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Effects of Experimentally-Induced Muscular Tension and Frequency of Motivational Instructions on Pursuit Rotor Performance.

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EFFECTS OF EXPERIMENTALLY-INDUCED MUSCULAR TENSION AND
FREQUENCY OF MOTIVATIONAL INSTRUCTIONS ON
PURSUIT ROTOR PERFORMANCE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by
Albert Howard Bell
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ABSTRACT

The purpose of this study was to investigate the effects of experimentally-induced muscular tension and the frequency of the introduction of motivational instructions on pursuit rotor performance. Previous studies have shown that both muscular tension and motivational instructions may be either facilitating or inhibiting to performance. This experiment was designed to yield additional information regarding these relationships. Muscular tension was defined in terms of the amount of weight the subjects were required to hold in their non-preferred hand; motivational instructions were defined in terms of the frequency of the introduction of instructions to improve during the experimental session. Based on the premise that induced muscular tension represents a primary but irrelevant drive, and motivational instructions represent a secondary but relevant drive, it was predicted that performance would be increased as these sources of drive are increased or combined. This hypothesis was derived from Hull's assumptions that any effective habit strength (H) is sensitized into reaction potential (E) by all the needs operating within the organism at a particular time, and that the effective drive operating on a given habit would involve the summation of these needs.

A total of 216 graduate and undergraduate students were used as subjects, 24 being assigned to each of the nine experimental conditions. Each of the two motivational variables was varied in the following three ways: high, medium, and no muscular tension; and maximum, minimum, and zero frequency of instructions. The muscular tension groups were required to hold a 5 - lb. (medium tension), or 10 - lb. (high tension) dumbbell in the non-preferred hand in a vertical position with the arm extended toward the floor. The no tension groups held no weight at all. The instructions groups were treated in the following ways: maximum frequency groups received verbal instructions between each 20-sec. trial and between each block of five 20-sec. trials and minimum frequency groups received verbal instructions only between each block of five 20-sec. trials. Motivating instructions were withheld in the no instructions groups. All subjects were given six blocks of five 20-sec. trials with a 60-sec. rest interpolated between blocks to allow time for recording and for the experimenter to give the instructions to the instructions groups.

The results indicate that under the conditions studied in this experiment experimentally-induced muscular tension and the frequency of the introduction of motivational

instructions do not influence performance on the pursuit rotor. The analysis of variance reveals a very significant main effect for the practice variable, but no other significant effects were obtained. The author favors the hypothesis that the negative results may be accounted for by the subjects' initially high motivational state due to the intrinsically interesting properties of perceptual-motor tasks.

INTRODUCTION

In the experimental investigation of human learning, various methods have been used to manipulate motivational level. The most widely used techniques to control the motivational state of the subject have been reviewed by McGeoch and Irion (9). Included in their discussion are the influence of the introduction and removal of special incentives, the effects of instruction and set, and experimentally-induced muscular tension. Following the McGeoch and Irion publication, another method has become popular, namely, selecting subjects according to the scores obtained on the Taylor Anxiety Schedule (13, 14). The present study represents an attempt to manipulate motivational level in a pursuit rotor task in terms of the following motivational operations: (1) experimentally-induced muscular tension, and (2) the frequency of the introduction of motivational instructions.

Theoretical Considerations

Within Hull's (7) theoretical framework, any effective habit strength (H) is sensitized into reaction potential (E) by all the primary needs operating within the organism at a particular time, and the magnitude of E is the product

of an increasing function of H and drive D. In Hull's formulation the symbol D represents generalized drive. Reaction potential, then, is a multiplicative function of effective habit strength and drive strength, the mathematical statement of which is

$$E = (H) \times (D).$$

Assuming also, as Hull does, that other alien needs have the capacity to activate habits, the total effective drive (D) that is operating on a given habit would involve the summation of all drive strengths operative in the situation, both relevant ($\bar{D}$) and irrelevant ($\dot{D}$). Hull's tentative summation formula was negatively accelerated: $D = 100 \left(\frac{\dot{D} + \bar{D}}{\dot{D} + M_d} \right)$. Therefore, if induced muscular tension represents a primary but irrelevant drive, and motivational instructions represent a secondary but relevant drive, one would expect in the present experiment an increase in performance as these sources of drive strength are increased or combined, unless the initial level of motivation is very high.

