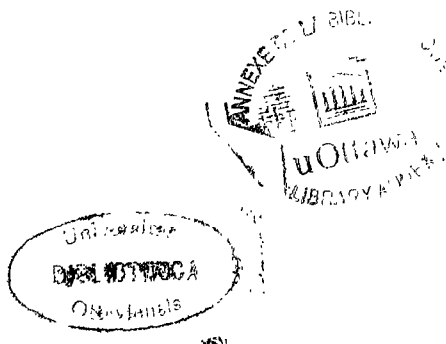


AN EXPERIMENTAL INVESTIGATION OF THE
EFFECT OF CHANGES IN THE SPEED OF PRESENTATION
OF COMPLEX VISUAL DIRECTIONS ON BI-MANUAL PERFORMANCE

by Bernard L. Bonniwell

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INTRODUCTION

The present experimental study was concerned with the effect of speed upon bi-manual performance. The primary object of the research was to determine if a complication of the task would reflect individual differences, and if so their magnitude and general profile characteristics. The literature, relative to this area of research, indicates a need for the analysis of individual performances in such tasks.¹

The study attempted to determine if speed, the independent variable, would distinguish initially between individuals in a bi-manual motor task involving a complication of visual directions. It was assumed that an increase in speed would bring about some tension or stress within the individual, leading ultimately to error in bi-manual response. Error was designated the criterion or consequent variable. The bi-manual performance test, consisting of three sub-tasks, was held constant and repeated at each of the five speed levels.

Empirical evidence suggested that individuals differ in their ability to cope initially with the speed factor,

1. Lazarus, R.S. and J. Deese and S.F. Osler, "The Effects of Psychological Stress upon Performance", in the Psychological Bulletin, Vol. 49, No. 4, Part 1, July 1952, p. 304, 307

especially in complex response situations where integration and time is of the essence. If these response differences are real, that is, not resulting from chance differences, then these differences ought to be subject to quantitative measurement. The present study is not concerned with the causes of these presumed differences but merely their presence and measurement under given conditions.

The study was limited to the responses accomplished during the administration of an unfamiliar bi-manual task, the task requiring approximately one hour for administration per subject. The study was not concerned with memory processes as such. It was not concerned with the establishment of habit patterns. It was not concerned with the effects of repetition upon learning. It recognized the de facto presence of these factors and others but was not attempting to exceed or verify the knowledge already reported by the many well established researches in these specific fields. The study was interested in obtaining objective records of initial performance in a new or unfamiliar motor response situation, in this instance, of one hour's duration. In substance, the question was: How does this individual perform in this new and unfamiliar tension provoking situation? It was an experimental attempt to duplicate the behavioral situation where the unfamiliarity of the experience is the crux of the problem for the

participating individual.

It was theorized that (a) if motor differences in initial response were quantifiable, the differences ought to be greatest at the point of first contact with a new problem, and, (b) that the introduction of some tension or stress ought to be the means of magnifying these assumed differences. What might occur with later practice was of no concern. It was observed that the fully accomplished motor task is a task free of tension or stress. Thus under the usual experimental learning conditions of X subjects, involved in adjusting to Y variables over a period of time, all subjects may eventually perform at Z capacity level, practice erradicating the initial recordable performance differences. The critical point of learning, proper to this study, is initial learning. The experimental design followed from the thesis that a given task is new only once. The principle has its counterpart in reality where the individual, momentarily involved in a near-fatal accident, is faced with a one-trial response task under stress where the criterion for success is not to err.

A search of the literature did not reveal a similar study. It was therefore necessary to design equipment and materials which would satisfy the demands of the investigation. These objectives having been attained, the final

test program was accomplished and certain response data accumulated.

The implications of the research, reported in detail under results and conclusions, may be summed up as follows: The use of complex visual directions introduced a selective factor (decision) which was sufficient to (a) bring about confusion in response, (b) temporarily interrupt the pattern of normal motor response, and (c) produce wide variations in individual performance. Interviews with the subjects confirmed these observations. It was concluded that the higher order function (decision) discriminates more effectively than the lower order function (motor) in this task. Theoretical and practical implications were then tacitly considered.

With the completion of these introductory notes, the following tasks now follow in order. A statement of the problem is given, immediately succeeded by a discussion of definitions and background material. A substantiation of certain of the introductory comment is noted in the review of the literature, especially those studies given to the investigation of motor stress effects which have appeared frequently during the past ten years under grants from the military.

With the information and cautions of past studies at hand, the present investigation then discusses in detail

the experimental design, the selection of subjects, the nature of the apparatus, and the procedures employed in developing and administering the bi-manual performance test. The analysis of results, statistical treatment, discussion and derivation of conclusions then conclude the body of the thesis. In keeping with this outline, a statement of the problem now follows.

CHAPTER I

STATEMENT OF THE PROBLEM

The problem was to investigate the effects, if any, of changes in the speed of presentation of complex visual directions on bi-manual performance.

The phrase, bi-manual motor performance, refers to the simultaneous use of both hands. For purposes of control, bi-manual performance was limited in this study to the coordinated response made by the index fingers.

The type of response required was complicated by the use of signs (arrowheads) which served as visual directions. The introduction of speed diminished the amount of time permitted to interpret the sign, adding stress (or tension) to the response demands.

The problem involved, therefore, was not only the ability to make correct coordinated motor responses but also the ability to organize response continuously under increasing conditions of complexity. It was assumed that individuals would respond to the test differentially.¹ But to what degree, if at all, the study sought to determine experimentally.

1. R.S. Lazarus and C. W. Erickson, "Effects of Failure Stress upon Skilled Performance", in the Journal of Experimental Psychology, Vol. 43, 1952, p. 103.

The following definitions are now given because they appear necessary for a full understanding of the problem.

Definitions

Proficiency: Proficiency stands for what the individual can do at any moment, that is, without further preparation. No reference is made to whether the response is primarily determined by inherited endowments or by the experiences of the past. In proficiency we are interested in finding out what power to respond the individual can manifest at the moment².

Capacity: Capacity refers to the highest level of ability to be expected from an individual after ample training and experience³.

Potentiality: This ability refers to reactions that the individual can learn to make if given the experience or training necessary but that at the moment he cannot perform. It signifies future promise, and is primarily, but not exclusively, conditioned upon inherited endowments⁴.

Discovery: The discovery process consists in obtaining some sort of information, usually through perception of stimuli, and the selection of the motor response to be made on the basis of this information⁵.

2. C. W. Brown and E. E. Ghiselli, Scientific Method in Psychology. New York, McGraw-Hill, 1955, p. 316.

3. C. W. Brown and E. E. Ghiselli, Ibid, p. 317.

4. C. W. Brown and E. E. Ghiselli, Ibid, p. 317.

5. W. F. Battig, "Transfer from Verbal Pre-training to Motor Performance as a Function of Motor Task Complexity," in the Journal of Experimental Psychology, Vol. 51, No. 6, 1956, p. 376.

Performance: The performance process involves the actual execution of the motor responses⁶.

Discriminate: Operationally defined as the score point difference (i.e., differentiation) which distinguishes the bi-manual performance of one subject or group of subjects from another.

Stress: A state of tension.

The distinction between discovery and performance is made by Melton⁷, the author noting that any motor task involves these two processes. The final term, stress, was defined operationally for purposes of this present study.

There was no attempt made to analyze the nature of stress or to differentiate among the many possible degrees. Stress was introduced experimentally to tease out, if possible, the various ways in which different individuals might initially react to discovery and performance when subjected to reasonably mild tension. The conceptualization of stress by Selye⁸ is neurologically pertinent but not the problem under investigation. The review of the literature which proved most useful was that

6. C. W. Battig, Ibid, p. 376.

7. A. W. Melton, "Learning", in W. S. Monroe's Encyclopaedia of Educational Research, Rev. Ed., New York, MacMillan, 1950, p. 668-690.

8. H. Selye, The Stress of Life, New York, McGraw-Hill, 1956, Chapter VII.

of Lazarus, Deese and Osler⁹.

The immediate discussion now turns to the background and conceptualization of the present study.

Background of the Study

The present study began some years ago and evolved from a routine observation of motor behavior and its temporary disorganization. It was evident that there were wide individual differences in this regard. The differences appeared to be marked and relatively persistent. Further, the differences seemed to be related to situations of a tension provoking type. Some individuals appeared to be more flexible than others, capable of maintaining efficient response even under increasing strain. A review of the literature did not, at that time, clarify appreciably the nature of the problem. The studies tended to report upon motor learning or mental learning whereas the problem appeared to be essentially one of the functional relationship between these factors. Quite early, it was assumed, that

9. R. S. Lazarus, J. Deese and S. F. Osler, "The Effects of Psychological Stress upon Performance", in the Psychological Bulletin, Vol. 49, No. 4 July 1952, p. 293-317 (Note: "The psychologist has no adequate way of defining the psychological condition that corresponds to the homeostatic steady state. Consequently, the use of the term stress must necessarily be a little looser than we would like it to be. When we speak of tension-systems, what we are really doing is postulating a psychological steady-state as a lack of tension" p. 295.)

any disturbance of the relationship between motor and mental functioning would cause some elementary and temporary disorganization in the total response system. Thus, it was felt, that a slip-of-the-tongue was neither a motor error nor a mental error, but rather, a sign of temporary malfunctioning of the response system. The unintended reversal of letters and numbers was considered to reside in the same category. These were conceived as functional errors, neither desired nor intended. Consideration was also given to the so-called errors-of-inattention. The illustration was noted of the professional teacher at the blackboard who misspells a word and does not recognize the misspelling. When his attention has been drawn to it, he indicates that he does not 'see' the error. Again, this type of error is quite different from the ordinary error which is recognized and immediately corrected. In this instance, however, the error persists and the subject is temporarily incapable of rectifying it.

The uniqueness of this type of behavior, noticeably observable in normal individuals under tension or stress, directed the experimenter's attention to the possibility of discriminating between individuals at this functional level of behavior. Perhaps it would serve as a more meaningful index to behavior than would the routine measurement of isolated mental or motor capacities. Thus

true differences among individuals might be more equably reflected in testing for complex functional capacity, under stress, than under the limited traditional methods of specific performances. The technique was allied to the work of Luria¹⁰,

Taking upon ourselves the problem of the study of the structure and dynamics of the processes of the disorganization of human behavior, we should stand firmly upon the ground of the psychological experimenters; we should on the one hand, produce the central process of the disorganization of behavior; on the other hand, we should try to reflect this process in some system accessible and suitable for examination. The motor function is such a systematic, objectively reflected structure of the neurodynamic processes concealed from immediate examination. And there lies before us the use of the motor function as a system of reflected structure of hidden psychological processes.

The theoretical concept of the functional relationship between motor and mental activities was then subjected to experimentation. The guiding principles were: (1) Motor response is subject to measurement. (2) motor response is initially directed by mental activity (decision), and (3) the functional relationship between the two is extremely sensitive. The question was: what would occur if tension was applied at (3)? Specifically, what would it have upon initial bi-manual performance?

10. A. R. Luria, Nature of Human Conflicts, or, Emotion, Conflict and Will, translated by J. E. Kanst, New York, Liveright, 1932, p. 18.

In two out of three preliminary experiments, bi-manual performance was employed by the writer with the experimental expectancy that the complexity of two-handed response would sensitize the situation and diminish the possibility of chance effects unduly affecting the results. A correct response required specific coordination of the hands. In each experiment the speed factor was employed as the tension producing agent. The experiments consisted of (I) a card sorting task, N-25, (II) a bi-manual performance paper-and-pencil task, N-110 and (III) a music note naming task involving mental set, N-220. The results of the three experiments were similar in objectifying motor difficulties as the speed factor was increased. Wide variations in individual performances were obtained. Subjects typically referred to confusion in response, temporary blocking and difficulty with the task when they attempted to hurry response. Objective results were obtained in experiments II and III although of a relatively crude form. In general, the experimental controls were not as rigid as desired in this type of research and it was difficult to determine the full significance of variations in performance. Further research was therefore planned.

The experimental approach was shifted from a group technique to that of individual testing, the presentation

of stimuli and the recording of responses being mechanically controlled. The experiment reported in the present study, therefore, differs essentially from the earlier work. It is of experimental interest to note that the results of the preliminary studies are in conformity with the findings of the present study.

In concluding the comments concerning the background investigations, a schema of two available research techniques was conceived as follows:

Measurement Method	Mental Activity		Motor Activity	Total Score	Test Format
Individual Test Technique	X		Y	X + Y	Summation
Functional Test Technique	X	x	Y	XY	Integration

The functional test technique (integration) was employed by the experimenter because it proved to be (a) more sensitive to individual differences, and (b) obtained a satisfactory range of variability in motor performance. Experimentally the functional test technique lent itself readily to the introduction of the stress factor. The probable effects upon bi-manual response were inferred from

the work of Luria ¹¹ and Selye ¹².

The contemporary literature contains many studies on the effects of stress upon mental activity, such as the reasoning process" ¹³. Frequent studies are also reported on effects of certain factors upon motor performance, such as reported by Gagne and his co-workers"¹⁴. The present study takes a mid-position: what is the effect of speed (or tension) upon the simultaneous functioning of motor and mental activities? Individuals may perform excellently in the tasks given individually. But how do they perform when the tasks are attacked simultaneously?

At this point, having noted certain preliminary work and given a concept of functional test technique as it applies to this study, the literature is now reviewed.

11. A. R. Luria, Ibid, p. 205.

12. H. Selye, Ibid, p. 32.

13. W. A. Lybrand, "The Effects of Certain Psychological Stress Conditions on Reasoning Performance", Thesis, University of Maryland, 1954, 119 p.

14. K. E. Baker, R. C. Wylie and R. Gagné, "The Effects of an Interfering Task on the Learning of a Complex Motor Skill", in the Journal of Experimental Psychology, Vol. 41, No. 1, 1951, p. 1-9.

Literature

The literature does not report bi-manual performance studies, involving the simultaneous integration of motor and mental components under tension, similar to the present study. The studies are of an either or character, emphasizing either the mental aspect or the motor aspect. The simultaneous functionalization of these two components under speed has been generally omitted.

Behavior usually requires a composite of activities, mental and motor, and it is difficult to visualize any conscious behavior totally free of both aspects. In this study, the speed factor represents experimentally the behavioral conditions under which response is frequently given, that is, under some form of routine or moderately stressful tension. From the experimenter's viewpoint it is difficult to hold as objectively real the statement that a given individual is ever without some degree of tension. Even equilibrium is a form of balanced tensions. All that can be granted is that the stable individual is less easily confused by swiftly impinging and demanding stimuli, compared to the easily confused individual. For purposes of this study these differences in response patterns are assumed to be of constitutional origin.

