SENSORY SENSITIVITY AND QUALITY OF PERFORMANCE AS FUNCTIONS OF LEVEL OF ACTIVATION

by

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SENSORY SENSITIVITY AND QUALITY OF PERFORMANCE AS FUNCTIONS OF LEVEL OF ACTIVATION

Introduction

Prior to the work of Cannon and Bard, psychologists investigating "emotion" per se concerned themselves almost exclusively with the "conscious elements of emotional experience." Their failure to accord more than honorable mention to the profound physiological changes accompanying "emotional" states resulted in a prolonged period of largely fruitless experimentation.[1]

Up until the 1920's the most popular theory of emotional experience was that of James and Lange. As James states in his Principles of Psychology,

> My theory is ...that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion.[2]

According to Lindsley, Lange's theory maintained that

> A stimulus object or situation gives rise immediately to vasomotor changes wherever blood vessels are found. The secondary changes occurring in the tissues were believed to give rise to the sensations that constitute the emotion.[3]

The Cannon-Bard thalamic theory of emotion, which appeared in the late 1920's, rigorously schematized the possible neural pathways and mechanisms of emotion. According to this theory, the "peculiar experience of emotion is added to simple sensation only when the thalamic processes are

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[1] The changes referred to here include variations in the physiological processes of the organism such as changes in metabolic rate, blood pressure, muscle tension, and electrical skin resistance.

[2] William James, Principles of Psychology (1890), p. 191.

[3] D. B. Lindsley, "Emotion", in Handbook of Experimental Psychology, ed. by S. S. Stevens, (1951), p. 501.

aroused."[4]

In addition to his thalamic theory of emotion, Cannon's important observation of the consistent patterning of physical responses prominent in pain, hunger, fear, and rage, a patterning he felt prepared the organism for action in emergency situations, also encouraged investigators to turn away from analyzing conscious experience and toward a consideration of the organization of physiological processes.

Although ingenious methods and apparatus have been devised, it is still impossible to obtain totally inclusive records of all the changes which occur throughout the body, partly because they are regulated in complex ways by the endocrine glands and by both the somatic and the autonomic nervous systems. Out of the mass of these physical changes, however, psychologists have studied a number of selected indicators singly and in combination. It appears from this study that, instead of a peculiar patterning of gross physiological processes analogous to the conventional distinctions among different emotional states, there exists only

> a relatively widespread increase in the level of activation or of energy mobilization corresponding roughly to an increase in what the layman calls "tension" or "excitement".[5]

Such findings it would seem may best be accounted for by a new and productive wave in psychological thinking -- activation theory.

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[4] W. B. Cannon, "The James-Lange Theory of Emotions: A Critical Examination and an Alternative Theory," Amer. J. Psychol., Vol. 39 (1927), p. 126.

[5] R. S. Woodworth and Harold Schlosberg, Experimental Psychology (1960), p. 133.

By describing behavior solely in terms of direction and intensity, Duffy attempts to replace the ambiguous inutility of such constructs as emotion, drive, and libido with more mensurable behavioral dimensions.[6] In a manuscript now in press, she describes one of these, level of activation or degree of excitement, in the following manner:

> The construct energy-mobilization or activation derives from and emphasizes the fact that a living organism is characteristically an energy-system. The process of living, in any of its aspects, requires energy-release in varying degrees. Every response of the organism is fundamentally concerned with energy transformation and release. ... The level of activation of the organism may be defined then, as the extent of release of potential energy, stored in the tissues of the organism, as this is shown in activity or response.[7]

In his description of how the galvanic skin reflex (sweating) supplemented by blood pressure prepares the organism for activity, Darrow also points out the facilitative function of the body's physiological processes.

> Palmar perspiration is functionally valuable for the improvement of tactual acuity and grip upon objects, and it is called forth in situations demanding increased alertness and mobilization of energy for adaptive responses.[8]

Malmo, in his stimulating paper, "Activation: A Neurophysiological Dimension", attempts to explain variations in the level of activation as

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[6] E. Duffy, "Emotion: An Example of the Need for Reorientation in Psychology," Psychol. Rev., Vol. 41 (1934), p. 184-185; "An Explanation of 'Emotional' Phenomena without the Use of the Concept 'Emotion'," J. Gen. Psychol., Vol. 25 (1941), p. 283-293; "The Conceptual Categories of Psychology: A Suggestion for Revision," Psychol. Rev., Vol. 48 (1941), p. 177-203.

