had the second highest loading (.74) in the factor analysis (Rozhdestvenskaya, *et al.*, 1960) on the strength dimension.

(c) & (d) *Shape of Curve Methods #1 & 2*
These are referred to by the Russian reports as Shape of Curve versions of the Induction Method. These methods consisted of plotting the change in AVT as a function of increased intensity of the peripheral light source. The measures were derived by using two distinct values along this intensity continuum as reference points.

(e) *Absolute Auditory Threshold* (AAT)
This measure involved the measurement of auditory threshold using a standard audiometer and a modified method of limits procedure.

(f) & (g) *Brief Condition* and *Long Condition* (Auditory Threshold)
These two methods employed a bright point source light being used as a visual distractor while the subject was being measured for AAT. The light emitted a number of pairs of flashes per second giving the light a pulsation effect. Under the *Brief Condition* the AAT was measured under alternate light (distractor light on) and dark (standard measurement) conditions, with the mean AAT under each condition put into a ratio to each other. The *Long Condition* allowed a comparison between pre- and post-AAT measures with a number of light trials in between.

(h) & (i) *Long Ratio and Brief Ratio* (Auditory Threshold)
These measures are both derived ratio measures which use data obtained in the brief and long conditions of AAT described earlier.

(j) *Reaction Time* (RT)
The last of the ten measures used was reaction time to a light stimulus as a function of the luminance of the visual stimulus. RT to onset of light was measured under partial dark adaptation conditions, [illegible] ind-deadened room. The mea[illegible] was derived from the ratio $\bar{X}$ RT [illegible] brightest light to $\bar{X}$ RT across five other luminance levels.

The two additional threshold measures not employed by the Russians but used in the present study were two measures of *2-Flash Threshold* (TFT). The TFT was defined as the longest interval between two flashes of light at which they are seen by the subject as a single flash. A Photo-Stimulator was used to provide a point source of light to the subject. The first condition for the TFT measurement was full dark adaptation while the second measure was taken under partial dark adaptation.

The five measures replicated from the factor analysis were included because of their high significant loading on what the Russians refer to as the "strength dimension." On the rotated factor matrix the loadings varied from .49 to .76 (Rozhdestvenskaya, *et al.*, 1960). The other criterion for inclusion of a measure in this study was the practicality and feasibility of being able to replicate th measure with equipment that could be obtained. The five additional measures taken from Russian reports but not included in the factor analysis were chosen on the basis of their judged significance to the strength dimension. The four derived measures from the AAT which include the Brief and Long Ratio and the Brief and Long Conditions, were taken from a study by Yermolayeva-Tomina (1964). This study found that weak subjects differed significantly from strong subjects in their reaction to the four AAT conditions. The results of the study basically indicated that the "strong" subjects increased their sensitivity to the main auditory stimulus when the visual distractor was presented while the "weak" subjects showed an opposite effect by decreasing their auditory sensitivity as a function of the distractor. [illegible] measures were then taken as significant and consistent indicators of strength and were included in the present study.

The last of the Russian measures to be included in the study was Reaction Time (RT). This method has been used in Russian studies (Nebylitsyn, 1960a, 1967b, and Vasilev, 1960) as a measure of strength of the nervous system and has been replicated in Western psychology (Mangan, 1967). Nebylitsyn (1960b) points out that while in theory transmarginal inhibition is the most important measure of working capacity it is evidently not the only one. In this case he argues that the point at which RT as a function of stimulus intensity flattens out or the point at which further increases in stimulus luminance do not result in an increase in RT, the speed of response can be referred to as the "limit of working capacity." Nebylitsyn then provides us with an operational definition of working capacity and in doing so he presents yet another method of operationally measuring strength. His results verified that "strong" and "weak" subjects could be accurately and consistently separated on the basis of this procedure.

The 2-Flash Threshold (TFT) indices were included as another threshold measure in order to check on the possibility that the strength dimension may reflect what some Western psychologists would call levels of central nervous system arousal or activation. The TFT is a relatively well-validated index of activation. Evidence that the TFT reflects cortical activation has been provided by Farley (1968) and Venables and Warwick-Evans (1967). Lynn (1966) has suggested further that the strength dimension may be indicative of anxiety with the weak subjects being more anxious or more easily aroused.

II

METHOD

SUBJECTS

The study was done using 33 Ss who were graduate students in Educational Psychology. The $\overline{X}$ age was 25 years with all Ss having normal hearing and vision and with no history of central nervous system disorders. All Ss were asked to not indulge in any alcoholic or high-caffeine beverages 3 hours prior to testing.