The literature reported upon was selected because it appeared most significant in its relation to structure

of the present study. Similar studies could not be located. The only study which makes use of bi-manual response in a manner approximating the present research is an early study reported by Beeby¹⁵. The title gives a clue to the nature of the investigation. This was a true bi-manual study. Both hands were employed, in similar tasks, simultaneously. Errors were counted. However, the subjects were blindfolded and always performed the same task with both hands. The experimenter made use of two brass squares and two metal stiluses, the task being to simultaneously follow around the squares in such a way that the contact between stilus-tip and figure was broken as seldom as possible. Both hands moved in an anti-clockwise fashion. Each break constituted an error, and was recorded kymographically. A particularly significant observation is made concerning the importance of skilled bi-manual performance and error in either hand¹⁶.

The total action then tended to 'crystalize out' around the dominant hand. The other hand simply followed. Such an organization about one constituent was always of a temporary nature, and was broken down by an error in the neglected hand.

15. C. C. Beeby, "An Experimental Investigation into the Simultaneous Constituents in an Act of Skill", in the British Journal of Psychology, Vol. 20, 1930, p. 336-353

16. C. C. Beeby, Ibid, p. 351.

The author concludes that when a factor prevents the formation of non-focalized consciousness there will be a resulting loss of efficiency in the performance of the constituents. Such a factor would be an error in either hand. The complexity of this bi-manual task, where the subject is forced to fluctuate attentively between the simultaneous action of the two hands, would be expected normally to lead to certain response difficulties. In general, the difficulties in response might be noted objectively in terms of blocking, omissions, time-lag, reversals, and simply making wrong responses. The accompanying degree of tension or stress, typically related to poor performances, would also be expected to differ among individuals. The polar extremes of the problem would be the individual who makes no error compared to the individual who errs on every response. Some individuals, under tension, might refuse to respond at all. The work of Hovland and Sears¹⁷ is a classically simple experiment affording insight into this problem of variation in motor response. Working with the vector and field concepts of Lewin, the authors developed a very simple yet interesting experimental technique to investigate the problem of conflict

17. G. I. Hovland, and R. R. Sears. "Experiments on Motor Conflict and their Modes of Resolution", in the Journal of Experimental Psychology, Vol. 23, 1938, p. 477-493.

situations. In brief, their procedure was to establish a situation of either direct or selective response to certain stimuli. Suddenly they presented the subject with neither expected stimulus, and then awaited the resolution of the problem. It was concluded there are four easily discernible kinds of reaction, three of which can be called resolutions (or solutions), and the fourth, complete blocking. The subjects, meeting a new and unfamiliar task situation, reacted differentially, some solving the problem by not reacting in any observable motor fashion. As in any complex mental-motor task, it is interesting to note that the subject may find a satisfactory solution in simple non-reaction.

In the bi-manual task, which is the subject of this thesis, some subjects simply refused to be hurried. This meant they permitted stimuli to pass unheeded. The inability to cope with the task did not disturb them. Upon inquiry, the subjects reported that it was the way (technique) in which they paced themselves and thus kept from becoming excited or confused. This form of non-response, which acts to preserve the balance of the response system, is admirable in some situations but not acceptable in rigorous situations requiring immediate response, such as in air combat where hesitancy in response may result in loss of life. Other subjects reported a quite different

problem. They were unable to resolve a given stimuli pattern and found their motor responses temporarily immobilized. The research work of Postman and Bruner¹⁸ bear on this particular aspect of motor response.

The problem of blocking, in a motor system, appears to be extremely complicated when related to the mental aspect of the task. Thus the authors states¹⁹: "On the most general level, we may say that multiplicity of set or intention impairs the efficiency of perceptual selectivity". The inability to respond, temporarily, in a bi-manual task may have particular relation to this finding. Individual differences, whatever their origin, appear to be involved. In attacking the problem of multiple set experimentally, the authors were able to conclude that multiple set, at the level of recognition, serves strikingly to inhibit the effects of practice. In addition they noted that there appeared to be important individual differences in perceptual flexibility, i.e., in the ability to adapt to new perceptual situations. The experimenters concluded that multiple set impairs the efficiency of perceptual selectivity. In the present thesis, the employment of

18. L. Postman and J. S. Bruner. "Multiplicity of Set as a Determinant of Perceptual Behavior". in the Journal of Experimental Psychology, Vol. 39, No. 3, 1949, p. 369-377.

19. L. Postman and J. S. Bruner. Ibid. p. 376.

complex visual directions resulted in the same form of response difficulties. Subjects reported they were unable to decide upon the correct response when under severe tension. The subject referred to tension by referring to the speed of presentation of stimuli, such as speed 60, or speed 75, or speed 90. The speed factor is discussed under the experimental apparatus and its use in the bi-manual performance test.

The complexity of mental-motor functioning, reflected in the initial aspect of bi-manual response under increasing tension (speed), was inferred from the experimental results of Ausubel and co-workers²⁰. They found that individuals classified under high and low anxiety groups, were differentiated, on the first trial of a maze task. The high anxiety group required more time and made more errors. The differences were significant. The authors conclude²¹,

It is precisely with respect to the need for improvising solutions to new problems that the individual with personality anxiety experiences feelings of inadequacy.

20. D. P. Ausubel, H. M. Schiff and M. Goldman, "Qualitative Characteristics in the Learning Process Associated with Anxiety", in the Journal of Abnormal and Social Psychology, Vol. 48, No. 4, 1953, p. 537-547.

21. D. P. Ausubel, H. M. Schiff and M. Goldman, Ibid, p. 544.

In the present thesis, subjects who tended to have difficulty with speed increments, reported approximately the same reactions. They recognized their ability level as having been attained at a given speed. Knowledge that the task required further responses at even higher speed levels, initiated some apprehension and resulting motor tension. The subjects discussed the matter quite freely and candidly. The theoretical aspects of this phase of performance is cogently summed up by Gregory²² in his report on a speculative account of brain function. The author likens the brain to an induction machine continually making decisions, stating for his first principle the following:

The decision mechanism is limited in capacity, both in regard to speed of making reliable decisions and number of decisions made simultaneously. We postulate a maximum decision rate. Within limits, reliability of decisions will increase with extra time allowed.

The present thesis would tend to re-express this concept in terms of individual differences, said differences being assumed as constitutional and subject to only limited modification. Stated by Hick²³, the viewpoint is:

Selection of a few out of the vast number of incoming channels is thus one of the functions of the brain. But it also imposes a code transformation on the information it does condescend to receive before passing it on to the musculature.

22. R. L. Gregory, "A Speculative Account of Brain Function in Terms of Probability and Induction", mimeographed publication of the Psychological Laboratory, Medical Research Council, Cambridge (APU/183/52), 1952, p. 4.

23. W. E. Hick, "Why the Human Operator?", mimeographed publication of the Psychological Laboratory, Medical Research Council, Cambridge, (APU/181/52), 1952, p. 6.

In a bi-manual task, the mental-motor function is projected over a continuum of time, that is to say, it is an event over time. Decision, stated as the resultant of voluntary activity upon the part of the subject, involves a refractory period in any motor task. There is a sequential function involved. The significance of this time element is succinctly expressed by Conrad²⁴.

This term, as applied to voluntary responses, means the short period, following the receipt of a signal to respond, during which another signal (for a second response) cannot take place.

The present thesis, facing the individual with a bi-manual task involving decision and speed, attempted to set up such an experimental response situation. At high speeds some subjects reported their inability to clear themselves of a blocking stimuli pattern. They reported that they could not free themselves immediately in order to proceed with the newly presented stimuli. They said they were conscious of the difficulty. Two subjects compared the situation to 'freezing at the wheel' of an automobile. They knew what they wished to do, but could not bring about the necessary responses. These motor blocks, if this is the proper term, accounted for part of the quantification of

²⁴. R. Conrad, "Issued Signals in a Sensori-Motor Skill", mimeographed publication of the Psychology Laboratory, Medical Research Council, Cambridge. (A 3/187/53), 1953, p. 22.

individual response differences. Individuals also reported that even when they knew they had made a mistake in interpreting the visual stimuli, they could not withhold the outgoing motor response. Conrad²⁵ comments on this phenomena stating:

The emphasis here is another way of looking at the matter - namely, that a decision, once taken, cannot be immediately revoked.

In an initial bi-manual mental-motor sequence, there is a logical and necessary order of events. In order to respond successfully to a given stimuli the continuum is: Stimuli-apprehension-decision-response. This continuum can be temporarily disrupted by stress. The disorganization of the continuum may occur in any one or a number of the following areas: (1) The stimuli may be apprehended incorrectly, (2) in a selective or choice situation, the wrong decision may be made, and (3) even when the proper decision is reached, the motor response may be erroneous or (4) temporarily blocked. The psychological response system is complex and subject to two main sources of disorganization, internal and external. In the present thesis, external stress is applied through the use of speed. Differences in internal stability are presumed, where stability is considered to be synonymous with efficient response under conditions of increasing tension.

25. R. Conrad, Ibid, p. 22.

Under normal response conditions, the voluntary direction of response is accepted as a basic tenet. A study by Katchmar, Ross and Andrews²⁶, however, directs attention to the effects of stress even upon volition.

The stresses employed in this study may be considered to have interfered with the voluntary ability to shift rapidly from one aspect of the situation to another.

The authors indicate that even relatively high anxiety does not interfere with performance until the situation becomes stressful. In the present thesis, this finding was corroborated, subjects reporting their response ability uninterfered with until the speed factor exceeded their proficiency level.

In concluding the review of the literature, it is evident that the present thesis owes direction to the many related studies. The emphasis of the present bi-manual study is upon individual differences, the importance of the approach being stated by Brown and Ghiselli²⁷: "We should convince ourselves that the observation of differences is just as important as the observation of similarities".

The advance of the study now requires the stating of the working hypothesis.

26. L. T. Katchmar, S. Ross and T. G. Andrews, "Effects of Stress and Anxiety on Performance of a Complex Verbal-Coding Task", in the Journal of Experimental Psychology, Vol. 55, No. 6, 1958, p. 562.

27. C. W. Brown, and E. E. Ghiselli, Ibid., p. 194.

Working Hypothesis

Based upon the empirical observation of variations in behavior resulting from tension, the experimental expectancy of individual bi-manual performance under speed, was as follows:^{28 29}

- (1) The motor task would not discriminate
- (2) The decision task would discriminate and individuals would 'fail' at different levels of speed (tension)

It was predicted that a small percentage of response errors would tend to be of the following types: reversals, omissions, and extra or unrequired responses³⁰. It was also predicted that individual performance profiles would be variegated. The types or classification of profiles could not be predicted, although the theoretical and practical value of being able to predict individual performances is noted in the literature³¹.

28. J. C. Townsend, Introduction to Experimental Method, New York, McGraw-Hill, 1953, p. 45-51.

29. C. W. Brown and E. E. Ghiselli, Ibid, p. 164.

30. P. M. Fitts and R. E. Jones, "Analysis of Factors Contributing to 460 'Pilot-Error' Experiences", photo-duplication copy, Aero Medical Laboratory, Wright Air Develop-Center, Ohio, July 1947, p. 1-32. (Note: Reversal Errors, Confusion Errors, Adjustment Errors, Forgetting Errors, Unintentional Activation Errors, p. 10-18.)

31. R. S. Lazarus, J. Deese and S. F. Osler, Ibid, p. 307.

With the completion of the statement of the problem, the review of the literature and the working hypothesis, the immediate task is a presentation and discussion of the experimental design.

The topic, experimental design, now follows.

CHAPTER II

DESIGN OF THE EXPERIMENT

In the present investigation the term speed is associated with the general concept of stress or tension as reported in the literature. The nature of stress or tension, however, is not under discussion. The experimental means of increasing stress or tension was implemented in the present bi-manual response task, through a demand for greater speed in response to complex visual stimuli. In a bi-manual task, where coordination is a prerequisite, the speed factor is of consequence.

Experimental Design

Figure 1. - Research effort was directed towards the construction of a test instrument which would involve some form of increasing stress, but stress that would be applied intermittently rather than persistently. The stress situations in real life are usually intermittent, where temporary surcease is obtained by one technique or another, depending on the needs of the situation and the adjustment capacities of the individual. The test was purposefully constructed such that stress could be applied, then diminished, with the expectation that individuals might recover psychological poise during this

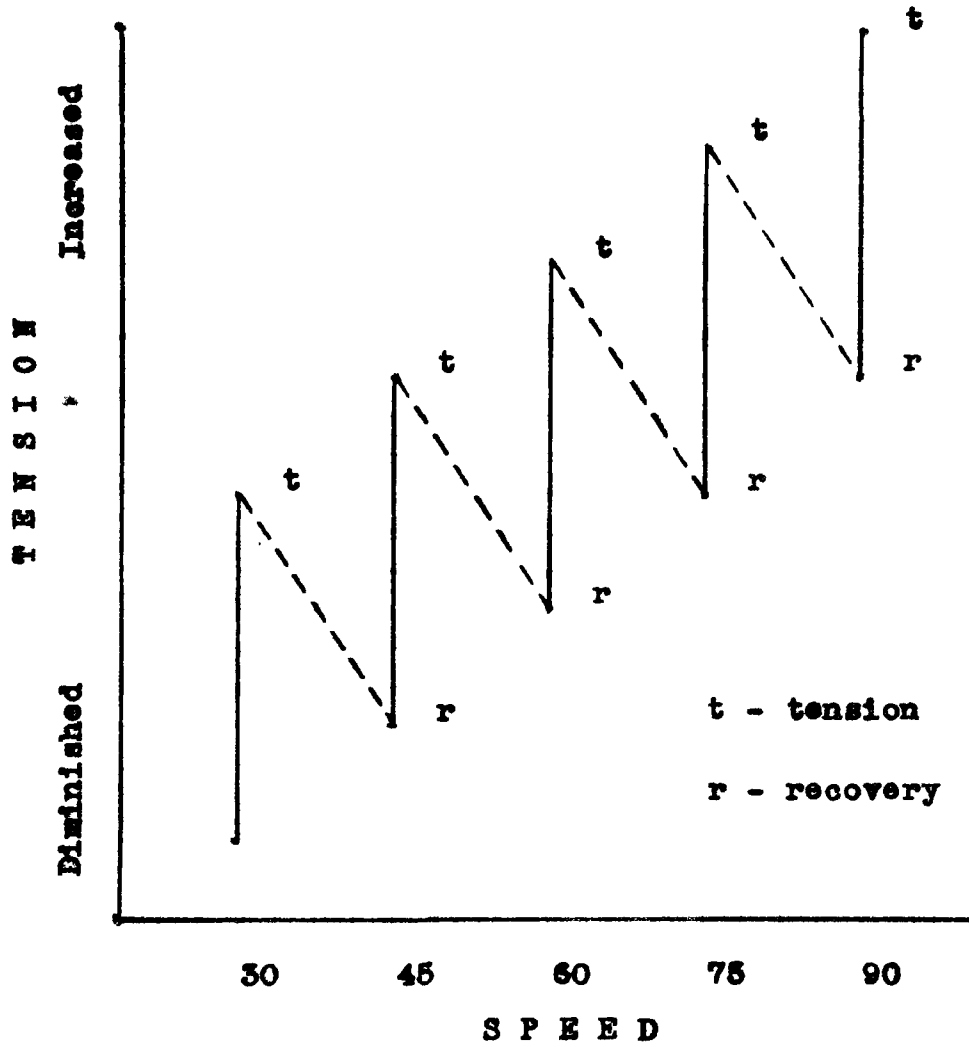


Figure 1. Conceptualization of the Relationship between Tension and Recovery as a Function of Speed

period of lessened tension. When stress was again applied, the individual would be, at least theoretically, in an improved response situation. The experimental procedure, therefore, introduced a recovery or reorganization period following each application of stress. The overall attempt was to tease out the best effort or highest proficiency level for each individual¹. There was no direct interest in forcing an individual into erroneous responses. Experimental interest was directed towards the attainment of the highest proficiency level of which this individual was capable under these conditions.