[7] E. Duffy, Activation and Behavior (1962), p. 17.

[8] C. W. Darrow, "The Galvanic Skin Reflex (Sweating) and Blood Pressure as Preparatory and Facilitative Functions," Psychol. Bull., Vol 33 (1936), p. 73-94.

a "function of the amount of cortical bombardment by the ascending reticular activating system, such that the greater the cortical bombardment, the higher the activation." [9]

Whatever the cause of variations in the level of activation, they occur, as Duffy contended long ago, on a continuum with deep sleep and drowsiness appearing on one end and highly aroused or excited states on the other. [10] Variations in the level of activation as measured by a number of physiological processes appear to be directly related to the energy requirements, or to the perceived significance of the situation. That is to say that "there are a number of physiological conditions which show variations in one direction with increased stimulation or increased demands upon the organism, and variations in the opposite direction with decreased stimulation or decreased demands." [11]

The electrical resistance of the skin, for example, appears to be related inversely to the general level of activation. When the individual first wakes up in the morning, his skin resistance is usually quite high and his general level of activation low. As he goes about his work, however, he becomes more alert; his level of activation rises and his skin resistance falls. During the day the individual becomes more and more fatigued: His skin resistance rises gradually throughout the evening while his level of activation falls, reaching its lowest point as he becomes drowsy and goes off to sleep.

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[9] R. B. Malmo, "Activation: A Neurophysiological Dimension," Psychol. Rev., Vol 66 (1959), p. 384.

[10] E. Duffy, "The Concept of Energy Movilization," Psychol. Rev., Vol. 58 (1951), p. 30-39.

[11] E. Duffy, Activation and Behavior (1962), p. 22.

The measurement of activation, by definition, must be approached by measuring the intensity of response "not as indicated by overt behavior but as indicated by those processes which supply the energy for overt behavior." [12] The physiological processes most frequently employed in studying the level of activation (because they are readily accessible to quanitfication and measurement) include the electrical activity of the brain, metabolic rate, blood pressure, heart rate, blood volume, respiration, muscle tension, body temperature, and electrical skin conductance.

Although there appears to be general agreement that studies employing a number of these physiological processes provide the best method of investigating the level of activation, there seems to be much confusion and disagreement among investigators as to which single physiological measure would provide the best <u>rough</u> indicator of the level of activation.[13] For example, Schnore suggests that heart rate, systolic blood pressure, respiration rate, and right-forearm muscle tension provide better measures of arousal than skin conductance, skin temperature, and left-forearm muscle tension.[14] Woodworth and Schlosberg, however, feel that the electrical activity of the skin is among the best indices of the general level of activation, partly because it is one of the "key functions of sympathetic

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[12] Ibid., p. 51.

[13] The writer feels that more investigations designed to determine the physiological measures and techniques which provide the best rough indication of the level of activation are greatly needed, especially since the cost of adequately constructed polygraphs is phenomenal.

[14] M. M. Schnore, "Individual Patterns of Physiological Activity as a Function of Task Differences and the Degree of Arousal," J. Exp. Psychol., Vol. 58 (1959), p. 117-128.

activity" and also because of the "speed and sensitivity with which the G.S.R. follows stimulation."[15] Their opinion is shared by such other authorities as Duffy, Freeman, and Lindsley.

The resistance of the skin to the passage of an electrical current seems to be intimately related to the functioning of the sweat glands. In fact, it is believed that the actual response of sweating, and not the sweat itself, somehow increases the permeability of the cell membrane and causes changes of polarization in the sweat gland cells. It has also been suggested that skin resistance may be influenced by hormones present in cellular substances.