APPARATUS AND EQUIPMENT

All apparatus was located in two sound-deadened rooms. The first room in which the visual threshold and related measures were taken was a 6 ft. by 6 ft. room which was partitioned in half to separate the *E* from the *S*. The room's walls were completely covered with matte black cloth and the *S* was further enclosed by a flat black wood shroud that surrounded the *S* as he viewed the face of the adaptometer. The table and all apparatus was painted flat black with only the fixation point of the aperture of the adaptometer visible to the *S*. The NDRC Model III adaptometer was used to measure AVT and related measures. The light source was provided by using a low intensity bulb powered by a 6-volt D.C. power supply. The luminance was varied by a neutral density wedge with a Kodak color filter keeping the color content constant at 540 millimicrons. Located directly beneath the adaptometer was a peripheral light apparatus built specifically for this experiment. The light was provided by a 1.5-watt bulb powered by a 6-volt D.C. power source. Color was taken as constant due to constant current to the light source, with intensity as presented to the *S*, however, being systematically varied by using a combination of Kodak 2 in. x 2 in.Wrattan filters of .2, .4, and 1.0 log luminance reduction values, filtering the light through 2 in. x 2 in. slides filled except for central apertures varying in area arithmetically, beginning with 1 cm.^{2}, from slide to slide. The light was projected down an 18 in. cylindrical tube with the aperture facing the *S* 1/2 in. in diameter. The *S* was seated at a table bisected by the matte black cloth room divider. The *S* was seated at a stool that could be adjusted for height and comfort with his chin fitted into a Bausch and Lomb Model BA5372 chinrest. The chinrest was adjusted 9 1/2 in. from the base of the table and 22 in. from the face of the adaptometer.

A second sound-deadened room which measured 10 ft. by 5 ft. was used for the AAT and related measures as well as the RT measure. The *S* was seated at one end of the room with his chair being positioned 3 feet from the wall and facing it. This wall was covered with a 4 ft. by 4 ft. white screen to be used in presenting the visual stimulus for the RT procedure. The *S*'s chair (a student's desk) had a large armrest and writing board extending along his right side and front, on which a Bausch and Lomb Model BA5372 chinrest and RT button were located. The chinrest was adjusted such that it was 10 in. from the base of the chin to the surface of the armrest. With the *S* in the chinrest his eye was 18 in. from a 1/2 in. light source generated by a Grass Model PS-2 Photostimulator, and at a visual angle of 5°. This point source light was used in the 2-Flash Threshold (TFT) procedure and as a distractor light for the Absolute Auditory Threshold (AAT) measures. The Photostimulator generated a light source with approximately square wave characteristics, in that it had a flash duration of 10 microseconds and a fall time of 7 microseconds. The point source of light was enclosed in a soundproof, cork-insulated enclosure (14 in.

x 9 in. x 9 in.) painted flat black. The aperture was provided by diffusing the light through a 1/2 in. dia. solid plastic rod 1 in. in length. The light intensity reaching the S's eye was approximately 90,000 candlepower or 1,113,000 lumens. [It must be noted that this value would be somewhat attenuated by the passage of the light through solid lucite aperture.] The TFT light source was controlled by the Photostimulator control panel that could vary the delay between pairs of flashes from 20 to 150 msecs. The number of pairs of flashes per sec. could also be varied from 1 to 30 pairs.

Directly in back of the *S*'s chair was a 4 ft. by 4 ft. screen used to separate the *S* from the *E*. A Beltone Model 9D audiometer was located behind this screen with the *S* wearing TDH-39 headphones for the AAT and related measures. The audiometer was connected to a Hewlett-Packard Model 350A Attenuator which was used to lower the reference point of the audiometer to .0002 dynes/cm^2 to allow for absolute auditory threshold measurement. Threshold measurement was binaural.

Reaction Time (RT) apparatus was also located at the far end of the room. The RT light stimulus was provided by a Bell and Howell slide projector with a 500-watt bulb. The front of the projector was equipped with a solenoid-activated photo shutter which was terminated by the *S* depressing the 1-inch reaction button which activated the microswitch beneath it. The time between onset, as controlled by the *E* and offset as controlled by a *S*'s depressing the RT button, was measured to the nearest thousandths of a second by a Hunter Model 120A electronic timer.

The luminance value of the RT light projected on the *S*'s screen was controlled with the use of 2" x 2" Wrattan filters of log luminance reductions values of .30, .60, 1.0, 2.0, 3.0, and clear plastic, the latter representing the lowest resistance to light transmission. Each filter reduced light transmission by a factor of 10. During this procedure the *S* was required to wear highly insulated Telex Model DR—66C headphones in order to dampen any ambiant sound in the room and particularly to prevent auditory cues from the RT apparatus. A warning tone of 50 dbs. at 1000 cps, was delivered binaurally through these headphones as a "ready" signal for the RT procedure.

PROCEDURE

The procedures used by Teplov and his associates and described by Gray (1964) were replicated as closely as possible. The limitations in the attempt at exact replication were due primarily to an incomplete description of both equipment and procedures by the Russian investigators.

The experiment was divided into two 1-hour sessions. The first session was used to take the Absolute Visual Threshold (AVT), Exhaustion measure, and the Shape of Curve (SOC), Modified Shape of Curve (MSOC), and the first Two-flash Threshold Index (TFT). Subjects were dark-adapted while wearing red lucite goggles in a semi-dark (15 watts of illumination) 6 ft. x 6 ft. sound-reduced room for 30 minutes. Following this, each *S* was moved to a similar testing room (6 ft. x 6 ft.) where, while seated in the threshold testing apparatus in total darkness, he was dark-adapted for a further 10 minutes. The ambiant noise level, caused primarily by the air-conditioning system, was measured at 23 db. at the *S*'s ear level. For the actual testing the *S*'s chin rested in a Bausch & Lomb chinrest, such that his eyes were 22 in. from the face of the adaptometer and directly in line with the center of the main light source. Binocular viewing was used. The test patch diameter was 1/2 in. and the fixation point was 20° angular distance above the test patch with the angular size of the aperture 1° 30". The *S* was located in a totally darkened cubicle within the experimental room itself, while the *E* was located outside this cubicle. The interior of the cubicle, including apparatus, was entirely matte black in finish.