The general design of the present investigation, suggested by the design used by Lybrand², is now presented in Table I, following.

1. E. Kretschmer, A Textbook of Medical Psychology, translated by E. E. Strauss, London, Hogarth Press, 1952, p. 48-57 (Psychomotility: "We must emphasize the fact (...) that with regard to the type of psychomotor predisposition in normal persons it has not yet been possible to establish with any certainty what parts of the whole psychomotor system are responsible for idiosyncratic peculiarities (...) Normal psychomotor patterns demand not only intactness of each separate participating element of the motor system, but, above all, smooth integrated functioning (...) p. 54)

2. W. A. Lybrand, "The Effects of Certain Psychological Stress Conditions on Reasoning Performance". Thesis, University of Maryland, 1954. p. 30.

Table I. - General Design of the Investigation to Determine the Relative Proficiency of Bi-manual Response to Three Differentiated Sub-tasks Exposed Visually at Five Different Speed Levels

Bi-manual Test	S p e e d ¹				
	30	45	60	75	90
Repetition Task	(1)	(1)	(1)	(1)	(1)
Motor Task	(2)	(2)	(2)	(2)	(2)
Decision Task	(3)	(3)	(3)	(3)	(3)

1. SRA Accelerator Speed Settings. Sequence 1-3, repeated at each speed level.

The bi-manual performance test required the subject to respond quickly to visually presented stimuli by simultaneously depressing two keys, one with either hand, on a special recording device. The exposure speeds, relative to the five speed levels, are given in the following section, page 29, the footnote.

The sequential relationship of the three sub-tasks, ranging from the least difficult to the most difficult, was significant in the design of the bi-manual performance test. The three sub-tasks of the test were presented in an ascending order of difficulty. The order was:

Repetition Task

Motor Task

Decision Task

The repetition task, Task R, was the simplest of the tasks. The motor task, Task M, was relatively complex. The decision task, Task D, was the most difficult and discriminating of the three sub-tasks.

The length of the bi-manual test, approximately 1 hour, was adjudged sufficient to permit the individual

3. Refer Appendix 1.

to overcome any initial nervousness which might have inhibited motor response. The practice period was employed for the direct purpose of permitting individuals to calm down. During the practice period, usually lasting between five and ten minutes, the requirements of the test were explained. The subject was then given use of the recording apparatus, practicing until he had attained sufficient ability to make clearly printed responses. Because of the extreme simplicity of the practice task, depressing two keys, the time required was usually one or two minutes.

The technique employed in this study was in contrast to the use of false norms, administrative pressure, reporting of erroneous scores and similar devices. The subject was always aware of his progress. He was aware of the speed factor. The general tenor of the testing situation was informal and no attempt was made to emotionalize the subject. The subject was offered verbal encouragement when it appeared necessary, otherwise the testing went on routinely. The test challenged the subject, attention and interest becoming increasingly evident with the continual increase of speed.

Apparatus and Procedure

The apparatus consisted of two standard mechanical devices. The devices were the SRA Reading Accelerator⁴ and the common Stenograph Machine⁵. The Accelerator was used as a timing and exposure device. The Stenograph was used for purposes of permanently recording bi-manual responses. In summary form the experimental apparatus was the following:

<u>Exposure Apparatus</u>	<u>Recording Apparatus</u>
SRA Reading Accelerator	Stenograph
Covering Shield ⁶	Keys ⁹
Slit-Window ⁷	Paper Tapes ¹⁰
Stimulus Sheets ⁸	
Speeds 30, 45, 60, 75, 90	

-
4. SRA Reading Accelerator, Model 1341, Chicago.
 5. Stenographic Machines, Inc., Chicago.
 6. Opaque paper, firm, 6-7/16 x 11 inches, attached to lower edge of Accelerator Shutter Bar when retracted.
 7. Slit-Window: 1-5/8 inches in length, 3/16 inches in width, located in Covering Shield, 1 inch from top, centered and lying horizontally.
 8. Stimuli Sheets, Appendix 1.
 9. Keys: O and U, front row, operated by the index fingers, left and right hand respectively.
 10. Paper Tapes: one standard filler accommodated 3 subjects for five response levels.

The only modification made to the Accelerator was the addition of the opaque shield which served to cover the stimulus sheets when laid upon the inclined surface (i.e., Reading Stand). The Covering Shield was attached to the lower edge of the shutter bar when retracted. This procedure permitted the subject to view the stimuli through the slowly moving slit-window. The slit-window, actually an opening just large enough to accommodate typed stimuli¹¹, was 1-5/8 inches in length and 3/16 inches in width. The slit-window was located in the Covering shield, 1 inch from the top and centered, providing a horizontal exposure.

The Stenograph was unmodified other than for the addition of white tape on the two response keys. The tapes served to identify the keys. In some instances this was an important precaution, especially when a subject inadvertently removed his fingers from the keys and had to quickly return to the response position. The only two keys employed on the Stenograph are found on the front row and are marked O and U, being easily operated without interference from adjacent keys. No difficulties were encountered in respect to this aspect of bi-manual response.

11. Appendix 1. The exposure speed per line, measured in seconds, was approximately: Speed 30, 3.5" per line; speed 45, 2.3" per line; speed 60, 1.7" per line; speed 75, 1.3" per line; and speed 90, 1.1" per line.

The two machines, the Accelerator and the Stenograph, were placed before the subject on a table 37 inches in height. The Accelerator was to the right, the Stenograph to the left, the subject being permitted to position the machines slightly for his own convenience. The movement of the machines was no more than one or two inches, the subjects re-positioning the devices on the bases of vision and the facility of motor response.

The subjects remained standing, hands resting lightly on the stenograph keys. The subjects expressed a preference for the standing position, stating that it permitted greater flexibility in adjusting to the task. A second, and preferred experimental factor, was the ability of the subject to free himself of some tension by simply moving away from the machines during the few seconds it required to change the stimulus sheet and put the Accelerator in the "ready" position.

All the subjects were tested in a room set aside for this purpose. The subjects were tested at one hour intervals, testing beginning at 1PM. The light was good, daylight ceiling lights flooding the room¹². No subject reported visual difficulty. A total of three subjects

12. Testing Period: It was necessary to schedule the tests in the afternoon due to class schedules.

were tested daily, all tests being carried out by the experimenter. The testing sessions were held only on weekdays. The testing sessions continued for approximately one month. The subjects were cautioned not to discuss the specific nature of the test with others. Observation of the subjects who had not yet taken the test indicated that the earlier subjects were cooperating effectively. Subjects were not aware of what was expected of them in terms of significant details.

In regard to the mechanical apparatus, a further discussion of the use of the Accelerator and the Stenograph is given in Chapter III. It is of interest to note that the need for these particular machines was dictated by the task itself. The complicated bi-manual task required these devices for satisfactory exposure and recording purposes. Actually, the desired instrumentation is not available¹³. The present coordinated apparatus makes use of a step-interval speed technique, represented by the Accelerator at speeds 30, 45, 60, 75, and 90. A more subtle recording, it is proposed, would be obtained if the speed technique was of a stepless-variable type. Such exposure-recording

13. W. Grings, Laboratory Instrumentation in Psychology, California, Palo Alto, National Press, 1954, p. 282.

apparatus is now under experimental investigation.^{14 15}

Attention now turns towards the subjects and their selection. Having completed a presentation of the experimental design, apparatus and procedure, the logical task is to enquire into the nature of the test group.

Subjects

The subjects were fifty male college students. The average age was 21.7 years. All subjects were white with the exception of one negro. The subjects were obtained with the understanding that they would be available for two and one-half hours of testing. The time was distributed as follows: 1 hour for the bi-manual performance test, 1 hour for paper and pencil tests, and 1/2 hour for the discussion of individual results. The three phases of the investigation were given at different times. The total commitment for all fifty subjects was approximately 80 hours.

14. G. Auth, Director, Mechanical Engineering Division, Villanova University. (Note: An original, mechanical stepless-interval exposure-recording device is now being subjected to exploratory investigation.)

15. J. Hicks, Assistant Professor, Electrical Engineering Division, Villanova University. (Note: An electronic approach has been instituted, the principal elements of the exposure-recording device consisting of a thyratron controlled D. C. motor with bi-manual responses to be electrically recorded on paper tape.)

The total college group, N-50, was divided into three sub-groups. The sub-groups, identifying symbols, the criteria for selection, and the related N's are given in Table II.

The sub-groups were purposefully instituted on the assumption that, when bi-manual performances were compared, the differences would tend to be as follows¹⁶:

- Group N Average performance would be superior to Group V and Group S
- Group V Average performance would fall between that of Group N and Group S
- Group S Average performance would be inferior to Group N and Group V

The performance of Group N was expected to excel because these subjects, Naval Reserve Officer Training Corps candidates, were pre-selected mentally and physically and generally superior individuals.

The performance of Group S, was expected to be poor. With the increase of tension in the bi-manual task, it was presumed that errors in response would increase. These subjects (neurotic mild) were selected by the experimenter on the basis of observed behavior.

16. C. V. Good, and D. E. Scates, Methods of Research; Educational, Psychological, Sociological, New York; Appleton, 1954, p. 289. (Note: "The choice between extensive and intensive study must be made (...) on careful consideration of the kind of knowledge one wishes to obtain".)

Table II. - Subjects

Sub-groups	Bases for Selection	N
College (N)	NROTC	10
College (V)	Volunteer	30
College (S)	Selected	10
	TOTAL	50

N - Navy Reserve Officer Training Corps
 V - Volunteer
 S - Selected (Neurotic, Mild)(Observed behavior)

The volunteer group, N - 30, was obtained by asking for volunteers in class.

Two paper-and-pencil tests were given to each of the fifty subjects. The first test was an intelligence test¹⁷. The second test was a manifest anxiety scale¹⁸. The relationship of intelligence and of anxiety, as measured by these devices, was judged to be of value in an analysis of results obtained from the tension provoking bi-manual performance test.

With the selection of subjects completed, the introduction of the subjects to the bi-manual performance test followed as a matter of logical procedure.

The succeeding chapter, Chapter III, describes the bi-manual test in detail.

17. A. S. Otis, Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form D, New York, World Book Company, 1939.

18. J. A. Taylor, "A Personality Scale of Manifest Anxiety", in the Journal of Abnormal and Social Psychology, Vol. 48, No. 2, 1953, p. 285-290.

CHAPTER III

BI-MANUAL PERFORMANCE TEST

The Test

An experimental investigation of the (a) effect of changes (b) in the speed of presentation (c) of complex visual directions (d) on bi-manual performance required a specific type of performance test. It was necessary that the test contain certain characteristics relative to both motor and mental components. It was essential that the test represent a functional test approach, that is to say, both motor and mental elements frequently occurring concomitantly. A discussion of this matter has already been given in Chapter I, background of the study.

A search of the test literature did not indicate the availability of the required bi-manual test.¹

The especial needs of the test, characterized by initial simplicity (repetition), increasing motor complexity (motor task), and finally the super-impositioning of a mental component (decision) upon the motor task, distinguished this bi-manual performance test from those reported in the literature. The test format is discussed

1. O. Buros, Fourth Mental Measurements Yearbook, New Jersey, Gryphon, 1953, xxiv-1163 p.

in outline form in Chapter II, under experimental design. A graphic conceptualization is given in Figure 1.

The problem of instituting complex visual changes, while not disturbing the composition of the motor task, was accomplished by the introduction of arrowheads². The direction of the arrowhead gave particular significance to the stimuli³. The reversal of the arrows, the use of double-headed arrows, and even the omission of arrowheads, proved sufficient to complicate the task at the level of decision (Task D). When the arrowheads became a part of the total bi-manual response task, the stimuli then had to be interpreted (decision) and could no longer be responded to in terms of direct vision (motor task). Thus Task M (Motor task) was quite different from Task D (decision task).

The super-impositioning of Task D (decision) upon task M (motor) was accomplished in terms of a favorable experimental technique. Task D was an exact copy of Task M. The decision task differed from the motor task only in the addition of the arrowheads. A review of the bi-manual performance test, Appendix 1, indicates that pages 2 and 3 are comparable to pages 4 and 5, the patterns of stimuli being similar. The differences in the

2. Appendix 1, p. 4, 5.

3. Appendix 2, p. 3, 4.

tasks lie in the introduction of the arrowheads. If a subject could perform well on Task B, the motor task, and yet found great difficulty with Task D, it was inferred that the decision component was of significance in total response.

The problem of speed was worked out on the basis of exploratory findings. Various forms of visual presentation were attempted. Various forms of stimuli were considered. The outcome favored a very simple, easily perceived visual stimulus. The experimental effort was to locate stimuli of sufficient difficulty to discriminate among individuals, if possible, while not yet being so difficult as to confuse the subject. The use of typed stimuli proved satisfactory.

The bi-manual test was basically developed from the use of the single letter O. A referral to the actual Bi-manual Performance Test, Appendix 1, indicates the use of the symbol O in various configurations. When introducing increased speed, the symbol patterns remained perceptively intact, and the subjects did not report any difficulty in this area. At no time did the subjects indicate, in any manner, that they were having difficulty in perceiving the pattern of stimuli. This held true, regardless of the speed of presentation and the necessary introduction of the arrows in Task D (decision). Subjects frequently reported difficulty in interpreting the arrows, especially

under increased speeds of 75 and 90, but did not report visual difficulties. The subjects were carefully queried on this matter.

The actual bi-manual performance test was, therefore, an organized dual response, made by the index fingers to variations in the following basic stimuli patterns:

	0	0	
Left Hand	00	00	Right Hand
	0	00	
	00	0	

The initial response was always simultaneous. Both index fingers always depressed the respective recording keys (Stenograph Machine) at one and the same moment. In those instances where either the left hand or right hand had to make an additional response, such as under conditions 0--00, and 00--0, the initial phase of the total response was still accomplished simultaneously. Under high speed, 75 or 90, this became an absolute prerequisite. The exposure time was so limited that the subject was forced to make simultaneous responses merely to keep pace with the machine. If responses were not made simultaneously, errors were counted. The permanent records, obtained from the Stenograph, indicated whether or not the subject was conforming to this demand.