The resistance of the palmar and plantar areas has been repeatedly shown to vary in a fashion different from that of other parts of the body. Richter[16] maintains that palmar and plantar resistance are controlled by the thermoregulatory activity of the sweat glands under the influence of the somatic and sympathetic nervous systems, and that resistance of other body areas is controlled by the thermoregulatory activity of the epithelial cells themselves. Duffy perhaps best summarizes the important distinctions between the resistance of the palmar and plantar areas, and that of other body areas:

> The sweating of other parts of the body is primarily for the purpose of regulating body temperature. Palmar and plantar sweating on the contrary while not unaffected by variations in temperature is

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[15] R. S. Woodworth and Harold Schlosberg, op. cit., Cpt. 6.

[16] C. P. Richter, "The Electrical Skin Resistance: Diurnal and Daily Variations in Psychopaths and in Normal Persons," A.M.A. Arch. Neurol. Psychiat., Vol. 19 (1928), p. 488-508, as in E. Duffy, Activation and Behavior (1962), p. 25-26.

> most responsive to changes in muscular activity (overt or covert) or in the perceived significance of the situation.... It may be, however, that the difference between the reaction of palmar and plantar areas and other areas of the body is chiefly a difference in the ease with which the various areas are excited to activity. The palmar and plantar areas appear to become more active first and then to approach their limit of responsiveness as the non-palmar and non-plantar areas become increasingly more responsive.... Whatever the cause of the differences in their reactions, the palmar and plantar areas have been found more useful than other areas in the study of behavioral correlates of changes in resistance.[17]

It is a common observation that variations in the level of activation of the body are associated with variations in the level of performance of many tasks. In fact, there appears to be an optimal degree of arousal for most kinds of performance. Malmo[18] schematically represents this relationship as follows:

Activation level:	Low	Moderate	High
Expected performance level:	Low	Optimal	Low

The optimal level, however, varies with the nature of the task, lying somewhere between a low degree of activation (which affects performance through a reduced sensitivity to stimulation) and a high degree of activation (which affects performance through a general disorganization of responses). The relationship between level of activation and performance therefore may be expressed by an inverted U-shaped curve, a curve which may be skewed to the right or left, depending on the task employed.

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[17] E. Duffy, Activation and Behavior (1962), p. 25-26.

[18] R. B. Malmo, op. cit., p.376.

Freeman's study correlating reaction time scores with palmar conductance provides evidence for the inverted-U curve. These measures, however, are based on only one subject.[19] In another study, in which he employed 20 subjects, Freeman investigated the relationship of finger oscillation and reaction time to skin resistance. Although the study was not designed to demonstrate the inverted -U curve, the findings were in keeping with such a relationship: when further aroused, the subjects manifesting a high level of activation did not improve in performance, while those manifesting low levels of activation did improve.[20]

One of Schlosberg's students attempted to repeat Freeman's "single subject" study of the inverted-U curve with an additional independent variable -- hand steadiness. She reported positive results and extended her study to include five other subjects. Although she again reported positive results, she had accumulated only ten sets of data per subject. Schlosberg and Kling, deciding to repeat the experiment themselves before offering their support to the student's publication, failed to obtain similar results, although they employed 22 subjects, with 2 to 57 sessions each.[21]

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19 G. L. Freeman, "The Relationship Between Performance Level and Bodily Activity Level," J. Exp. Psychol., Vol. 26 (1940), p. 605.

20 Ibid.

21 H. Schlosberg and J. W. Kling, "The Relationship Between Tension and Efficiency," Percept. and Motor Skills, Vol. 9 (1959), p. 395. As reviewed by D. Evans, "The Relationship Between Level of Activation and Reaction Time," Honors Paper, W.C.U.N.C., 1961, p. 5-6.

Bills, in studying the relation of muscle tension to mental efficiency, found that "the increased muscular tension which accompanies intense mental activity (learning nonsense syllables) increases the efficiency of the mental work as indicated by the number of correct responses, the number of presentations needed to learn, and the per cent saved in relearning."[22]

Using muscle tension as a measure of activation and memorization as a measure of performance, Courts found that memorization improved as dynamometer tension increased up to an optimal level, beyond which memorization became less efficient.[23]

Although Travis and Kennedy were interested in studying only the effects of low and high levels of activation on the performance of a tracking task, their results certainly do not contradict the curvilinear hypothesis. In fact, using muscle tension as a measure of activation, they found that non-alert subjects, or subjects with a low level of activation performed poorly but improved their performance as their level of activation rose.[24]

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[22] A. G. Bills, "The Influence of Muscular Tension on the Efficiency of Mental Work," Amer. J. Psychol., Vol. 38 (1927), p. 231.