The *S* was instructed to fixate upon the red fixation cross. He was told that the *E* would deliver an auditory cue (pure tone for 1 sec.) following which the main visual stimulus directly below the fixation point would be presented for 1 sec. He was to respond with a simple "yes" or "no" as to whether or not the light was perceived on that trial. A modified method of limits was employed with the criterion of two consecutive "yes" responses on the descending series and two consecutive "no" responses on the ascending series. The mean of the two series was taken as the AVT.

The second phase of the first testing session was used in obtaining the SOC index. This consisted of introducing the additional, peripheral, visual stimulus located directly below the main test patch at an angular distance of 24°. The luminance value of the peripheral light was 100 times the threshold for all *Ss*. The *S*'s threshold to the main stimulus was then taken once in the presence of the additional light source. The identical procedure used in AVT measurement was used here to obtain the threshold and the *S* fixated on the red fixation cross throughout. This index measured the decrease in sensitivity to a main stimulus caused by the presence in the visual field of an additional stimulus a hundred times more intense than the AVT (Gray, 1964, p. 200).

A Modified Shape of Curve (MSOC) index was also taken during this session. The procedure used for this method was the standard measurement of AVT followed by an AVT measure with the peripheral light source present (light value 100 x threshold), and then another standard AVT measure. The index was derived by subtracting the first AVT measure from the second AVT measure which followed the peripheral light trial.

The next measure taken was the Exhaustion method. This procedure involved the measurement of AVT with the peripheral light present (50 x threshold) followed by 20 repetition trials of AVT to the main stimulus at 30 sec. intervals, and finally an AVT measurement with the peripheral light present again. The Exhaustion index measured the direction and extent of change in sensitivity under the same conditions after sensitivity to the main stimulus had been consecutively measured 20 times. This was done by subtracting the first trial under peripheral light condition from the last trial and expressing the signed difference in log units.

The AVT, SOC, MSOC, and the Exhaustion method data were expressed in log luminance units derived from the calibration on the neutral density wedge at the main light source. Periodic checks with a photocell indicated the luminance to be constant at given wedge locations.

The *S* was then asked to turn to his left approximately 20° while remaining in the (torque-type) chinrest, in order to face a second light source. The 2-Flash Threshold (TFT) light enclosure was located such that the 1/2 in. light source was 18 in. from the *S*'s eye and 5° below retinal center. The *S* was asked to fixate upon the light aperture and respond by saying either "one" or "two" depending upon the number of light flashes he was able to see. The *S* was instructed that there would be either single or paired flashes of light emitted from the aperture at 10 to 15 sec. intervals. Practice demonstrations were given by showing the *S* a pair of flashes 150 msec. apart and being informed that this was an example of what two flashes would look like. He was then shown a pair of flashes 20 msec. apart and told that this was an example of a single flash. Threshold was measured using a procedure similar to Farley (1969) in which *S* is first presented with a long interflash interval and if he reports two flashes he is then presented with a short interflash interval. If he reports one flash, the procedure is repeated with decreasing range in 10 msec. steps initially, until the point is reached at which occur two interflash intervals two msec. apart for which *S* reports two flashes for the longer and one for the shorter. These pairs of flashes were then twice repeated, and if *S* maintained the same responses to them, the last interflash interval at which he reported one flash was taken as his threshold.

The experimental procedure took approximately 25 minutes following dark adaptation. The *S*s were tested between 9 a.m. and 2 p.m., with no *S*s being tested during lunch hour. The *S*s were asked not to drink coffee or other high caffeine drinks on the day of testing, as caffeine has been shown to influence the measures employed by the study (Gray, 1964) and has been used extensively in the Russian work on strength as a variable held to influence "cortical excitability." All *S*s tested had normal visual acuity with no history of eye problems.

The next test session (Session 2) used 33 of the original 40 *S*s because of subject attrition. Session 2 was used to derive the remaining 7 variables on all subjects.

The room used for this session was sound-reduced and 5 ft. x 10 ft. in size. The subject was seated at one end of the room facing the wall at a distance of 3 ft. The room was indirectly illuminated by one incandescent 15-watt bulb covered by a white diffuse semi-opaque screen.