The Bi-manual test, sub-divided into the three sub-tasks, repetition (Task R), motor task (Task M), and decision task (Task D), is structured in terms of the different use of the basic stimuli. Thus:

Task R	Task M	Task D
O O	O --- O	O ← O
O O	OO --- O	OO --- O
O O	O --- OO	O ←→ OO
O O	OO --- OO	OO --- OO

In the actual test, Task R consisted of 32 lines of repetitious bi-manual response patterns. The patterns appeared in groups of four lines each.

Task M consisted of 64 lines of randomized stimuli patterns. As in the preceding task, the patterns appeared in groups of four lines each.

Task D consisted of 64 lines of stimuli patterns similar to the motor task. Differentiation and complexity had been added by the use of arrows which modified the meaning of the symbols.

The total number of coordinated responses, made by each subject in completing the entire test at all five speed levels, is given in the succeeding table, Table III.

The total number of bi-manual responses made by all fifty subjects was 40,000, this sum representing all

Table III. - Total Number of Bi-manual Responses Made by the Subject on the Bi-manual Performance Test

Task	Response Patterns		Speed Levels	Bi-manual Responses
Repetition	32	x	5	160
Motor	64	x	5	320
Decision	64	x	5	320
			TOTAL	800

responses to the three sub-tasks⁴. The comparative data for the individual profiles obtained from a study of Task M and Task D, involved 32,000 bi-manual responses⁵. The difference, 8,000 was accounted for by Task R, the repetition or recovery task. The task of repetition was so simple as to provide no meaningful differences at any speed level and, in some instances, was an easily memorized motor task. The purpose of this task, Task R, is stressed in the design of the experiment, Chapter II.

A brief description of the three bi-manual sub-tasks and the related patterns of stimuli is now given:

Task R	(Repetition)	Employed initially to check on the possibility of bi-manual motor difficulty.
		This task represented the basic qualifying task for all subjects. The principal use of this task, however, was to provide a period of recovery from the effects of tension.
0	0	
0	0	
0	0	
0	0	
00	00	
00	00	
00	00	
00	00	
(etc.)		

4. The sum total of individual movements made by the two index fingers of each subject was 2,410; for all fifty subjects, 120,000 flexions.

5. Refer Table IV, Analysis of Errors.

Task N	(motor)	A relatively difficult bi-manual motor task involving the coordinated use of both hands. The stimuli was variable and required the simultaneous depressing of a mechanical key under the control of each index finger. The stimuli were presented visually and in random order, repeated at each of five speed levels.
0	--- 0	
00	--- 0	
0	--- 00	
00	--- 00	
0	--- 00	
00	--- 00	
0	--- 0	
0	--- 00	
	(etc.)	
Task D	(decision)	A duplication of Task N, complicated by the use of arrows which modify the meaning of the stimuli. Depending upon the direction of the arrows or a line the subject must accommodate the bi-manual response accordingly. This task involves the motor aspects of Task N plus the added factor of immediate decision under increasing speed.
0	← 0	
00	← 0	
0	← 00	
00	← 00	
0	--- 00	
00	--- 00	
0	← 0	
0	→ 00	
	(etc.)	

The complete Bi-manual Performance Test, as previously noted, is located in Appendix 1. A brief survey of the actual test indicates the relationship of the three sub-tasks and the use of arrowheads to distinguish the decision task. The question now arises as to the details related to the administration of the test.

A discussion of test administration, in this particular test situation, encompasses a discussion of the relationship between the three correlated units. The test units are: (a) the exposure apparatus (Accelerator), (b) the recording apparatus (Stenograph), and (c) the Bi-manual Performance Test itself.

Test Administration

The bi-manual Performance Test was administered in a sequence of six steps:

- a. The subject was given Instructions for the operation of the Recording Apparatus.
- b. The Bi-manual Performance Test was explained.
- c. The Exposure Apparatus and its use with the Bi-manual Test was indicated.
- d. The role of the Experimenter was noted.
- e. The test was begun at Accelerator speed 30.
- f. The Bi-manual Test was repeated at speed levels 45, 60, 75 and 90. (Testing time: 1 hour)

The Accelerator was placed on the testing table, slightly to the right of the subject⁶. In adjusting the positioning of the Accelerator, the subject was enabled to gain the optimum visual distance for accurate perception of the stimuli.

The speed of the Accelerator, governed by moving the vertical marker, was set for the first speed level at speed 30. The bi-manual test began at this initial speed. The entire test, pages one to five, was exposed before the marker was changed to speed 45. The full test was then given at this new exposure speed. The same procedure was repeated for all five speed levels, 30, 45, 60, 75 and 90.

The Stereograph (recording machine) like the Accelerator, was free and capable of being moved by the subject until a comfortable position had been attained. In general, the machines were roughly parallel, although most subjects preferred to place the Accelerator at a slight angle to the recording machine. Once the actual test began, few subjects changed the position of either machine. The original positioning of the machines appeared to be satisfactory.

6. Calibration: Preceding each administration of the test, the Accelerator was permitted to operate and checked for running speed. If required, standard calibration procedure was carried out as suggested in the 3HA Reading Accelerator Manual of Instructions.

The subject was introduced to the Recording Machine and given instructions and time to acquaint himself with its operation.⁷ The experimenter checked that the recording tape (paper tape 2-3/8" wide) was sufficient for the complete recording of the task. It was critical that the recording machine was properly checked in this regard. The bi-manual response task could not be interrupted.

The two keys used for response, O and U were at the front of the machine. The subjects never changed from these two keys. The left index finger operated the key to the left, marked O. The right index finger operated the key to the right, marked U. The subjects tended to hold their hands positioned above the keys, apparently obtaining a greater sense of confidence with this procedure than under a procedure suggested by the experimenter. It was originally suggested that the hands might be supported by resting the unused fingers on the metal framework of the machine, the index fingers thereby being free to make the responses accurately and without error. Only one or two of the fifty subjects made use of this technique. The remaining subjects reported a desire to keep the hands free and so more mobile. Some subjects reported that when the hands were supported on the framework of the machine, tension developed and a cramped feeling resulted. Subjects were

7. Appendix 2, Test Instructions

permitted to attack this problem in the manner most suitable to their own needs. Subjects accomplished this bi-manual response task efficiently, displaying no difficulties in this motor phase of response.

It was necessary for the experimenter to assume a participating role during the testing procedure, certain mechanical limitations of the machines making this procedure mandatory. The experimenter clearly explained his position to the subject just before the actual testing began, simply stating: "It is necessary to move this paper tape forward. It has no effect whatever upon your response. It is done only for scoring convenience." A check upon the bi-manual performance test, Appendix 1, indicates the necessity of this procedure. The stimuli are always grouped in series of four lines, followed by a brief opening. By manually drawing the tape forward a quarter of an inch upon the completion of each group of stimuli, the relationship between the presentation of the stimuli and the recording of the responses was maintained.⁸ Without this procedure, scoring of tests would be impossible. There would be no way of ascertaining the relationship between specific stimuli and the required responses.

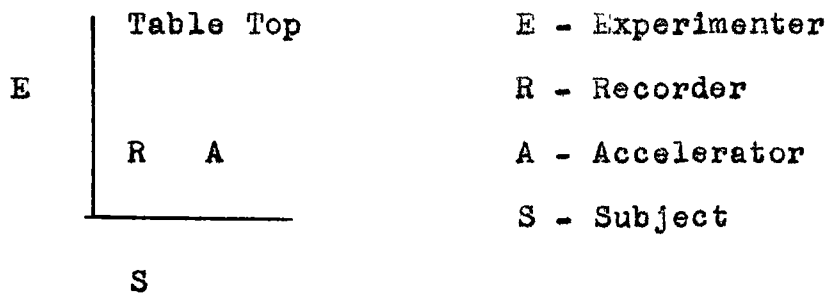
8. Appendix 3, Scoring Keys

Expressed graphically, the technique displays the relationship between the grouped stimuli and similarly grouped responses:

Stimuli		Response	
0	0	0	0
0	00	0	00
00	0	00	0
00	00	00	00
00	00	00	00
00	00	00	00
00	0	00	0
0	0	0	0

In actual practice, after some five hours of testing, the task for the experimenter became so habitual as to be almost meaningless. Simply listening to the responses on the Recording Machine was sufficient clue for the forward movement of the tape. The paper tape was held lightly between the thumb and forefinger at the point of issue from the Recording Machine roll. When the sequence of four lines of stimuli had passed from view in the slit-window, the tape was gently tugged forward. There was no sound in this operation. The subjects stated that they were not disturbed by the experimenter's presence. The subject was intently peering at the Accelerator and quite likely unaware of the continuing role played by the experimenter. However undesirable this technique may be from an experimental point-of-view, it was necessary and

had to be carried out for purposes of scoring⁹. The experimenter remained standing at the left side of the testing table, completely removed from the subject who stood facing the machines. The relative position of the machines, the subject and the experimenter were:



The experimenter remained in the background as much as possible. The required work was accomplished efficiently and unobtrusively, and in an extremely routine manner.

The opportunity for close visual scrutiny of the subject's bi-manual responses was excellent. Thus the temporary disruption in motor response was clearly evident in some subjects. The omission of responses was noted. Slight hesitancy, such as a momentary time-lag, was frequently apparent especially under the decision task. The qualitative differences in motor performance, especially between contrasting subjects, was most evident. In this

⁹. Apparatus: Chapter II, footnotes 14 and 15. It is expected that certain new machines, now being considered, may obviate this difficulty.

sense, the required participation of the experimenter in the task was experimentally valuable. As would be expected, the constant observation of fifty subjects, for a full fifty hours, was clinically rewarding. Certain of the derived observations are discussed in Chapter IV, under Results and Discussion.

During the administration of the bi-manual test the responses were being continuously recorded on the response tapes. For each page of the bi-manual test, a response tape was obtained. Immediately upon completion of a given page of the test, the tape was identified with the following data: subject's name, the task, R, M, or D, and the speed level, 30, 45, 60, 75 or 90. The test consisted of 5 pages. The number of speed levels was also five. Therefore, for each subject there were 25 response tapes. For all fifty subjects there was a total of 1,250 response tapes.

The technique for the scoring of the tapes, or permanent records, is now presented.

Scoring of Test Records

The tapes or response records were corrected individually. Corrections were made in reference to the following types of error: (a) a wrong response, (b) a reversed response, (c) an omitted response, and (d) an extra response.

An error was an incorrect response. In contradistinction to an erroneous response, a correct response was bi-manually correct, that is, the total pattern was correct.

A pattern of stimuli consisted of any group of stimuli which appeared in the slit-window at a given moment. A study of the bi-manual test indicates four possibilities: 0 --- 0, 00 --- 00, 0 --- 00, and 00 --- 0. The total number of patterns of stimuli, as previously reported, was 800 for each subject for the entire test. (Task R - 160, Task M - 320, Task D - 320).

Illustrations of the various types of response error are now presented:

<u>Bi-manual Test</u>		<u>Response Errors</u>		<u>Scoring</u>
0	0	0		Wrong
00	0	0	0	Wrong
0	00	00	0	Reversed
00	00			Omitted
0	0	00	00	Extra

The mechanical operation of the Recorder permits the keys to be depressed simultaneously. The keys, if not depressed simultaneously, print the responses at different and distinguishable levels on the tape. The norm was: Simultaneous bi-manual response. If the keys were not activated simultaneously, an error was recorded. This type

of error, although occurring very infrequently, appeared in this form on the tape:

<u>Bi-manual Test</u>		<u>Response Tape</u>		<u>Scoring</u>
0	0	0	0	Wrong
0	0	0	0	Correct
00	00	00	00	Wrong

The requirement for individual correction of all 1,250 tapes was due to the sensitivity of the recording process via the Recorder. If the subject depressed the keys evenly, the responses were printed evenly spaced. However, when the subject became excited or attempted to hurry response, the printed responses (although correct) tended to crowd together. In virtue of this differential in the printed response, it was necessary to carefully check each group of stimuli individually. The common stencil technique could not be used. An illustration of the problem as it pertains to the use of a stencil, is clearly noted when responses are correct but erratic. The subject was not responding easily and steadily but hesitantly and then hurriedly, the recorded responses falling at irregular intervals on the tape. Thus:

<u>Bi-manual Test</u>		<u>Response Tapes</u>		<u>Scoring</u>
0	0	0	0	
0	0	0	0	
0	0	0	0	(correct
0	0	0	0	but
				erratic)
0	0	0	0	
0	0	0	0	
0	0	0	0	
0	0	0	0	

The Stenograph was selected as a recording device because it was capable of performing three distinct operations: (1) record response, (2) accommodate bi-manual responses simultaneously, and (3) indicate variations in individual motor responses.

The flexibility of recording provided the experimenter with a further opportunity of classifying motor responses under three general headings. Based upon visual inspection, the response tapes were evaluated and coded under one of the following headings: constant (regular spacing), irregular (some variation), and erratic (severe and unusual variation)¹⁰.

A concluding illustration of the relationship between the stimuli presented on the Accelerator and the

10. Appendix 4: It is assumed that the variations may provide clinical clues to the proficiency level of performance in later studies.

correct responses as physically recorded on the actual recording machine tape, is now given:

<u>Bi-manual Test</u>		<u>Response Tape</u>		<u>Scoring Key</u>	
0	0	0	0	0	0
00	00	0	0	0	0
		0	0	0	0
0	00	0	0	0	0
			0		0
00	0	0	0	0	0
		0		0	

The scoring key, made on the Recorder, corresponded to the actual or obtained response tapes taken from the same machine. Correction procedures were thus facilitated.

Total errors were noted at the bottom of each tape, the total error score for the subject being accounted for in terms of summing up scores for all 25 of the response tapes. All tapes for a given subject, which had been carefully identified during the administration of the bi-manual performance test, were filed in a separate packet.

The error count was 1 point for each erroneous pattern¹¹.

11. Error: The sum total of errors could only equal the number of stimuli patterns contained in the Bi-manual Performance test. The penalty for an error was never greater than 1, however compounded the errors might be in the bi-manual pattern. The pattern was considered to be a psychological response unit, accomplished correctly or incorrectly.

With the tests scored, the individual performances recorded and certain profiles developed, the processing of the results was carried to a conclusion.

In the concluding chapter, Chapter IV, the results and discussion are presented.

CHAPTER IV

RESULTS AND DISCUSSION

Group Data

A discussion of the experimental data is now given, initial attention centering upon an analysis of group data. Individual data is then discussed¹.

In Figure 2, where a comparison of the overall performances for both the decision task and the motor task are reported, the divergence of the two curves is evident. The curves, identified as Task D and Task M, are essentially different in configuration.