[23] F. A. Courts, "Relations Between Experimentally Induced Muscular Tension and Memorization," J. Exp. Psychol., Vol. 25 (1939), p. 225.

[24] R. C. Travis and J. L. Kennedy, "Prediction and Automatic Control of Alertness," J. Compar. Physiol. Psychol., Vol. 40 (1947), p. 457-461; "Prediction and Control of Alertness," J. Compar. Physiol. Psychol., Vol.42 (1949) p. 45-57, as review by E. Duffy in Activation and Behavior (1962), p. 55.

The results of French's study, however, do not in any way support the hypothesized curve. He measured left-hand finger tremor and skin resistance while the subject engaged in mental multiplication, in right-hand reaction time performance, and in the squeezing of a dynamometer with his right hand. Although his subjects showed a marked increase in finger tremor and a marked decrease in skin resistance when exposed to a sudden noise, they failed to show such corresponding changes with any degree of regularity during mental multiplication, performance on the hand dynamometer, or reaction time performance.[25]

Additional evidence for the inverted-U curve may be found in Shaw's study of the relationship between muscular tension and the perception span for tachistoscopically presented digits. He pointed out the importance of the difficulty of the task in determining the optimal tension level.[26]

Also interesting are the positive results Stennett obtained when he tested the hypothesized curvilinear relationship between the level of arousal and the level of performance. He compared the performance of 31 subjects on an auditory tracking task under different conditions of incentive.

> These conditions ranged widely from one in which S. (subject) was under the impression that his scores were not being recorded to one in which his scores determined whether or not he avoided a 100-150 v. shock and earned a bonus of from $2.00 to $5.00. 27

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[25] J. W. French, "A Comparison of Finger Tremor to the Galvanic Skin Reflex and Pulse," J. Exp. Psychol., Vol. 34 (1944), p. 494-505.

[26] E. Duffy, Motivation and Behavior (1962), p. 64.

[27] R. G. Stennett, "The Relationship of Performance Level to Level of Arousal," J. Exp. Psychol., Vol. 54 (1957), p. 60.

The data of this study strongly support a curvilinear hypothesis whether palmar conductance level or the EMG response of any one of the four muscle groups employed is used as the criterion of arousal.

Sensory sensitivity also manifests spontaneous variations which appear to be related to diurnal fluctuations in the level of activation. Wertheimer, Herren, Kleitman, Travis, and Patrick and Gilbert have all shown that variations in the auditory threshold under normal conditions are not random.[28] In fact, they suggest in a number of ways that sensory sensitivity is directly related to the degree of arousal of the organism.

In a recent experiment, however, Gerall and Snyder, using non-specific muscular tension as a measure of activation, failed to demonstrate any relationship between level of activation and the auditory threshold.[29]

Purpose

It is the spontaneous or diurnal fluctuations in the individual's level of activation which are of great interest to the present writer. In the investigation of these random variations which follows, the relationship between the level of activation and the quality of performance and the degree of sensory sensitivity is studied. Electrical skin conductance is used as a measure of activation and the auditory threshold

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[28] E. Duffy, Activation and Behavior (1962), p. 128-133.

[29] A. A. Gerall and Charles Snyder, "Non-specific Muscular Tension and Auditory Threshold," Percept. and Motor Skills, Vol. 14 (1962), p. 179-182.

as a measure of sensory sensitivity. Measures of two performances are provided by the subjects' scores on a steadiness task (the number of seconds a stylus is in contact with a steel frame during a 32-second interval) and on a number-matching task (the number correct). In view of the research cited above, a curvilinear relationship between the level of activation and the quality of performance and the degree of sensory sensitivity is hypothesized.