After 5 minutes, during which the subject was partially dark-adapted, auditory threshold measures were begun. The experimental room was air-conditioned to keep temperature and humidity constant. The sound of the air conditioner was used as a background masking noise, and was measured to be 44 db, at the level of *S*'s ear. The first measure taken during this session was Absolute Auditory Threshold (AAT). The stimulus was a pure tone of 1000 cps. delivered binaurally from a Beltone audiometer through TDH-39 earphones. The audiometer was adapted for this experiment by using a Hewlitt-Packard Attenuator inserted between the audiometer and headphones. The reference point used was .0002 dynes/cm². The *S* was asked to respond verbally with a "yes" at any time a tone was heard. A modified method of limits (Woodworth & Shlosberg, 1954) was used with descending and ascending order of (db.) intensity. The subject was started well above threshold at 40 db. and the intensity was decreased by 2 db. until two consecutive trials were attained in which the subject failed to respond. The ascending order was begun 5 db. below the descending limit and the db's were increased by 2 until two consecutive "yes" responses were obtained. The mean of the ascending and descending criterion was taken as the AAT. The stimulus was a 2 sec. presentation of the tone at intervals randomly spaced from 5 to 30 sec.

Following this initial measurement it was explained to the subject that a flashing light would be present for varying amounts of time during this phase of the experiment and that any time the light was on he should look directly at it. Also during this time, whether the light was present or not, the AAT procedure would still be followed and he was to respond with a "yes" any time he heard a tone through the headphones. The subject was not to make any response to the light but just attend to it. The light used was a 1/2 in. diameter point source diffused through a polyester plastic aperture, situated directly in front of the subject at 5 degrees below retinal center. The light source was surrounded by matte black for contrast and the intensity was 100 candlepower. The light had square wave characteristics and the power source for the light was a Grass (Model PS-1) Photo-Stimulator. The distractor light consisted of four pairs of flashes per sec. with each pair of flashes 50 msec. apart. It was 10 min. from the start of the session before the distracting light was initiated so that the *S* was partially dark-adapted by that time. The "brief" method of AAT was initiated first. Under this method the S's AAT was taken 10 times under alternating "light" and "dark" conditions. The light condition refers to the fact that the distracting light was on during that phase while the dark condition referred to the standard AAT conditions. Under this procedure AAT was measured by the procedure described earlier, for a total of 10 times, or 5 times under both the light and dark conditions. The Long condition consisted of the AAT being taken first under standard procedures, followed by 5 consecutive AAT measurements at 2 min. intervals under the light condition, then AAT in dark, and then 5 more AATs under light condition, and finally a post AAT taken in dark.

The last measure taken in this session was Reaction Time (RT). Nebylitsyn's (1960a) and Mangan and Farmer's (1967) conditions were replicated as closely as possible. Their simple RT method was employed using six stimulus intensities of *2000*, *200*, *20*, *2*, *.2*, and *.02* lux. These intensities were produced in the following ways. The light source for all stimuli was a 500-watt bulb in a standard slide projector. This was projected from one end of the test room from behind a screen which divided the room between *E* and the *S*. The aperture size on the projector was 1" in diameter. [The light was projected on a white screen directly in front of the subject.] Six slides were used to vary the light intensity. The filters were 2" x 2" Kodak Wrattan filters of densities 1, 2, 3, 4, 5, and clear plastic. The ambiant illumination in the room was produced by a 15-watt bulb suffused in the rear corner of the room and measured at .004 lux at the exposure panel and .02 lux at the *S*'s eye.

Response times were measured in the following way. A solenoid-activated shutter was mounted on the front of the projector such that when the shutter opened it simultaneously activated a Hunter timer which was in turn stopped by the subject depressing the response button. The projector was located 8 ft. from the screen. The response button was 1" in diameter and located on the arm of the *S*'s chair. Response times were measured to the nearest hundredth of a second. A pure tone signal of 1000 cps. at 30 db. wad delivered binauraly through earphones 2 sec. before the stimulus as a preparatory signal. The *S* was asked to rest his forefinger of his right hand on the response button and adopt a comfortable postural stand before each trial. He was instructed to press the button as quickly as possible as soon as he saw the light.

After 10 practice trials in which an asymptotic level of performance was reached, each *S* completed 30 trials, five at each intensity, under the onset condition.

The intensities were randomly ordered. Intertrial interval varied from 10 to 30 sec. with a 2-min. rest after each block of 15 trials.

Following Nebylitsyn's (1960a) data-analysis procedures the mean was computed for the brightest intensity (2000 lux) and put in a ratio to the combined mear RT to the other 5 intensity values. This ratio was the derived RT measure used in the analysis.

III
RESULTS

The data collected from all subjects for the two test sessions were analyzed to maximize as much as possible comparisons with Teplov's results. Descriptive statistics (as shown in Table 1) were not reported by Gray and were not available to the author for comparison. The 2-Flash Threshold (TFT) and AVT data were plotted and found to approximate normal distributions when compared with similar data from other studies (Venables & Warwick-Evans, 1967, and Mote, 1955, respectively). The SOC, MSOC, and Exhaustion measures also approximated a normal distribution although each had a slight positive skew. The AAT distribution was leptokurtic in shape but showed no skewness. The five transformed variables were not plotted as they were transformed during the factor analysis and were not available in raw score form.