Task M. - The motor task approximates a horizontal-line curve. The greatest variation occurs between the error scores at speeds 30 and 60 (i.e., 58-18), a differential of forty points. Based on an N of fifty, this represents an error per subject of less than one. A comparison of errors at speeds 30 and 90 indicates a difference of only twelve points, emphasizing the lack of relationship between speed and error in this bi-manual task.

1. R. S. Lazarus, J. Deese and S. F. Osler, "The Effects of Psychological Stress upon Performance", in the Psychological Bulletin, Vol. 49, No. 4, 1952, p. 310 (Note: "An integrated theoretical picture about the effects of stress upon performance must take account of individual differences, the finding of impairment as well as improvement of performance, the influence of different situations, and the effects of different kinds and amount of stress").

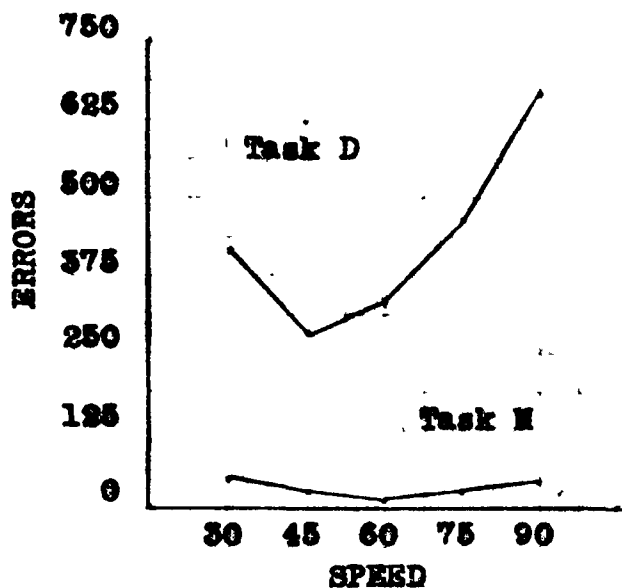


Figure 2. Total Errors¹

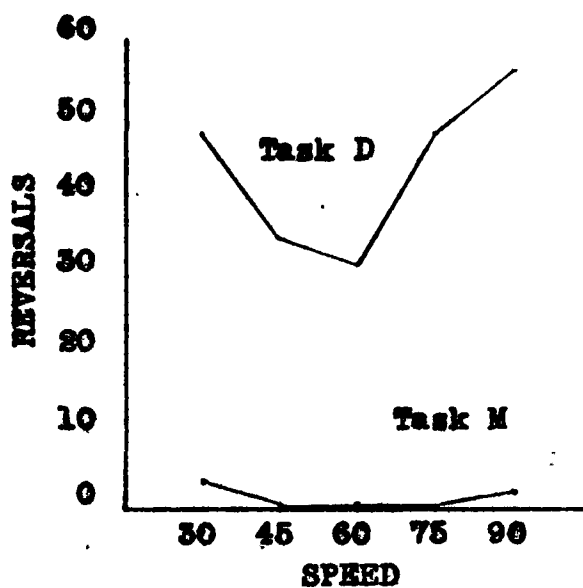


Figure 3. Total Reversals

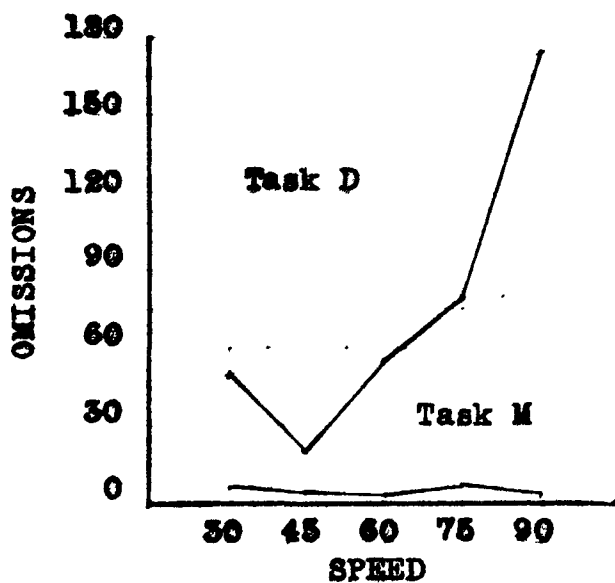


Figure 4. Total Omissions

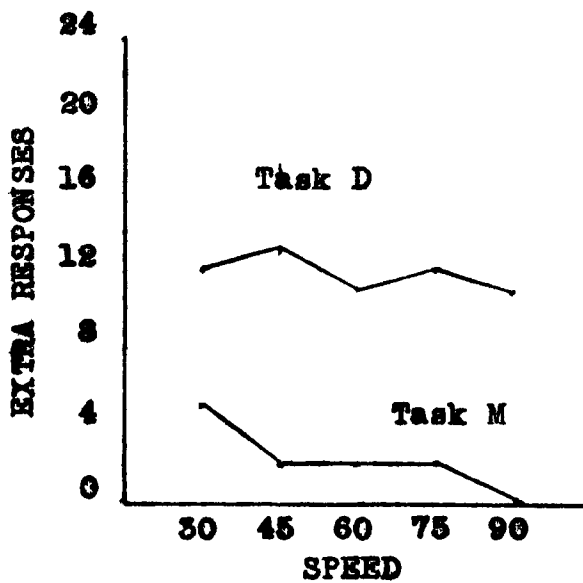


Figure 5. Total Extra Responses

1. Totals refer to errors of all fifty subjects at each of the five speed levels in the figures 2 to 5 inclusive. D - Decision Task. M - Motor Task.

The subject was capable of responding to the challenge of speed and, essentially, was improving in his ability to respond bi-manually to this complicated task. The maximum score for the motor task on any single trial was 58 errors, the minimum 18, the range 40, with an average error score of 36 points per trial or speed level. On theoretical grounds, this curve was expected to display continuing increments of error with each increase in speed. In contradistinction to the expected curve, the group error totals occurred at the five speed levels as follows:

Speed	30	45	60	75	90
Error	58	30	18	29	46

Summary: Task M (motor) did not discriminate among individuals nor did it reflect an expected association between error and acceleration. This held true for the total group, N-50, as well as for each of the sub-groups, Group N (N-10), Group V (N-30) and Group S (N-10).

Task D. - The decision task, unlike the related motor curve, generally followed the predicted pattern, an association being evident between error and acceleration. With the exception of the first trial, speed 30, the average error for each succeeding speed was quantitatively

higher. The error scores for each speed trial indicate the character of the curve:

Speed	30	45	60	75	90
Error	419	280	338	457	678

Unlike the motor curve, the decision task requiring a split-decision (or interpretation of the continually changing stimuli) by the subject, caused great difficulty for some individuals while being accomplished with only limited error by superior subjects. The range of difficulty on the decision task is observed in a study of individual performances, the least proficient subject scoring 174 errors and the most proficient subject scoring 0 errors. The entire distribution of scores is noted in Appendix 4.

Summary. - Task D (decision) discriminated among individuals as well as among the various sub-groups identified as the NROTC Group, the Volunteer Group and the Selected Group. The maximum group score for the decision task on any single trial was 678 errors, the minimum 280, the range 398, with an average score of 434 errors per trial (speed level). In terms of group results, no inversions occurred between Task M and Task D. The minimum point difference between the two curves was 250, this error

score difference occurring at speed 45. The smallest point discrepancy occurred at speed 90, the error score being 632. Carry-over effects, if any, favored Task C.

Table IV. - In table four a quantitative analysis of errors is presented. A comparison is noted between the maximum errors possible and the obtained error scores. In every case an error refers to a wrong bi-manual response pattern, hence, each subject was theoretically capable of making 640 errors in these compared tasks (i.e. responding incorrectly to every bi-manual pattern for Task C and Task D at all speed levels.) For the entire fifty subjects, the total bi-manual responses amounted to 32,000 patterns. The distribution of errors, expressed in per cent, shows the motor task accounting for 1.1% of the errors and the decision task accounting for 13.5%. On Task C, 26% of the subjects completed the task without error. On Task D, only 1% of the subjects completed the task without error. A comparison of obtained errors for Task C and Task D, at all five speed levels, indicates a wide disparity in task difficulty. Errors were 101 for the motor task and 2,142 for the decision task.

Summary. - The differences in performance between the motor task and the decision task are persistent and based upon a comparison of 32,000 bi-manual responses. The

Table IV. - A Quantitative Analysis of Errors for the Motor Task and the Decision Task for Fifty Subjects Based on the Maximum Errors Possible and the Obtained Errors

Task	Possible Error Per Subject	Error Per Group	No. of Ss Made Error	Some Error	Range of Error	Total Obt. Error
M	320	16,000	13	37	0- 14	181
D	320	16,000	1	49	0-174	2,172

M - Motor Task

D - Decision Task

total group of subjects, N-50, and the three sub-groups (N, V, and S.), display the same trend.

Table V. - In table five an inquiry was made into the kinds of error which constituted the total error score. Before the bi-manual task was administered, the following probabilities were considered: (1) The curve of erroneous responses would continually rise with the increase in speed. (2) The greatest number of errors would undoubtedly occur at the highest speed levels because of possible confusion. (3) Subjects would not make recordable errors at slow speeds, the slowest speed of exposure permitting the subject to correct tentatively erroneous responses. (4) Finally, the scant possibility was entertained that an increasingly smaller number of errors would be made on each trial (i.e., speed) because of familiarization with the task, the curve of errors constantly diminishing although speed constantly increased.

The results indicate the difficulty of logically predicting behavior in a complex bi-manual task. In the precise sense, none of the predictions were correct. A study of Table V verifies this observation. Additional discussion of this topic is presented under Individual Data.

Table V. - Comparative Error Scores on Task D and Task M for Total Reversals, Omissions and Extra Responses at all Five Speed Levels

Type of Error	Task	Speed ¹				
		30	45	60	75	90
Reversals	D	49	35	32	49	56
	M	3	0	0	0	2
Omissions	D	46	18	55	77	174
	M	4	3	2	6	2
Extra	D	12	13	11	12	11
	M	6	2	2	2	0

1. SMA Accelerator Speed Settings

D - Motor Test

M - Decision Task

Summary. - Task M and Task D continued to be differentiated at all speed levels in terms of three types of error, namely, reversals, omissions and extra responses. There were no inversions between the motor task and the decision task. The error curves for the three types of error were quantitatively and qualitatively different². In all instances, the decision task accounted for the greatest response differential. Subjects, while performing the bi-manual motor task proficiently, displayed once again wide individual differences when responding under conditions of the decision task. The mental component, decision, initially had been predicted as the differentiating component in this complex motor-visual bi-manual task. A visual inspection of the distribution of individual errors, Appendix 4, pertains to the preceding discussion.

Table VI. - A comparison of the total error scores, for each of the three types of error, reversals, omissions, and extra responses is given in table six. The error trends are irregular. On the motor task level the quantity of errors is limited with fifty subjects contributing only a total of 17 omissions, 11 extra responses and 5 reversals³.

2. Refer: Figure 3, Figure 4, and Figure 5.

3. Reversals: The elements of the response pattern are correct but reversed. Stimuli 00 0; Response 0 00.

Table VI. - Cumulative Error Scores for Total Reversals, Omissions and Extra Responses for Fifty Subjects on Task M and Task D

Tasks	Extra Responses	Omissions	Reversals
Motor	11	17	5
Decision	59	372	221
D : M	5:1	22:1	44:1

In contrast, the decision task, Task D, produced 372 omissions, 59 extra responses, and 221 reversals. The omissions can be accounted for in terms of speed, the omission curve, Figure 4, rising sharply at speed 90. The extra responses were lower than expected. The curve for the extra responses, Figure 5, was completely unpredicted. The assumption was that extra response would arise from the confusion engendered by the stress of acceleration. Actually, extra responses were extremely few in number and followed a horizontal-line curve. For the moment, the extra responses serve the purpose of negative evidence, that is, informing the experimenter that this type of error is not expected to loom large in this special type of bi-manual response.

The phenomena of the reversals is of direct significance to the experiment. The reversals mean, in the plainest of terms, that the left hand has carried out the work of the right hand; further, the right hand has successfully carried out the work of the left hand. In brief, the response pattern is correct but the elements of the pattern have been mis-placed. An inspection of the reversal curve, Figure 3, presents a crude "V" curve which is quite different, qualitatively and quantitatively, from either the curve of omissions, Figure 4, or the curve of extra response, Figure 5. There appears to be a changing relation

between speed and response. The reversals are comparatively high at both the beginning of the decision task and at its completion. A point of efficiency is attained midway through the task, speed level 60 accounting for the minimum of reversals. Of particular interest was the fact that subjects reported making the reversals even when conscious of the impending error. The comment was to the effect that even the knowledge of the impending error did not permit correction procedures to be immediately applied. It is the experimenter's opinion that the complex response mechanism, whatever its neurological construct may be, once fully activated seeks completion and is not, under these conditions, subject to voluntary withdrawal. The involved subjects were probed carefully concerning this matter. The position taken was that once the action began it could not be withdrawn. The reaction, in this limited area, has something of the character of compulsive behavior and is to be the subject of future research by the experimenter. The individual differences in this task, at the decision level, Task D, ranged from 0 reversals to 32 reversals with various subjects obtaining scores within these limits. The data is reported in Appendix 4.

Summary. - The experimentally obtained curves for extra responses, omissions and reversals were qualitatively and quantitatively different. The higher error scores occurred, without inversions, at the decision level. Expressed in terms of a ratio, the relationship between the decision scores and motor scores, $D : M$, were: Extra Responses, 5: 1, Omissions, 22: 1, and Reversals, 44: 1, respectively.

The discussion is now directed towards an analysis of individual results, the preceding group results providing a general basis for further analysis.

Individual Data

The general impression that error is directly associated with speed in a bi-manual task involving complex visual directions, is fairly well substantiated if the analysis is held to group results.

An inspection of the total error curve, Figure 2, appears to validate the observation. A careful consideration of the reversal curve, Figure 3, and the omissions curve, Figure 4, does not seem to warrant the necessity of establishing an opposing hypothesis. The horizontal-line curve for extra responses can be logically dismissed

on the basis of extremely limited number of errors so recorded. It was in this general frame of mind that the experimenter routinely began the construction of fifty individual profiles, constructing individual curves for both the motor task and the decision task for each of the subjects. It was felt that in this way a set of comparative performances for each subject might be obtained, the subject's performance on Task M being compared to the subject's performance on Task D.

Figure 6. - Although variations in bi-manual performance had been predicted, nothing of the diversity of individual profiles actually obtained had been expected.

The initial problem was to obtain scores for all speeds, 30, 45, 60, 75, and 90, for both the motor task and the decision task. With these scores obtained for all subjects, the profiles were then placed on 5 x 7 cards and initial classification attempted. The profiles fell into certain crude categories from the outset although overlapping was present. It was necessary, therefore, to establish a set of directions for the inclusion or rejection of a given profile within the accepted sub-classifications. Following a study of the similarities and dissimilarities noted in certain tentative groupings, an arbitrary set of selective directions were formulated.