Apparatus

In this study the instrument employed to measure the electrical resistance of the skin was a Fels Dermohmmeter, Model 22A, with a total range of zero to approximately 500,000 ohms.[30] Although it was possible to select sensitivity settings ranging from a full-scale sweep of 120,000 ohms (minimum sensitivity) to one of 6,000 ohms (maximum sensitivity), it was found that a setting which gave a full-scale sweep of 60,000 ohms was most appropriate for the responsiveness of the subjects employed. The range selector was manually instead of automatically operated, to give the experimenter optimal control in recording the skin-resistance data; the latter were recorded on an Esterline-Angus Model AW Recorder, at a paper speed of 40 seconds per inch.

The zinc electrodes serving the dermohmmeter were 13/16 inch in diameter, forming the bottoms of plastic cups which were, in turn, packed with a conductive jelly. This jelly was composed of 1 per cent zinc sulfate, 10 per cent bacto-agar, and 89 percent distilled water, plus the preservative, phenyl mercuric nitrate. The resistance afforded by the electrodes themselves was checked periodically, and each time no resistance

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[30] Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio.

was recorded.

A Western Electric Audiometer, Model 6B, calibrated in five-decibel steps and held at a constant frequency of 1024 cycles per second, was used in determining the subject's auditory threshold. To enable the experimenter to obtain more accurate records, an attenuator calibrated in one-half decibel steps was placed in series with the audiometer.

A steel plate perforated by nine holes which became progressively smaller,[31] a stylus, the right-pen marker of the Esterline-Angus Recorder, a Hunter timer, an electrical timing-clock and a six-volt dry cell were all placed in series, so that, each time the subject allowed the stylus to touch the plate during the 32-second interval regulated by the Hunter timer, the duration of contact was recorded by the clock in hundredths of a second, while the 32-second interval itself was simultaneously recorded on the Esterline-Angus chart. The steel plate and the stylus were periodically sandpapered to provide a good electrical contact.

Fifty number-matching sheets similar to the Minnesota Vocational Test for Clerical Workers were made up by use of a table of random numbers. A column of 50 ten-digit numbers was first taken from the table; after which, using the criteria of odd and even numbers, the writer decided to make up the second column with which the first was to be matched by changing those numbers in the first column which were designated as even by the table of random numbers and by leaving those designated as odd unchanged. In the long run, therefore, one-half of the matched numbers were identical. The table of random numbers was used a third time to determine which two

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31 The holes employed in this study ranged from 11/50 to 6/50 inch, each being 1/50th of an inch smaller than the hole preceeding it.

of the ten digits were to be interchanged in the numbers already designated to be changed. The digit appearing in the table and the one immediately following it were invariably the ones interchanged. One of these sheets appears in Appendix A. The subjects were timed by a stop watch, and the interval was recorded by the left pen marker of the recorder, which was driven by a six-volt cell and controlled by a telegrapher's key.

The frame of the nine-hole stylus apparatus was taped securely at the front edge of a small table, before which the subject sat. The earphone of the audiometer appeared on the subject's left, and the number-matching sheet, face down, on her right. The experimenter communicated with the subject by way of a Webster Electric Teletalk system, the loudspeaker of which was placed behind a lamp to the far left of the subject. Another loudspeaker, which was connected with a tape recorder, was located on the floor behind the subject. All equipment, except that which appeared on the subject's table and the two loudspeakers, was set up outside the subject's room. The latter, approximately 10 feet by 13 feet in internal dimensions, was soundproofed and electrically shielded; air conditioning equipment (silenced during actual experimental trials) maintained a constant room temperature of 72° throughout the experimental sessions.

Subjects

The three subjects in this study were college students, ranging in age from 19 to 21 years. They were selected solely because they were willing to devote the necessary time involved to perform the experiment. They were paid according to a regular student rate of 75 cents an hour.

Procedure

The dermohmmeter was turned on one hour before each experimental session, to allow time for all circuits to warm up and to be functioning properly.