The 12 variables were intercorrelated by product moment correlation, with the results of this analysis being summarized in Table 2. From Table 2 it can be seen that eight correlations are significant at the .05 level of significance ($r \geq .34$) as indicated by an asterisk. Only 4 of these r's were significant at the .01 level or $r \geq .44$. Therefore eight significant correlations were obtained, where three significant correlations would be expected by chance. The similar intercorrelations from the Russian work as reported by Gray (1964) are shown in parentheses next to the appropriate correlation based on the present data. In seven of the eight correlations available for comparison the Russians obtained higher and more significant correlations often in the opposite direction of the present study. Of the eight correlations being compared, only three correlations in these data were significant at the .05 level while the correlations taken from the Russians' work had 6 of the 8 reported here as significant.

The intercorrelation matrix was submitted to an Incomplete Principle Components analysis with subsequent analytic rotation by normal varimax. The raw factor matrix was first rotated for all eigen values, the results of which are presented in Table 3, choosing only eigen values greater than 1.00. The latter results are shown in Table 4. The five variables in which factor loadings are shown in parentheses in Table 4, are taken from a factor analysis by Rozhdestvenskaya, *et al.* (Gray, 1964), although the rotated factor matrix was not compared between studies since Gray does not report what method of rotation was used by the Russians, making a direct comparison of questionable validity. Additionally, the unshared variables would have a definite but unknown effect on the loadings. To a much lesser effect this may also be true of the unrotated factor analysis (FA) but a comparison was seen as useful. Three of the six significant correlations from the first factor on the unrotated factor matrix correspond in magnitude with Teplovian results. Two other significant loadings reported by the Russians are not matched by these data but are close to significance. On the first unrotated factor there are five significant variable loadings with two others close to being significant. The second unrotated factor in Table 4 shows two variables significant while the Russians reported only one. Factor III has three significant loadings while the data reported from the Russian work reveal none. The rotated factor matrix should reveal a single factor in which most variables would load significantly if the hypothesis of a single underlying dimension is true. Factor I on the rotated matrix reveals that five of the twelve variables loaded significantly at the .01 level (Table 4). The second rotated factor revealed three significant loadings while five significant loadings were obtained on Factor III. The variance accounted

Table 1. Descriptive Statistics

Variable	$\overline{X}$	Standard Deviation	Minimum Score	Maximum Score
1. Absolute Visual Threshold (AVT)	5.01	1.10	2.40	6.45
2. Exhaustion Method (Visual Threshold)	.97	.39	-.60	+1.15
3. Shape of Curve (SOC)	-.51	.54	-1.65	+.50
4. Modified Shape of Curve (MSOC)	-.26	.54	-1.00	+1.10
5. 2-Flash Threshold (Dark Adapted)	72.30	8.45	40.00	100.00
6. 2-Flash Threshold (Partial-Dark Adaption)	99.00	6.26	81.00	118.00
7. Brief Condition (Auditory Threshold)	.99	.06	.81	1.18
8. Long Condition (Auditory Threshold)	.96	.25	-.17	+1.27
9. Long Radio	1.02	.24	-.24	+2.02
10. Reaction Time (RT)	1.14	.12	-.98	+1.54
11. Brief Ratio	1.06	.20	-.85	+2.03
12. Absolute Auditory Threshold (AAT)	1.80	.57	+1.50	+3.40

Table 2. Correlation Matrix

Vari-able	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	-.20 (44)	1.00										
3	-.13 (45)	*-.37 (.55)	1.00									
4	-.09	-.02	**.71	1.00								
5	**-.44	-.06	-.06	-.10	1.00							
6	.06	.03	-.13	-.08	-.25	1.00						
7	.31 (.30)	- 21	-.01 (.29)	-.12	.24	**-.45	1.00					
8	-.08	-.04	.24	.03	.26	-.16	.30	1.00				
9	.29 (34)	.06	-.06 (42)	.07	.01	-.06	*.40 (.25)	-.21	1.00			
10	-.12	-.15	.15	.01	-.01	-.15	.07	.02	-.01	1.00		
11	.18	-.30	.11	-.07	.23	*-.42	**.69	.22	*.39	.10	1.00	
12	.08	.16	.00	-.05	-.11	-.05	.21	.04	.21	.12	-.08	1.00

*$p < .05$

**$p < .01$

Correlation Coefficients in parentheses taken from a study by Rozhdestvenskaya, *et al.*, 1960 (taken from Gray, 1964).

Table 3. Rotated Factor Matrix; Varimax Rotation Procedure; Principal Factor Procedure (All Eigen values used)