INDIVIDUAL DATA

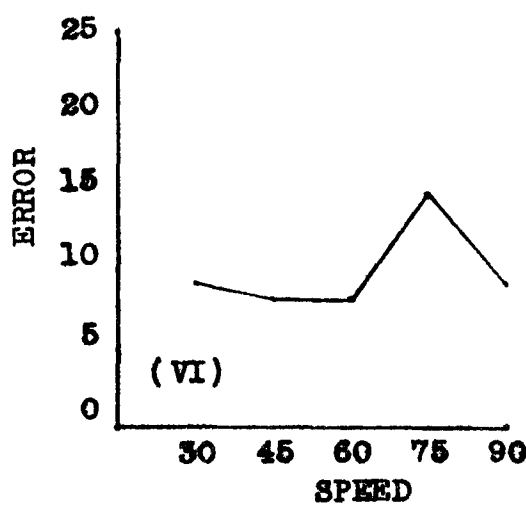
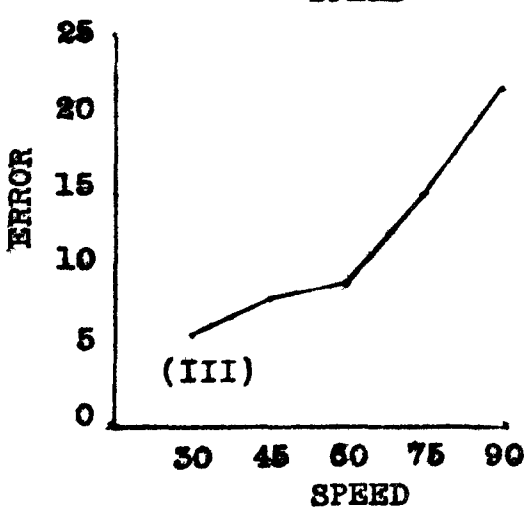
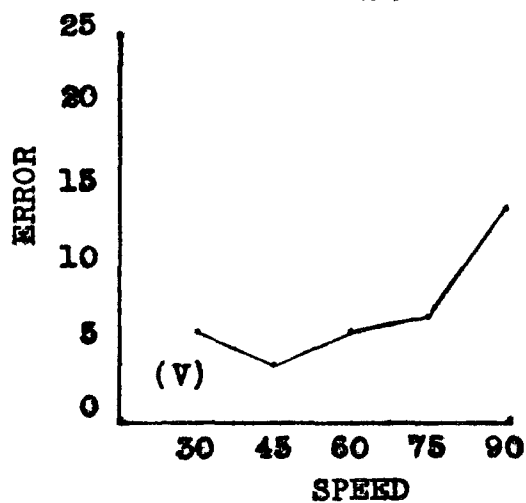
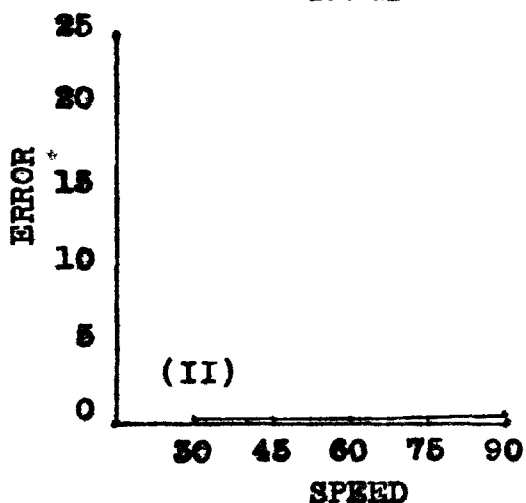
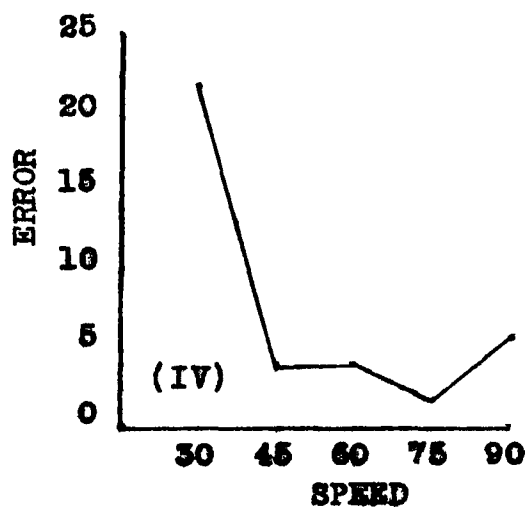
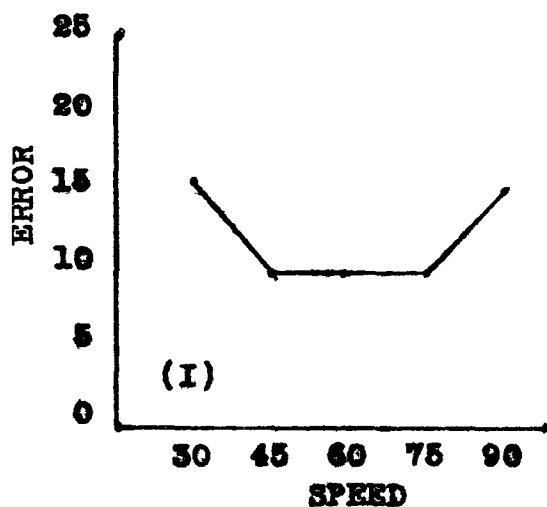


Figure 6. A Classification of Fifty Individual Error Curves into Six Sub-groups, Based on the Average Error Scores Obtained from the Decision Task Performances

Table VII. - The directions established for the classification of the profiles is given in Table VII. The problem appears technically difficult in terms of verbal procedures while, in actual practice, the individual profiles were classified rather readily. As in all experimental work, overlapping always presents a problem. In the present instance, with fifty subjects, it did not appear feasible to proceed into further ramifications. The percentage of subjects for each of the six sub-classifications was as follows: (I) U Curve, 10%; (II) Horizontal Line Curve, 6%; (III) Rising Curve, 22%; (IV) Descending Curve, 8%; (V) Irregular Curve, 40%; (VI) End-drop Curve, 14%. With the limited number of subjects per classification, the diversity of individual performances was considered to be of especial experimental interest. In terms of probabilities, it seemed likely that such variations might occur with a very large number of subjects and randomized sampling present. It seemed unlikely, however, that such variations would appear unless the bi-manual test was relatively sensitive and the subjects had been appropriately selected to tease out the phenomena of individual differences. In view of the fact that the typical bi-manual

Table VII. - Criteria for the Classification of Fifty Experimentally Obtained Individual Error Curves into Six Sub-Groups for the Decision Task

Sub-Group	Designation	Characteristics and Limitations
I	Curve	Definite "J" configuration. Difference between U peaks five points or less, speeds 30 and 90.
II	Horizontal Line curve	Variation plus or minus one point only, all speeds.
III	Rising Curve	Clearly resembling a continually rising, smooth curve. Generally rising at each speed level.
IV	Descending Curve	From high to low, curving up at speed 90. Point differential at peaks 30 and 90 more than five points.
V	Irregular Curve	A generally rising curve of irregular configuration. Limited form when the point rise between speeds 75 and 90 not in excess of four points. Unlimited form when the point rise between speeds 75 and 90 five points and above.
VI	End-Drop Curve	Curve drops at end. Point drop between speeds 75 and 90, no limit.

testing time for each subject was approximately one hour, involving some 800 related bi-manual patterns, the variations among the fifty subjects was considered to be sensibly real. With an extremely large N, it was hypothetically posited, there might be an "X" number of yet undetermined individual bi-manual profiles, each with its own particular configural qualities. Only further research can answer this question. At the moment, the obtained curves were considered clinically valuable and containing within themselves implications for further study.

Summary. - The original prediction for individual differences in bi-manual performance failed to anticipate fully the experimentally obtained results. On the basis of fifty profiles, constructed from the motor task and the decision task error scores at all five speed levels, a six-fold classification resulted. Task D, the decision, task, proved to be the differentiating component. The motor curves, Task M, were generally non-discriminating. The profiles were considered to be of possible clinical value, representing the most informative outcome of the thesis. Further research would appear to be worthwhile in this area.

The final consideration of the experimental data was accomplished in terms of the evaluation of three sub-groups. The sub-groups were the following: Group N (NROTC), Group V (Volunteer), and Group S (Selected).

Sub-Groups

It was predicted that in a bi-manual task, involving changes in the speed of presentation of complex visual directions, differences in individual performances would occur, if any, in the decision task, Task D.

It was further predicted that with the total group, N - 50, broken down into three sub-groups, designated N, V, and S, the following relationships would more than likely take place⁴:

Group N: Average performance would be superior to the other two groups.

Group S: Average performance would be inferior to the remaining two groups.

Group V: Average performance would lie between the attained performances of Group N and Group S.

4. Refer: Chapter II, sub-groups.

Table VIII. - The attained relationship between the sub-groups evolved as predicted.

The limited number of subjects, however, in Group N and in Group S, tended to diminish undue experimental expectation. The number of subjects in each group was ten, representing only 10 hours of bi-manual testing. It may be recalled that these subjects were expected to react quite differently to the task. Group N was expected to do well because they were in effect pre-selected mentally and physically and assumed to be psychologically stable individuals⁵. In contradistinction to this group, the group designated as Group S represented, in terms of behavioral observation by the experimenter, individuals not likely to perform too successfully on this type of stress task. The subjects appeared to lack stable personality organization, being easily disturbed or unduly emotionalized under the ordinary stress of everyday activities.

The volunteer group, designated as Group V, represented a group free of purposeful selection on the part of the experimenter. The thought was that if this bi-manual task did distinguish in terms of average scores,

5. NROTC: Naval Reserve Officer Training Corps.

Table VIII. - Average Errors Occurring on the Decision Task at Each of Five Speed Levels for the Three Sub-Groups Designated as Group N, Group V and Group S

Sub-groups	S p e e d ¹				
	30	45	60	75	90
Group N	0.7	0.6	1.2	2.3	5.0
Group V	9.5	4.9	6.6	8.0	14.0
Group S	12.6	12.6	12.8	19.3	20.6

1. SRA Accelerator Speed Settings

between two selected groups representing the theoretical extremes, than this volunteer group ought to be subject to the stresses of the task but, on the average, better able to adjust to it than the 'inferior' group and yet not capable of adjusting to it as well as the 'superior' group.

The average error scores, based on fifty hours of performance on this bi-manual task, followed the patterns expected of the sub-groups.

Figure 7. - It was expected that Group N would perform most efficiently, that is, display the lowest error score. It was also indicated that Group S, the poorest of the groups, would perform inefficiently and reflect inefficiency in comparatively high error scores. Finally, it was expected that Group V, the volunteer group, would tend to fall somewhere between these two score differentiated groups. Experimental results confirmed these observations, the three curves falling at different levels in terms of average error scores. The question of whether or not these scores were due to chance was then considered, the analysis concerning itself with score frequencies rather than averages.

The chi-square test was applied to the total error scores obtained by each of the three sub-groups at all five

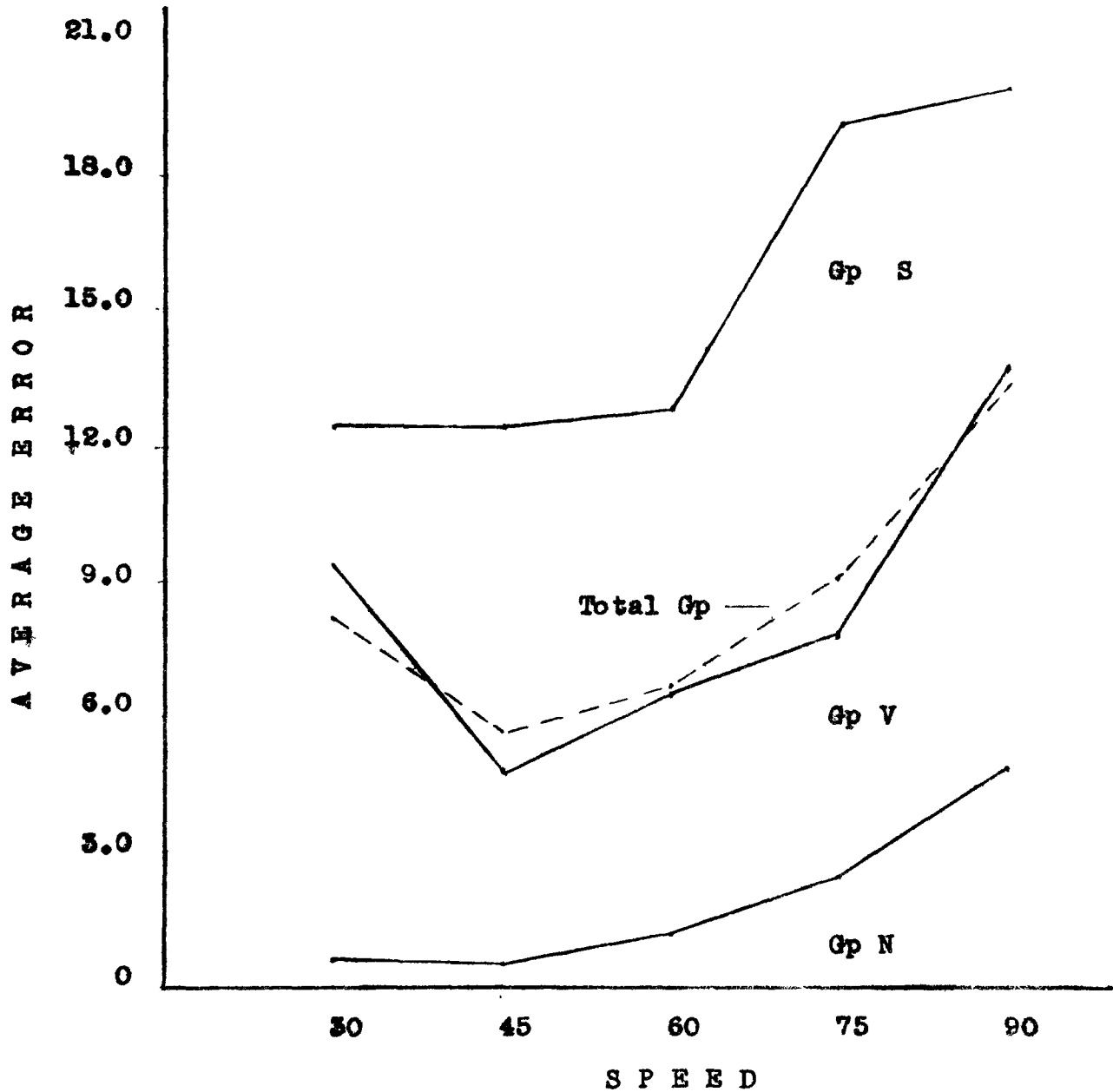


Figure 7. A Composite Graph of the Average Error Curves for the Total Group and the Sub-groups Designated as Group N, Group V and Group S at each of Five Speed Levels on the Decision Task

speed levels⁶. The degrees of freedom were four. Each sub-group was treated separately. The question was to what degree, if at all, did the observed frequencies (f_o) differ from the expected frequencies (f_e). In all three sub-groups the P value was .01, indicating that the obtained scores could have occurred by chance in one instance out of one-hundred. The hypothesis that the obtained scores were due to chance was rejected, the P value of .01 serving as the criteria in each instance.