When the subjects arrived, the electrode cups were appropriately filled with jelly, mounted in their plastic-spring holders, and placed on a particular area of the sole of each foot (thus leaving the subject's hands free for her experimental tasks); the area employed was determined in a pre-experimental session, outlined with indelible ink, and used invariably throughout the experiment. After the electrodes had been attached to the feet, the subject sat for a 20 minute rest period to allow the skin to hydrate and thereby to establish a good electrical contact. The subject sat in a straight-back chair at her table with her feet propped up on a wooden stool spaced a comfortable distance from the chair.

At the end of the 20 minutes, the subject held the earphone up to her left ear while her auditory threshold was taken by first locating the approximate intensity at which she reported hearing the 1024 cps tone as it was increased in intensity. The experimenter then set the audiometer five decibels lower than this approximate threshold. By slowly increasing the intensity of the tone in half-decibel steps with the auxiliary attenuator, the experimenter was thus able to determine the subject's auditory threshold more accurately.

Following a 30-second rest period, the subject began performing the nine-hole stylus-steadiness task.[32] A time sequence was set up in

[32] In a pre-experimental session, it was found that the last six holes in the frame provided adequate measures on two of the subjects' right-hand steadiness and that the last four holes provided adequate measures on the third subject.

which the subject, without supporting her arm in any way, held the stylus in her first hole for 32 seconds and then rested for 32 seconds. This same procedure was repeated for the remaining holes.

After roughly one minute, the subject began the last phase of the experimental session - the number-matching task. She was allotted exactly two minutes to select from the 50 paired numbers on the number-matching sheet all the pairs whose members were identical. Practice effects were controlled by having each subject, in a number of pre-experimental sessions perform the tasks until their familiarity with and performance on the two tasks showed no further marked improvement.

If, at the end of a session, the subject's skin resistance had shifted materially to either a higher or lower level, she was tested again; however, no subject repeated the procedure more than four times in succession.[33]

By employing a number of devices, the experimenter was successful in producing desired variations in the subjects' skin resistance or activation level during performance. This was done so that measures representative of a broad section of the activation continuum as indicated by skin resistance, rather than a preponderance of measures representing only the habitual levels of activation, could be obtained. The level of skin resistance was sometimes lowered and, as a logical consequence, the level of activation raised by introducing white noise into the soundproof room by means of the tape recorder and associated loudspeaker, and by having the subject drink black coffee. (It is interesting to note that, for one of the three subjects, the black coffee seemed to have just the opposite effect). To lower the subject's level of activation, a cot was placed in the soundproof room so that the subject could sleep while being monitored

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33 There was a total of 65 separate experimental sessions.

by the dermohmmeter. Usually, after approximately 30 minutes of sleep, the subject's skin resistance drifted up to a much higher level. She was then awakened and tested. In a further attempt to obtain a number of measures representative of even lower levels of activation, the equipment was moved to a dormitory and, later, to the college infirmary. The experimenter awakened and tested all three subjects at regular intervals throughout the night in both of these situations.

Each time, before concluding the session, the outline on the subject's feet, indicating the correct placement of the electrodes, was examined, and occasionally it was necessary to renew the indelible ink marks.

Results

The mean resistance reading for each 32-second interval on the nine-hole stylus-steadiness task was computed by averaging the resistance values recorded at 8-second intervals. Five readings were thus averaged to find the mean resistance for each subject during her performance on each hole. The mean resistance recorded during the two-minute number-matching period was also found by averaging the resistance readings which appeared at 8-second intervals. These mean resistance values and the skin-resistance reading at which the subject reported her auditory limen were converted into conductances by use of a table of reciprocals. A series of graphs, with skin conductance plotted along the abscissa, was made up for each subject, who thus served as her own control. A graph was made for each hole she used on the nine-hole stylus task, with the number of seconds the stylus was in contact with the frame plotted along the ordinate; one for the number-matching task with number correct plotted along the ordinate; and one for her auditory threshold with decibels plotted along the ordinate. A total of 55 to 57 measures was obtained and plotted on each graph for each subject, in such a way that the regular sessions could be distinguished from those in which either white noise or coffee was employed to lower the subject's level of resistance. The ranges of conductance for all three subjects for each measure (or division thereof) are presented in the table of Appendix B. The ranges obtained from the measures of performance (number correct and number of seconds in contact) and of sensory sensitivity (decibels) employed are recorded in the table of Appendix C.