Variable \ Factor	1	2	3	4	5	6	7	8
1. Absolute Visual Threshold (AVT)	.24	-.11	**.66	-.08	-.18	.09	-.18	.00
2. Exhaustion Method (Visual Threshold)	-.16	-.11	-.10	-.06	**.64	.19	-.17	.00
3. Shape of Curve (SOC)	.02	**.82	-.02	.19	-.27	-.01	.20	.02
4. Modified Shape of Curve (MSOC)	-.03	**.83	.01	-.05	.06	-.02	-.02	-.01
5. 2-Flash Threshold (Dark Adapted)	.28	-.10	**-.64	.15	-.04	-.08	-.03	-.01
6. 2-Flash Threshold (Partial-Dark Adaption)	**-.51	-.09	.14	-.13	-.12	.03	-.26	.08
7. Brief Condition (Auditory Threshold)	**.81	-.10	.06	.17	-.14	.24	.02	-.01
8. Long Condition (Auditory Threshold)	.20	.09	-.16	**.60	-.05	.06	-.03	.01
9. Long Ratio	**.47	.05	.10	*-.43	.01	.31	-.17	.07
10. Reaction Time (RT)	.06	.05	-.05	.00	-.09	.09	*.39	.00
11. Brief Ratio	**.79	-.01	-.03	.03	-.23	-.07	.04	.05
12. Absolute Auditory Threshold (AAT)	.06	-.02	.10	.02	.13	**.53	.13	.00
Per cent of total variance accounted for	16.4%	11.8%	7.7%	5.5%	5.3%	4.2%	3.1%	.1%

*$p < .01$ **$p < .01$

Table 4. Unrotated and Rotated Factor Matrix; Varimax Rotation Procedure (Eigen values > 1.00)

Variable \ Factor	Unrotated Factor Matrix			Rotated Factor Matrix; Varimax Rotation		
	I	II	III	I	II	III
1	.22 (.70)	.32 (.32)	**.60 (.17)	-.16	.00	**.59
2	*-.33 (.70)	.24 (.26)	-.15 (-.23)	-.21	*-.34	-.17
3	.21 (.69)	**-.85 (-.08)	.21 (-.29)	.11	**-.58	-.12
4	.02	**-.71	.29	-.10	**.75	-.09
5	.29	-.05	**-.61	**.58	-.15	*-.33
6	**-.50	.09	.20	**-.53	-.10	-.07
7	**.84 (.43)	.21 (.41)	.01 (.01)	**.69	-.01	**.53
8	.32	-.21	-.31	**.45	.13	-.17
9	*.39	.25	*.35	.12	-.01	**.57
10	.14	-.13	-.03	.14	.13	-.01
11	**.80	.07	-.01	**.68	.09	*.43
12	.10 (.53)	.12 (-.07)	.14 (-.05)	-.00	-.03	.21
			Per cent of total variance accounted for	15.6%	12.8%	12.5%

Factor loadings in parentheses are taken from a factor analysis by Rozhdestvenskaya, *et al.*, 1960 (taken from Gray, 1964).
*Significant at .95 level **Significant at .01 level

for by the first rotated factor was 15.6%, while the second and third accounted for 12.8% and 12.5%, respectively.

In the first rotated factor the variables which loaded significantly were the two methods of 2-Flash Threshold (arousal measures) and three derived ratio measures of the Auditory Threshold (Table 4). The second rotated factor has three variables which were significant and they were the Exhaustion Method and the Shape of Curve, Methods 1 and 2. All three variables are derived measures from the visual sense modality or visual threshold. Factor III of the rotated matrix has five variables which loaded > .33. They represent the best cross section of variables of any factor. The AVT and AAT load very highly at .69 and .57, respectively. The two brief conditions of AAT also load significantly as they did in Factor I. The fifth variable in Factor III was the long ratio of the AAT measure. The only type of measure which did not load significantly in Factor III was the Reaction Time, which did not load significantly on any factor in the present analysis.

The results of the Rotated Factor Matrix using a criterion including all eigen values, as shown in Table 3, are not clear. The first factor which accounts for 16.4% of the total variance has four variables which load greater than .47 or are significant at the .01 level. They are the TFT #2 (partial dark adaptation), Brief Condition, Long Ratio, and Brief Ratio variables. The SOC and MSOC variables both load very highly (.82 and .83, respectively) on the second factor but there was no other groupings of two or more variables on any single factor.

A discriminate function analysis of the data was done using the AVT as the dependent variable and the other 11 variables as independent. The *Ss* were divided in high AVT and low AVT groups. The two groups included 13 subjects, each with 7 subjects who could not be categorized, dropped from the analysis. The criterion used for inclusion in the high group was that the S's AVT score was equal to or greater than .75 standard deviation from the mean of AVT. The criterion for the low group was equal to a greater than .55 standard deviation because of the slight positive skew on the distribution.

The *F*-ratio for the multivariate test of equality of mean vectors was 1.43. With degrees of freedom of 11 and 14 the probability level of alpha is .26. This means that one cannot reject the hypothesis that the multivariate populations are the same. In other words, when the mean of all variables for the high AVT group is compared with the mean scores for all independent variables for the low AVT group, the difference is not statistically significant. The standardized discriminate function coefficients are included in Table 5 but as one would expect from the non-significant multivariate *F*-ratio, the standard scores show no significant results. Significant results in this analysis would predict the AVT category of a subject on the basis of his score on any of the 11 independent variables.

A regression analysis was also done on the data with the AVT grouping described above used as the dependent variables. The results (Table 6) are consistent with the discriminate function analysis in that none of the 11 variables were very significant in predicting the AVT scores. There were, however, four variables with regression coefficients of .50 or greater. These were the 2-Flash Threshold (dark-adapted), Long Condition (auditory threshold), Long Ratio (auditory threshold), and the Brief Ratio (auditory threshold). The high standardized regression coefficient of these four variables would appear to be of some value in predicting the AVT score of the same subject but a word of caution is required. The regression coefficients are not dependent upon order but they are affected by the other variables included in the analysis. Hence, one must consider the non-significant variables and their relation to the four significant variables mentioned, and not deal with these four variables in isolation. The deletion of any single or combination of variables would strongly affect the coefficients of the remaining variables.