The present thesis, considered statistically, did not materialize as expected. It was planned originally to concentrate upon a comparison of mean performances at the various speed levels, comparing the obtained mean error scores of Task M (motor) and Task D (decision). The average or mean scores on Task M were so minimal as to make comparisons with the mean score of Task D appear to be without purpose. The mean error score on Task D, for all fifty

6. Technique: Where five grades, A,B,C,D,E, might be used, here five speeds were employed, namely, 30, 45, 60, 75, and 90. Where there might be 9 A's, 13 B's, etc., here errors were used, hence, 7 errors at speed 30, 13 errors at speed 45, etc.

subjects at all five speed levels were as follows:

Speeds:	30	45	60	75	90
Mean					
Errors,					
Task "":	1.16	0.60	0.36	0.58	0.02

The relative paucity of error under task " is noted when a comparison is made with the total of 10,000 bi-manual Task " responses actually accomplished by the fifty subjects⁷. Mean comparisons between Task D and Task " were therefore omitted and attention directed towards an enquiry into the possible correlation of performances on Task D (decision) and two series of test scores which were available for all subjects. The tests in question were, theoretically, related to the question of performance under stress. The two tests were concerned with mental ability and manifest anxiety. One test was designed for experimental purposes and the second for the derivation of an intelligence quotient^{8, 9}.

The relationship between mental ability and bi-manual performance was not expected to be high. The ques-

7. Refer: Table IV; Figures 2 to 5, inclusive.

8. Otis, A. S., Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form D, New York, World Book Company, 1939.

9. J. A. Taylor, "A Personality Scale of Manifest Anxiety", in the Journal of Abnormal and Social Psychology, Vol. 48, No. 2, 1953, p. 285-290.

tion of degree, however, was of experimental interest. The relationship between bi-manual performance and the degree of anxiety as measured by the test of manifest anxiety, was an unknown quantity. In the bi-manual task it was reasoned that the degree of anxiety was not the significant factor but, rather, the degree to which the anxiety could be controlled and directed by the given individual. It was inferred that an anxiety score was not as important as that factor which might give insight into the level of mastery of anxiety. In a bi-manual task, under speed stress, the anxiety score might or might not correlate with actual performance levels. In some instances anxiety would prove destructive to performance; in other instances, anxiety would be directed effectively and contributed to high levels of performance. The problem appeared to be one of individual differences, therefore, and not one logically related to test scores of this nature¹⁰.

The product-moment correlation technique was not used because of the small number of subjects involved.

10. J. A. Taylor, *Ibid.*, p. 289. (Note: "The anxiety scale was developed for, and has been used exclusively as, a device for selecting experimental subjects, without regard to the relationship of the scores to more common clinical definitions".)

The rank-difference correlations were low and of limited predictive value. The correlation values obtained between Task D and the anxiety scores were in the order of .14. The values obtained between Task D and the mental ability scores were somewhat higher, the rho values being .61, .36, and .27, for Groups N, V, and S, respectively. The critical ratios and P values were determined. From these data it followed that prediction of individual performances on the bi-manual tasks was, for all practical purposes, nil.

In the present status of the research, it is not yet known just what factor or group of factors may correlate with bi-manual performance under stress. Insofar as bi-manual response, in this experimental situation, requires the integrated functioning of the mind (decision) and the nervous system (motor system) under stress (emotion), the prediction of such factors or combination of factors is considered temporarily beyond recognition. The thesis holds to the general assumption that these performance differences are of a constitutional origin but has in no way demonstrated this to be a fact.

The specific and limited objective of this thesis was to determine if bi-manual performance under stress would result in differentiation of response scores at the

level of decision. The score differences were reported upon in terms of individual differences and sub-group differences, the analysis of bi-manual response being accomplished in terms of objective performance records.

Summary

The experimental results partially confirmed the working hypothesis, the motor task proving to be non-discriminatory and the decision task indicating wide individual differences. For the fifty subjects the results were:

(a) Task M. - The motor task proved to be non-discriminatory, individuals performing proficiently at all speed levels. An observed finding, however, was that errors were quantitatively limited and did not increase proportionately with an increase in speed. This outcome did not conform to experimental expectations. The bi-manual task, on the average, was expected to show a commensurate increase in error as the task was accelerated. The working hypothesis for Task M was, therefore, only partially fulfilled. Errors did not increase proportionately with speed although the task did prove to be non-discriminating as predicted.

(b) Task D. - Individuals encountered difficulty in response with an increase in speed. Errors rose markedly as the decision task was accelerated. With the exception of the initial trial, the remaining four trials (speeds) displayed a sequence of increasing error with increasing speed. The working hypothesis for Task D was fulfilled. The task did discriminate and individuals did 'fail' at different speed levels.

(c) Errors. - On the basis of observation, it was assumed that errors would fall into certain categories, defined as reversals, omissions and extra or unrequired responses. These errors did occur. Reversals and omissions fell into the expected patterns, increasing with increasing speed. Extra responses, however, tended to be limited in quantity and to fall into a horizontal-line curve, not increasing with increases in speed. This outcome had not been anticipated. In terms of error prediction, the prediction was partially fulfilled.

(d) Profiles. - Individual differences were extreme. The resulting profiles, constructed on the basis of error scores obtained on Task D at all five speed levels, involved variations which were totally unexpected. Individual profiles ranged from a horizontal-line curve, indicating a constancy of error score despite speed increments,

to a descending curve, indicating a general lessening in errors as speed was increased. Other profile curves were just the reverse, error scores generally increasing with the acceleration of response. The overall outcome had not been anticipated. The original considerations were far too conservative. Variations had been expected, but not of this order.

(e) Group and Sub-Group Results. - The group and the sub-group results tended to confirm expected bi-manual performance curves, with the exceptions noted above. The significant and experimentally revealing factor was the undesired cancelling out of the individual differences when the data was treated in terms of averages. This is not to deny the need and usefulness of the averages but, rather, to indicate the needed caution in their experimental exploitation. The three sub-groups, Group N, Group V, and Group S, established generally similar performance curves but at different levels of proficiency as had been predicted.

At this point the review of the problem and summary of results is concluded.

A statement of the general conclusions now follows.

CONCLUSIONS

The experimental conclusions, expressed in terms of the objective data, were:

- (1) The motor task error was not a function of speed. The motor task, Task M, did not differentiate between either individuals or groups in terms of error scores.
- (2) The decision task error score was a function of speed, the task differentiating between individuals and sub-groups.
- (3) On the decision task, Task D, involving an interpretation of stimuli, the predicted types of error materialized, namely, reversed responses, omitted responses and extra or unrequired responses.
- (4) Individual differences on the decision task were marked, the differences being both qualitative and quantitative.
- (5) Sub-group differences were evident on the decision task. Average error scores, as predicted, differentiated between the performances of groups designated superior, average and inferior.

It was concluded that for this group of subjects and under the specific experimental conditions outlined, the higher order function (decision) differentiated effectively while the lower order function (motor) appeared to be negative in this particular respect for both individuals and sub-groups.

The implications of the study suggest that certain stress differences between individuals might be effectively and validly measured by properly applied functional motor tests involving decision and integrated response under speed. From a theoretical viewpoint it may be assumed that each individual is measureable in terms of a given stress level, capable of only a given latitude of behavioral motility, and thus 'failing in adjustment' when subjected to pressures beyond his potential. The selection of individuals by this means for stress-provoking occupations is therefore evident. The rich research area, however, would appear to lie in the clinical field where psycho-motor difficulties are frequently correlated with an individual's inability to adapt to the routine tension of everyday activities. A valid stress-level score would thus serve as a valuable adjunct to other psychological indices.

A clinical investigation of bi-manual performance stress-level scores and the possible correlation with brain damage, deterioration and personality disorders should prove useful.

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Ausubel, D.P., H.M. Schiff and M. Goldman, "Qualitative Characteristics in the Learning Process Associated with Anxiety", in the Journal of Abnormal and Social Psychology, Vol. 48, No. 4, 1953, p. 537-547

The experiment was concerned with an analysis of performances of high and low anxiety groups on two tests, one, a mirror drawing test and, two, a blindfold stylus maze test. Results indicated that high anxiety individuals tend to respond poorly on the first trial of the maze, said trial being related to the concept of a new problem. However, after ten trials, the high anxiety group were as proficient as the low anxiety group on the maze. The mirror drawing task displayed no significant differences between the two groups. The groups consisted of 50 Ss each, the two groups being comprised of subjects selected on the basis of Rorschach anxiety scores. Subjects were taken from the upper and lower quintiles. Aspects of the problem included a discussion of the relations of anxiety to improvising ability, practice effects, preparation, and level of aspiration. The research was postulated on the concept of personality (neurotic) anxiety as the phobic overreaction of an individual with impaired self esteem to the threat anticipated in adjustive situations. The authors conclude: "It is precisely with respect to the need for improvising solutions to new problems that the individual with personality anxiety experiences feelings of inadequacy".

Beeby, C.E., "An Experimental Investigation into the Simultaneous Constitutents in an Act of Skill", in the British Journal of Psychology, Vol. 20, 1930, p. 336-353

This is a study concerned with the effect of simultaneous units of learning upon bi-manual response. The distinction is made between verbal learning which is unitary, namely, one unit of learning after another, and the muscular process which can be split into simultaneous as well as successive constitutents. The experimental procedure requires the subject to make response with both hands at one and the same time, forcing a split in the attention factor.

The value of the study lies in the derivation of data concerning the relationship of two stages of learning. The author indicates there are two stages of learning in the process of acquiring skill: one, the learning stage characterized by focality and fluctuation of consciousness and two, the expert stage which is characterized by non-focality of consciousness. The experiment made use of two brass squares and two metal stiluses, the task being to simultaneously follow around the squares in such a manner that the contact between the stilus tip and figure was broken as seldom as possible. Each break constituted an error and was recorded kymographically. Subjects were blindfolded.

Conrad, R., "Missed Signals in a Sensori-Motor Skill", mimeographed publication of Psychology Laboratory, Medical Research Council, Cambridge, (AP0/187/53), 1953, pp.16

The experiment sought to determine why speed increases in the demand rate of work in a sensori-motor skill led to a disproportionate deterioration in performance. An examination of performance indicated that omissions occurred close to the nearest responses more often than would be expected by chance, and as likely to occur just before the response as just after. Furthermore, the probability that a signal would be omitted when it occurred within a constant time interval from a response increased linearly with mean speed. The apparatus consisted of a display of four pointers each moving at slightly different speeds around four dials. The dials were marked at six equidistant points. The subject was required to respond by tapping a morse key whenever a pointer coincided with a perimeter mark. The subject's response did not affect the movement of the pointers, but both the moment of pointer coincidence and the subject's morse key response, were recorded on moving paper. "The skill of the subject lay in the difficulty of determining which was the next marker to merit attention in order to make an accurate response. Possible reasons for omitted responses were suggested: (a) attentional lapses at slow speeds, (b) blocks at fast speeds, and (c) narrowing of attentional span at high speeds. The experimenter concludes: "The results are clear. The further away in time a signal is from the nearest response, the less likely is it to be missed."

Deese, J. and R. S. Lazarus, "The Effects of Psychological Stress upon Perceptual-Motor Performance", Perceptual and Motor Skills Research Laboratory, Human Resources Research Center, Lackland Air Force Base, San Antonio, Texas, June 1952, pp. 15

The experiment was designed to study three questions: (a) Are stress-effects induced by ordinary psychometric procedures?, (b) Does failure-stress result in different effects when introduced early in learning as opposed to being introduced late in learning?, (c) What are the personality correlates of the effects of stress upon performance? Four findings are listed below.

The apparatus was the SAM Rotary Pursuit Test with Divided Attention. Some two-hundred and eighty Air Force enlistees acted as subjects. The control group, N-40, consisted of individuals not subject to stress by the threat of failure. Four experimental groups were employed all under the stress implications that failure in the test might terminate their present military tasks. Certain personality measures were obtained for all subjects with the exception of the control group. The authors list four findings: (1) ordinary testing procedures in which subjects are highly motivated may produce an impairment in performance, (2) there is apt to be a rapid adaptation on the part of subjects to the effects of certain stressful situations on performance, (3) stress introduced early in learning is harmful to performance while stress introduced late in learning appears to have a facilitating effect, and (4) no significant relationships were found between performance under stress and certain personality variables such as ratings of disturbance and Rorschach measures.

Novland, G.I. and R.R. Sears, "Experiments on Motor Conflict and their Modes of Resolution", in the Journal of Experimental Psychology, Vol. 23, 1933, p. 477-493

Working with the vector and field concepts of Lewin, the authors developed a very simple yet interesting experimental technique to investigate the problems of conflict situations. In brief, their procedure was to establish a

situation of either direct or selective response to certain stimuli. Suddenly they presented the subject with neither expected stimuli, and then awaited the resolution (or solving of the problem) that might take place. A manual response technique was employed. The experimenters concluded that there are four easily identifiable kinds of reaction, three of which can clearly be called resolutions, and the fourth, complete blocking. The importance of the study was in the use of the total situation where the subject was both consciously and attitudinally involved. In a certain limited sense, the subject was forced at times with the breaking of, or the modifying of, a given mental set. The experimental procedure simply involved the use of a plane surface, two colored lights, and the drawing of a pencilled line from a starting point to one of the lights. Routine procedure was to flash on one or the other light. When both lights were flashed on, the subject faced a choice situation: to make no response, to draw a line to one of the lights, or to attempt to solve the problem by drawing a line to both lights. Solutions to the conflict situation were varied, some refusing to respond overtly.

Katchmar, L.T., S. Foss, and T.C. Andrews, "Effects of Stress and Anxiety on Performance of a Complex Verbal-Coding Task", in the Journal of Experimental Psychology, Vol. 55, No. 6, June 1958, p. 559-584

As indicated by the authors, the study deals with the effects of ego-involvement, falsified knowledge of results, and manifest anxiety on the flexibility of performance on a complex verbal-coding task. In this study the term flexibility refers to the ability of the S to shift performance in virtue of the changing requirements of the situation. Selection of the subjects was on the basis of scores obtained on a modified Taylor Anxiety Scale, high and low anxiety groups being selected. Some 36 male and 18 female subjects were thus obtained. Performances were noted in terms of time, error and frequency of blocking. Scores were taken during the so-called pre-stress period and the post-stress period, and these scores then compared. During pre-stress trials, the two groups were not found to be significantly different in time required for the task. In post-stress trials the low anxiety group showed a decrease in time while the high anxiety group showed an increase in time. The differences were explained on the basis of anxiety as a function of stress producing situations.