Although the resistance readings were <u>fairly</u> well distributed over a <u>relatively</u> broad range, it was obvious from the first glance at the data that no consistent relationship between level of activation as indicated by skin conductivity and performance or sensory sensitivity had been established. Only one of the 22 graphs revealed any sort of relationship: The correlation between skin conductance and auditory threshold for subject II was .79. Although this correlation when viewed alone may appear significant, when it is considered in the light of the two other auditory threshold correlations, the combined probability value of such a correlation occurring by chance alone is not statistically significant.[34]

Conclusions

The results of this correlational study do not support the hypothesized curvilinear relationship between level of activation and the quality of

[34] The combined probability value referred to here was obtained by the writer in consultation with Dr. William S. Ray, Department of Psychology, Woman's College, Greensboro, N. C.

performance or sensory sensitivity. One of the greatest handicaps in this, and any, study of the individual's level of activation is that all the factors affecting the dirunal curve cannot be consistently controlled and systematically varied by the experimenter. Anyone who has worked with the physiological indices of activation can appreciate the complex difficulties which arise in obtaining reliable results. For example, the amount of muscular activity in which the subject engaged before the experimental session may have significantly influenced the subject's coordination and steadiness in performing the nine-hole stylus task. It was also impossible for the experimenter to control effects of fatigue which accumulated over a period of days when the subjects were exposed to extended stressing situations such as a series of academic examinations.

Another factor which inevitably interferes with efforts to obtain "activation" data free from contamination by other variables, is the difficulty one encounters in controlling the direction of the subject's behavior over a long period of time. Although one may attempt to control the direction of behavior by using the same tasks and by controlling the external experimental situation, there is as yet no means of satisfactorily controlling the subject's attitudes toward the testing situation.[35] Perhaps an example would illustrate this point more vividly: On one occasion, when subject III was pressed for time, she seemed somewhat reluctant to go through the experimental session. This avoidance set appeared to have a marked effect on her performance - the number of seconds her stylus was in contact with the frame increased considerably and the number of numbers she matched correctly decreased. The following day, when this subject

[35] That is to say, there is no way of standardizing the task the subject sets for herself from session to session.

had plenty of leisure time, she again seemed very interested in the testing situation and her performance on both the number-matching and the nine-hole stylus tasks improved significantly. Some would argue that this shift in the direction of behavior would probably show up also in the intensity of her response, or her level of activation; however, this was not the case. The subject was tested at the same time of day and on both occasions her skin resistance was approximately the same. The incompatibility of her scores was obviously due to a shift in the direction of her behavior; for when the subject manifested a positive attitude toward the experiment, her performance rose to an optimal level. It appears, therefore, that before dependable results can be obtained in the investigation of activation theory, extensive research should be carried out to develop and standardize reliable methods and accurate techniques for controlling all aspects of the testing situation and for dealing with the complicated physiological processes involved in the individual's energy-releasing activities.

In view of the fact that different parts of the body are activated in such a way that the degree of arousal of any one area may be quite different from the degree of arousal of other areas, one possible interpretation of the results obtained in this study would be that - rather than negating a curvilinear relationship between activation level and performance level of sensory sensitivity - the data are consistent with the view that there are significant advantages in employing several physiological measures instead of relying on only one. Perhaps, too, if skin resistance measures had been obtained during a period of rest before performing the various tasks and correlated with the performance and sensory sensitivity measures, something more nearly approximating a curvilinear relationship would have been found. That is to say, possibly the initial level of activation prior to stimulation may have been more curvilinearly related to performance and sensory sensitivity than the level of activation after stimulation. Also, it must be pointed out that the range of activation as indicated by skin resistance in this study was fairly narrow, and perhaps an extension of this range would reveal curvilinearity.

Obviously, since experimental methods for controlling all the factors which affect the level of activation are still in a fetal stage of development, results of any kind in this area - whether positive or negative - are extremely difficult to interpret. It is, therefore, the opinion of the writer that the results of this study as well as those of any of the studies cited should not be taken as conclusive evidence for or against the curvilinear hypothesis.