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Table 5. Discriminant Function Analysis

Discriminant Function Coefficients and Univariate F Test

Variable	Univariate F	P Less Than	Raw Coefficient	Standard Score
1. Exhaustion Method (Visual Threshold)	0.9671	.34	0.0239	0.98
2. Shape of Curve (SOC)	0.9478	.34	0.0221	1.18
3. Modified Shape of Curve (MSOC)	0.3425	.56	-0.0074	-0.38
4. 2-Flash Threshold (Dark Adapted)	2.7802	.10	0.0242	0.92
5. 2-Flash Threshold (Partial-Dark Adaption)	0.1590	.69	0.0076	0.30
6. Brief Condition (Auditory Threshold)	2.9876	.09	-8.6321	-0.56
7. Long Condition (Auditory Threshold)	0.6746	.41	1.0236	0.21
8. Long Ratio	1.0212	.32	0.3127	0.09
9. Reaction Time (RT)	1.0119	.32	[illegible]258	0.30
10. Brief Ratio	1.9732	.17	-0.8779	-0.19
11. Absolute Auditory Threshold (AAT)	0.0743	.78	-0.0196	-0.12

F-Ratio for Multivariate Test of Equality of Mean Vectors = 1.43
D.F. = 11 and 14
P = Less than .26

Table 6. Regression Analysis

Regression Coefficients - Independent X Dependent Variables

Variable	Raw Coefficient	Standard Score
1. Exhaustion Method (Visual Threshold)	-0.35	-.25
2. Shape of Curve (SOC)	-0.03	-.03
3. Modified Shape of Curve (MSOC)	-0.08	08
4. 2-Flash Threshold (Dark Adapted)	-0.84	.56
5. 2-Flash Threshold (Partial-Dark Adaption)	0.12	.08
6. Brief Condition (Auditory Threshold)	195.98	23
7. Long Condition (Auditory Threshold)	142.58	.51
8. Long Ratio	134.66	.66
9. Reaction Time (RT)	62.06	.13
10. Brief Ratio	-152.95	-.58
11. Absolute Auditory Threshold (AAT)	-2.92	-.32

Independent Variable = AVT

IV

DISCUSSION

The results of this study do not correspond very well with those found in similar studies conducted by Russian researchers. It is extremely difficult, however, to make comparisons between the data from this study and the results reported by the Russians. The Russians report raw data in some of their reports but are often ambiguous as to the exact procedures and numerical reference points used in obtaining the figures. The factor analysis reported (Rozhdestvenstaya, *et al.*, 1960) would appear to provide a ready comparison but again the method used, in this case the method of rotation, is not explicit. The correlation matrix and the unrotated factor matrix do provide possible comparisons but here it is evident that the many variables not held in common and the magnitude of relationship between those variables adversely affects the results of shared variables. With this caution in mind, the data available were compared to the Russian findings. Table 2 (see page 12) shows that in seven out of eight similar intercorrelations available for cross-study comparisons, the Russians obtained higher and more significant correlations. Of the eight correlations shown, the Russian study found five significant at the .05 level while in the same eight of this study only two were significant at the .05 level. The comparisons, however, are tenuous to say the least. Rozhdestvenstaya, *et al.* (1960), employed the rank-order method in computing correlations. The strong possibility exists that ties at a rank may well affect the accuracy of the reported correlations. Pearson-product moment correlations were computed in the present study. The rank-order correlation used by the Russian researchers provides less accuracy in absolute terms as well as limits the applicability of the data to a new sample (normative data based upon *Ss'* scores). The ranks and relative positions appear to be the important criteria for inclusion in a particular group and not the absolute or numerical difference between groups or within subjects in the same group. If the variables are distributed in an approximate normal manner then the research should be able to derive approximate numerical cut-off points (assuming standard procedures used in this deviation) for inclusion in various groups. The ranking criterion does not consider the variability or distribution of scores and hence negates the value of including continuous variables in the study. Plotting the distribution of scores in the present study indicates that although slight skewness exists for three of the variables, the normal curve is approximated with four other variables (five transformed variates were not plotted).

The unrotated factor matrix (Table 4) also shows some comparison between Russian studies and the present research. The comparisons, however, are highly tenuous because of the effect of unshared variables on the common variables in both the Russian factor analysis and the present factor analysis. Difference in the derivation of the correlations as well as possible methodological differences to be discussed later, make the comparison more academic than useful.

The primary hypothesis of the Russian work is the establishment and consistency of an underlying dimension of the central nervous system they label as strength. The actual numerical scores as well as statistical analysis used on them would appear to have diminished relevance, however, if in replication of their procedures one could establish the existence of a single factor that would account for a great deal of the shared variance of the variables used. By this reasoning the crucial comparison would appear to be the factor analysis of the present study to test the hypothesis that a single dimension exists.