Lindsay, D. B., "A Study of Performance under Speed", NDRG Project SC-70, NS-146, Boca Raton Field, Florida, 1945, p. 1-9 (Library of Congress: PB 13381)

An attempt was made to measure the effect of artificially induced stress on performance. The task consisted in reporting upon a series of circles, which resembled the typical oscilloscope screen, in terms of the contents to be noted within the field. Certain symbols were employed to represent planes, ships and land areas. The subject was required to discriminate and count the various symbols, reporting the results quantitatively. Stress was induced by interrupting the task and so indicating to the subject that a standard of performance was not being met. The initial performance rate was set by the subject without interference from the examiner. It was stated that the test was very important. One-hundred and ninety-six radar operator trainees served as the subjects. The experimenter indicates that under speed stress the group attempted more problems, making more errors and displaying greater variability in performance. The general result was a reduction in efficiency. Individuals reacted differently to stress, the majority speeding up performance in spite of an increase in error, some individuals, however, continued to react at the same pace, and did not show an increase in error.

Postman, L. and J.S. Bruner, "Multiplicity of Set as a Determinant of Perceptual Behavior", in the Journal of Experimental Psychology, Vol. 39, No. 3, June 1949, p. 369-377

In attacking the problem of multiple set experimentally, the authors were able to conclude that multiple set, at the level of recognition, serves strikingly to inhibit the effects of practice. In addition they noted that there appeared to be important individual differences in perceptual flexibility, i.e., in the ability to adapt to new perceptual situations. The particular value of this study was the fact that it was concerned directly with multiple set posited on the basis of conflict and inhibition. The experimenters concluded that multiple set impairs efficiency of perceptual selectivity. The results

were derived from a comparative study of response under a single set series and a multiple set series. The experimental procedure was as follows: A single set series of paired words, each containing a color word and a neutral word, were presented to the subject one at a time. The subject's task was to recognize the color word in each pair as soon as possible. In the multiple set series another group of eight word pairs, each containing a color word, was used. For this task the subject was to recognize either the food word or the color word in each pair. Presentation was by means of a Dodge-Lebrans tachistoscope.

APPENDIX 1

A Bi-Manual Performance Test Designed
to Determine Relative Response Proficiency
to Three Differentiated Sub-tasks when the Sub-
tasks are Exposed Visually at Five Different
Speed Levels

THE BI-MANUAL PERFORMANCE TEST

	Page
Task R (Repetition)	1
Task M (Motor)	2 & 3
Task D (Decision)	4 & 5

Bi-Manual Test

PAGE 1

98

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STOP
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STOP

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00 --- 00

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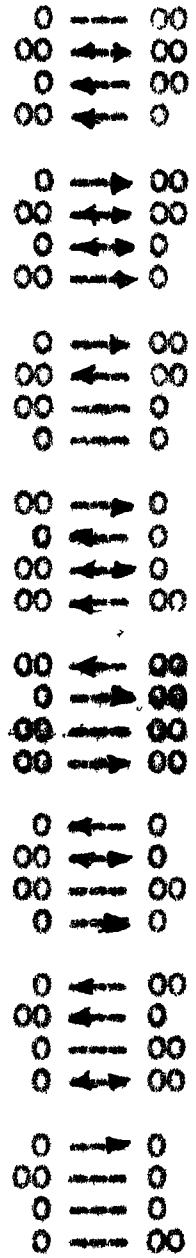
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00 ↔ 00
0 --- 00
0 ← 0

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STOP

Bi-Manual Test

PAGE 5

108



STOP
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STOP

APPENDIX 2

Instructions for the Bi-Manual Performance Test Designed to Determine Relative Response Proficiency to Three Differentiated Sub-tasks when the Sub-tasks are Exposed Visually at Five Different Speed Levels

The test administrator points to the RECORDER,
and says:

This is a very easy task. You are required to press only two keys on the machine. You always press the same two keys. Here they are: the two white keys.

The administrator demonstrates.

Use only the index fingers. Put your left finger on the left key. Put your right finger on the right key. Allow the fingers to rest lightly on the keys.

Have subject place fingers on the keys. Say:

Always begin each response by pressing the keys simultaneously. Press the keys gently but firmly. Don't try to go too fast. You can check your work by looking at the paper tape. Try to print evenly and clearly.

Answer questions which may be asked. Offer instructions as required. Put the subject at ease. Do not hurry this phase of the test. Say:

Now, go ahead and practice using the machine. Take your time.

When the subject has demonstrated his ability to use the RECORDER, then present the first practice sheet. (This practice sheet is Page (2) in the Instructions.)

(over)

Practice Sheet

- a. Practice this exercise.
- b. Press keys firmly and evenly.
- c. Move both fingers at the same time.

0	0
0	0
0	0
0	0
00	00
00	00
00	00
00	00
0	00
0	00
0	00
0	00
00	0
00	0
00	0
00	0

The test administrator will check for error.

(over)

TEST INSTRUCTIONS

106

The test administrator reads aloud the rules for the use of signs. The rules are:

Depending on the direction of the arrow or the appearance of a line, which are called SIGNS, you are required to -

modify the LEFT symbol	0 ←-- 0
modify the RIGHT symbol	0 ---→ 00
modify BOTH symbols	0 ←--→ 0
NO modification	0 --- 0

To modify a symbol, ALWAYS RESPOND WITH AN OPPOSITE RESPONSE. If 0, make 2 responses. If 00, make 1 response. (When the line appears, make no change. Thus, one symbol, one response. Two symbols, two responses.)

EXAMPLE: Correct responses are indicated in the brackets.

	0 --- 0	
	0 ---→ 0	(00)
(00)	0 ←-- 0	
	0 --- 0	
	00 --- 00	
(0)	00 ←--→ 00	(0)
	0 --- 0	
(00)	0 ←-- 0	

Answer all questions. Be certain all rules are clearly understood. Do not rush the subject. Do not begin the test until the subject can make correct bi-manual responses to the following practice exercise, page 4.

(over)

Practice Sheet

- a. Practice this exercise.
- b. Observe the use of SIGNS.
- c. Work slowly and accurately.

0 --- 0
00 --> 0
00 <-- 00
0 --- 0

00 <--> 00
0 --- 0
00 --> 0
0 <-- 00

Place the Practice Sheet, page 4, on the readied ACCELERATOR. Indicate the use of the slit-window, actually drawing the shutter down the inclined tracks. Say:

The symbols will be shown on this machine. You will see them appear in the window, like this. As soon as you see them, begin to press the keys.

Following the demonstration, ask:

Are there any questions? (If not, then say:) We will now begin the test.

-

Place page 1 of the Bi-Manual Test on the ACCELERATOR. Check that the entire stimulus sheet is covered. Begin the test at speed 30.

When the subject has responded to the complete test, pages 1 to 5 inclusive, repeat the test at the next higher speed level, namely, speed 45. Repeat this test procedure at speeds 60, 75, and 90. The test is then completed.

-

CAUTION: (a) Allow at least one full hour for the testing of each subject. (b) Perfunctory comments are permitted but do not offer comment unless required to do so by the subject's inquiry. (c) If the subject is obviously having great difficulty with the task, words of encouragement may be offered. Comments are only permitted during the brief periods when the subject is not operating the RECORDER. (d) Identify each tape as it is removed from the RECORDER, placing the subject's initials upon it. Number the tapes consecutively from 1 to 25. (e) The subject must not see the Bi-Manual Test except when it is exposed on the ACCELERATOR during the test.

APPENDIX 3

**Scoring Keys for the Bi-Manual Test
Designed to Determine Relative Response Pro-
ficiency to Three Differentiated Sub-tasks
when the Sub-tasks are Exposed Visually at
Five Different Speed Levels**

APPENDIX 4

Summary of Individual Data for Fifty
Subjects Obtained during an Experimental In-
vestigation of the Effect of Changes in the
Speed of Presentation of Complex Visual Di-
rections on Bi-manual Performance

SUMMARY OF INDIVIDUAL DATA
FOR ALL FIFTY SUBJECTS
ON A BI-MANUAL TEST

114

Subject		Bi-Manual Performance Test					Motor Records			Otis Test	Taylor Test
Number	Sub-Group	M Score	D Score	Revers.	Omiss.	Extra	Repat.	Irreg.	Const.	I.C.	Anxiety Score
1	V	5	15	3	2	0	x	-	-	112	4
2	V	3	24	4	6	0	-	x	-	111	9
3	N	5	5	0	1	1	-	-	x	135	16
4	V	0	32	1	7	1	-	-	x	106	15
5	N	4	48	9	6	2	x	-	-	126	20
6	N	1	5	0	0	0	-	-	x	135	19
7	V	2	31	5	3	2	-	x	-	126	10
8	N	0	1	0	0	0	-	x	-	131	19
9	N	9	10	1	3	1	-	-	x	135	13
10	V	2	6	3	2	7	x	-	-	113	6
11	N	0	13	1	3	0	-	-	x	129	6
12	N	1	2	0	0	0	-	x	-	133	9
13	N	0	0	0	0	0	-	-	x	136	18
14	N	2	5	1	0	0	-	x	-	130	23
15	N	2	11	1	0	0	-	-	x	133	9
16	V	0	63	9	9	0	-	-	x	123	18
17	V	4	22	2	3	1	-	x	-	126	13
18	V	8	10	0	0	1	-	-	x	134	11

SUMMARY OF INDIVIDUAL DATA
FOR ALL FIFTY SUBJECTS
ON A BI-MANUAL TEST

115

Subject		Bi-Manual Performance Test					Motor Records			Otis Test	Taylor Test
Number	Sub-Group	R Score	D Score	Revers.	Unass.	Extra	Expat.	Irreg.	Const.	I. . .	Anxiety Score
19	S	1	36	2	1	4	-	-	x	115	24
20	V	7	27	5	2	2	x	-	-	123	12
21	V	9	126	11	5	7	x	-	-	108	9
22	V	1	23	3	2	1	-	-	x	117	14
23	S	4	102	10	12	10	x	-	-	92	15
24	V	0	22	3	5	0	x	-	-	120	13
25	V	8	52	5	24	0	-	x	-	112	13
26	S	8	61	9	13	2	x	-	-	125	25
27	V	5	16	1	6	0	-	x	-	119	19
28	S	8	76	7	5	4	x	-	-	111	18
29	V	1	38	4	10	0	-	x	-	107	9
30	V	0	53	2	6	1	-	-	x	117	18
31	V	12	165	32	16	4	x	-	-	111	13
32	V	0	43	5	1	1	-	-	x	123	20
33	E	6	99	6	36	0	x	-	-	117	16
34	S	14	38	4	6	0	x	-	-	124	9
35	V	1	8	2	4	1	-	-	x	98	6
36	V	6	53	5	12	2	x	-	-	101	8

SUMMARY OF INDIVIDUAL DATA
FOR ALL FIFTY SUBJECTS
ON A BI-MANUAL TEST

116

1		2					3			4	5
Subject	Sub-Group	Bi-Manual Performance Test					Motor Records			Otis Test	Taylor Test
Number		M Score	D Score	Revers.	Omiss.	Extra	Errat.	Irreg.	Const.	I.Q.	Anxiety Score
37	V	3	108	13	33	0	x	-	-	104	9
38	V	2	23	4	1	0	-	-	x	133	25
39	V	3	17	0	0	3	-	-	x	117	22
40	V	3	82	7	16	2	x	-	-	104	25
41	V	0	39	3	0	0	-	x	-	126	15
42	V	0	11	2	0	0	-	-	x	128	7
43	V	0	5	0	2	0	-	-	x	132	5
44	V	0	72	7	14	2	x	-	-	120	24
45	V	2	18	1	0	0	-	x	-	120	25
46	S	12	174	14	52	4	x	-	-	117	22
47	V	0	22	0	1	1	-	-	x	101	14
48	V	9	66	8	23	1	x	-	-	112	6
49	S	2	53	6	11	0	x	-	-	119	5
50	S	6	84	5	14	2	-	-	x	122	13

1. Number - Number assigned subject. Sub-Groups: Naval Reserve Officer Training Corps (N), Selected Group (S), and Volunteer Group (V).

2. M Score - Motor Task. D Score - Decision Task.

3. Permanent records obtained on the Recorder.

4. A.S. Otis, Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form D, New York, World Book Company, 1939

5. J.A. Taylor, "A Personality Scale of Manifest Anxiety", in the Journal of Abnormal and Social Psychology, Vol 48, No. 2, p. 285-290

ABSTRACT

An Experimental Investigation of the
Effect of Changes in the Speed of Presentation
of Complex Visual Directions on Bi-manual Performance

ABSTRACT

An Experimental Investigation of the Effect of Changes in the Speed of Presentation of Complex Visual Directions on Bi-Manual Performance

The problem was to investigate the effects, if any, of changes in the speed of presentation of complex visual directions on bi-manual performance.

It was predicted that of two types of bi-manual tasks, (1) a motor task based upon direct perception, and (2) a decision task requiring interpretation of the stimuli, only the latter would effectively differentiate among individuals and groups.

The study attempted to determine if speed, the independent variable, would distinguish initially between subjects in a bi-manual motor task involving a complication of visual directions. It was assumed that an increase in speed would bring about some tension (stress) within the subject, leading ultimately to error in response. Error was designated the consequent variable. The bi-manual test, consisting of three sub-tasks, was held constant and repeated at each of five different speed levels.

A total of 1,250 objective records of bi-manual response were obtained, resulting from the responses of fifty subjects who had each completed 800 bi-manual responses involving 5 different speed levels. The stimuli, typed stimuli, were presented on a mechanical accelerator

via a slit window. Responses were recorded on tape, the subject simultaneously pressing two keys on the recorder for each stimuli pattern. Test time per subject averaged 60 minutes. Subjects were 50 male college students.

The results confirmed the general predictions, the motor task proving to be non-differentiating regardless of speed, whereas the decision task differentiated between individuals and designated sub-groups in terms of error scores. The variations in individual performances, noted in a study of individual profiles, was greater than anticipated.

It was concluded that for the subjects tested and under the experimental conditions outlined, the higher order function (decision) differentiated effectively while the lower order function (motor) was negative in this respect for both individuals and sub-groups.

The implications of the study suggested that stress differences between individuals might be effectively and validly measured by properly applied functional motor tests involving decision and integrated response under speed. The selection of individuals by this means for stress-provoking occupations was noted. The clinical investigation of bi-manual performance stress-level scores and the possible correlation with brain damage, deterioration and personality disorders was proposed.