APPENDIX A

Check if the two numbers are the same.

1. 0814914776 ----- 0814914776
2. 8359425074 ----- 8359425074
3. 0018483366 ----- 0018483366
4. 5299842104 ----- 4299842104
5. 8145011126 ----- 8145011126
6. 6939316793 ----- 6939316793
7. 2662503626 ----- 2662503626
8. 9330021854 ----- 9330021854
9. 7172518831 ----- 7172518831
10. 5290660561 ----- 5920660561
11. 0712728219 ----- 0712728219
12. 1591742137 ----- 1591742137
13. 1071395124 ----- 1071935124
14. 5796005683 ----- 5796005638
15. 4375605025 ----- 4375605025
16. 6744861562 ----- 6744861562
17. 4026623938 ----- 4026623983
18. 9095752162 ----- 9095752162
19. 0117790182 ----- 0117790182
20. 0845496561 ----- 0845496561

21. 8621453821 ----- 8624153821
22. 8197023142 ----- 8179023142
23. 4293393478 ----- 4923393478
24. 3037818495 ----- 3037818495
25. 4837397689 ----- 4837897698
26. 2156819342 ----- 2156819324
27. 0782129941 ----- 0782129941
28. 8409438074 ----- 4809438074
29. 2242967170 ----- 2242697170
30. 4100157467 ----- 4100157467

31. 8037695821 ----- 8037695821
32. 9776391328 ----- 9776391328
33. 2506302004 ----- 2506302004
34. 7150382970 ----- 7150382970
35. 6169283356 ----- 6169823356
36. 0426523100 ----- 0426534100
37. 7396445774 ----- 7369445774
38. 1575331831 ----- 1575313831
39. 5981720633 ----- 5981270633
40. 9226882581 ----- 9226882581

41. 5238267432 ----- 5283267432
42. 9439467879 ----- 9439647879
43. 1103341356 ----- 1130341356
44. 9666946031 ----- 9666946031
45. 8032798777 ----- 8032798777
46. 4194849970 ----- 4194489970
47. 5535381160 ----- 5533581160
48. 4320048243 ----- 4320048234
49. 3704446103 ----- 3704446103
50. 6546421671 ----- 6546421671

APPENDIX B

Subjects' Ranges of Electrical Skin Conductance (in Micromhos)

	Subject I	Subject II	Subject III
Nine Hole Stylus			
Hole No. 1	2.3-14.7	5.1-18.5	————
Hole No. 2	2.4-14.0	4.5-17.8	————
Hole No. 3	2.8-13.6	4.5-16.1	4.7-15.9
Hole No. 4	3.0-14.2	4.2-14.3	4.7-14.7
Hole No. 5	2.5-14.2	4.1-13.8	5.7-14.0
Hole No. 6	2.6-13.8	4.2-14.1	4.6-14.9
Number Matching	2.6-12.8	4.2-14.7	3.9-14.3
Auditory Threshold	2.8-33.3	4.1-17.8	5.1-16.1

APPENDIX C

Range of Measures

Time in contact, Nine Hole Stylus in hundredths of a second	Subject I	Subject II	Subject III
Hole No. 1	0-242	0-203	______
Hole No. 2	0-298	8-387	______
Hole No. 3	0-204	10-348	0-245
Hole No. 4	0-227	38-526	0-420
Hole No. 5	17-1199	70-670	0-463
Hole No. 6	109-880	407-1474	141-1956
Number Matching No. correct	21-36	24-40	16-30
Auditory threshold in decibels	-1 - -21	-14 - +10	-13 - +5

Range of Measures

Time in contact, Nine Hole Stylus in hundredths of a second	Subject I	Subject II	Subject III
Hole No. 1	0-242	0-203	——
Hole No. 2	0-298	8-387	——
Hole No. 3	0-204	10-348	0-245
Hole No. 4	0-227	38-526	0-420
Hole No. 5	17-1199	70-670	0-463
Hole No. 6	109-880	407-1474	141-1956
Number Matching No. correct	21-36	24-40	16-30
Auditory threshold in decibels	-1 - -21	-14 - +10	-13 - +5

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