The method of rotation used in the Russian factor analytic study was not clear except that it was of the centroid rotational type. The best approximation to their method (in which hand calculating may have been used) was believed to be the Varimax rotational procedure which is the orthogonal type. The results of this rotational method is shown in Tables 3 and 4 in which Table 3 shows all eigen values being used while Table 4 uses only those < 1.00. The results shown in Table 3 do not lend themselves to any straightforward explanation. The factor containing the greatest number of significant variables is Factor I with four variables significant at the .01 level. These are variables numbered 6, 7, 9, and 11 shown in Table 4. These include a 2-Flash Threshold or arousal measure, the Brief Condition, Long Ratio, and Brief Ratio of auditory threshold measures. These would not appear to reflect any relationship to each other except that three out of four are from auditory threshold measures. Of significance here may be the fact that the three AAT measures loading on this factor all make use of a highly distracting visual stimulus and test the effect of this visual distractor upon the AAT. A high score on any of these measures or in this case, all of them, could indicate that the distractor has had a great effect upon their auditory threshold. The study by Yermolayeva-Tomina (1960) indicated that *S*s classified as "weak" showed the greatest decrease in auditory sensitivity as a function of the visual distractor, while those *S*s classified as "strong" showed an opposite effect by the distractor having no effect on AAT or a slight increase in sensitivity. The data shown in Table 4 appear to show similar results for the present study, although it may not be appropriate to label these as strengths. An analysis of the way in which the ratio scores for these three variables are derived indicates that those *S*s showing the greatest effect on AAT of the visual distractor will obtain the highest scores. The high negative loading shown by the TFT #2 variable substantiates these findings. The TFT measure is such that a low threshold would indicate a weak *S* while a high score (high threshold) would be indicative of a strong nervous system. Following this reasoning the weak *S* as indicated by a high score on variables 7, 9, and 11 (derived AAT measures using light distractor), would be indicated by a low score or threshold on the TFT measure. If the variables belong to a single factor, then the relationship between the TFT and the other variables tested would have to be negative and this is in fact what happens.

One would not need to label this factor strength, however, since other measures which theoretically should indicate this dimension did not, in fact, do so in this study. It may be more realistic at present to label this an arousal factor.

Table 3 indicates 13 other significant factor loadings interspersed throughout the analysis, but since never more than two variables load at a significant level ($p < .05$) on any one factor, it is difficult, if not impossible, to delineate the importance of the loadings.

A discriminate function analysis was done on the data to determine with what accuracy it was possible to divide *S*s up on the basis of their score on one variable and predict their similar categorization or ranking on the remaining variables. This grouping or classification was done on the basis of an individual's level of AVT. The AVT measure was chosen on the basis of the Russian report that it had the highest loading on the strength dimension (Rozhdestvenskaya, *et al.*, 1960). A *S* was classified into either a high or low group corresponding to the Russian classification of *S*s as either strong or weak, respectively.

The analysis may be thought of as working in reverse in that the results are interpreted by the degree to which the other 11 variables predict to the classification or grouping of *S*s that has been performed on the 12th variable. The results of this analysis indicate that one cannot accurately predict classification on the AVT measure from an individual's score on any other variable. The unidimensionality of AVT with the other measures would appear to be in serious doubt. It would appear that classification on the basis of an AVT score, which theoretically was held to load highest on a strength dimension, and therefore underlies a number of the present variables, does little to predict subsequent classifications on these variables.

The regression analysis would be expected to follow the results of the discriminate function analysis and the results verify this. The results shown in Table 6 indicate that knowing a *S*'s AVT score does very little in helping one predict subsequent scores on other variables. This analysis further establishes that, in this study, the AVT did not appear to load on common dimension with the other variables and that knowledge of the AVT score provides little help in pre dicting the same S's score on other variables.

The results from the analysis on the data in the present study appear to lend little credence to the strength dimension as hypothesized by Teplov and his associates. The results do indicate, however, that one or more dimensions may underlie the task variables used, but do not load to the extent or magnitude predicted by Russian researchers. The dimensions that have been indicated by the factor analysis used indicate that instead of being pervasive throughout variables, their loadings are a function of the sense modality being measured or task variables. One exception to this was found in the factor analysis shown in Table 3 with the hypothesis set forth to explain these findings involving an arousal dimension. This dimension did not appear to be related to task or sense modality variables. The pervasiveness of this variable requires further study in that the other factor analysis did not fully verify these results; the findings may have been a function of the rotation used.

In conclusion, this study has attempted to replicate the Teplovian hypothesis that there is an underlying strength dimension, which is an important characteristic of a S's central nervous system, and that this dimension is indicated in various degrees by various threshold measurements of that S. The study included 10% of those variables held by the Russians to be the best indicators of the strength dimension, on the basis of their factor analytic results. Two additional threshold measures (TFT) were included to test the hypothesis that the strength dimension might be highly related to arousal measures. The results of this study did not verify that the strength dimension exists as an underlying CNS characteristic of the S. The possibility of an arousal dimension was less clear with this being a possible source of further research.

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