Experimental Background

Muscular Tension--The first systematic study of experimentally-induced muscular tension was published by Bills (3). He conducted four separate experiments in which muscular tension was induced by the maintenance

of pressure on a spring dynamometer. The nine Ss in Experiment I learned nonsense syllables by the anticipation method. There were nine syllables of three letters each. The criterion was one perfect recitation, and the measures were learning time, number of syllables recalled, and percent saved in relearning. In Experiment II paired associates were used that consisted of real words. The 10 Ss were all graduate students of considerable training. Eleven Ss in Experiment III were required to add columns of numbers; speed and accuracy were recorded. In Experiment IV the task involved a modification of color naming, namely, letter naming. Ten Ss were used in this experiment. In all four experiments the results show the experimental group was superior to the control Ss who did not maintain pressure on the dynamometer, i.e., under induced muscular tension faster acquisition was observed. Bills offered a speculative physiological explanation in terms of the flow of afferent impulses from proprioceptive organs that somehow act as facilitators.

Courts (5) reported a study on the effect of muscular tension on rotary pursuit performance. A pretest for maximum strength was determined for each S, then six groups of 32 Ss practiced under dynamometer tensions of $1/8$, $1/4$, $3/8$, $1/2$, $5/8$, and $3/4$ of the measure of maximum strength. A control group simply placed their hands

on the dynamometer without squeezing it. All Ss were given 50 20-sec. trials with a 40-sec. intertrial interval. The dynamometer was squeezed only during trials. There was a slight facilitative influence of intermediate amounts of tension and a detrimental effect with extreme degrees of tension. The value of this study would have been enhanced if some measure of statistical significance had been reported.

In the area of serial verbal learning, Courts (4) also demonstrated that degree of facilitation is an inflected function of the amount of induced muscular tension. There were 60 Ss who served in a counter-balanced design, and the same tension values were used as in the rotary pursuit study.

More recently Adams (1) published a study of the effects of experimentally-induced muscular tension on the acquisition of a psychomotor response. The Two-Hand Matching Test was used. The Ss were 160 basic airmen trainees. The 40 Ss in each of three experimental groups kept either 10, 20, or 30 lbs. suspended by pressing stirrups to the floor. The experimental groups did not differ significantly at any stage of training from the control group, which practiced throughout without weights. It was also reported that the

effect of tension was no different for high-ability Ss than for low-ability Ss.

Among the verbal and motor learning experiments, the common finding appears to be that induced muscular tension produces a facilitative effect under certain conditions but not necessarily at a statistically significant level.

Instructions--The importance of the effects of instructions and set in human learning studies is frequently mentioned in the literature (e.g., 9, 15, 16). In general, it is often reported that instructions to Ss have a facilitative effect upon performance; however there appears to be conflicting evidence with regard to the effects of instructions introduced in motor learning experiments.

In an unpublished report by Atkinson and Ammons (2), 38 Ss were given seven 10-min. periods of continuous practice on the rotary pursuit separated by 5-min. rest periods. All Ss practiced at least 10 min. on the rotor prior to the start of the experimental sessions. During alternate practice periods, each S assumed one of two motivational roles. In the "high" motivational condition, the Ss were told: "Now, you are to assume the role of being highly motivated. I want you to really knock

yourself out. Do the very best you can!" In the low motivational condition, they were told: "Now, I want you to try just hard enough to keep the stylus on the target, but don't knock yourself out." Periodically the motivational role was re-suggested. A significant difference was found in performance between the "high" and "low" motivational conditions. Inferences made regarding the facilitative effect of the instructions would have been more meaningful, however, if a control group had been used in which no motivating instructions at all were introduced.

In an attempt to manipulate incentive-motivation, Noble (12) gave one control and three experimental groups of 400 Ss 32 one-min. trials on the Two-Hand Coordination Test. The task involves the manipulation of two cranks that maintain a target follower on a circular target about the size of a dime as the target moves horizontally in an irregular clockwise direction. At the end of trials 8, 16, and 24, supplementary motivational instructions were given to the experimental groups. No comments were made to the control group. The instructions to the experimental group were as follows: "As a group you are now scoring on target 50% (60%, 70%) of the time; 50% (40%, 30%) of the time you are not even on the brass plate. To pass this test requires a

score of 75% (85%, 95%), so you must make a 25% improvement; from 50% (60%, 70%) to 75% (85%, 95%). Keep working." There were no significant differences found between the control and several experimental groups. Although Noble considered the possibility that the information provided by the treatments may have been irrelevant to performance because of visual feedback, he favored the hypothesis that the negative results may be accounted for by Ss' initially high motivational state.¹

Statement of the Problem

In view of the diversity of results obtained in earlier studies, the fruitfulness of conducting additional research in this area is suggested.

Accordingly, the present experiment was designed:

- a) to yield additional information regarding the motivational properties ascribed to induced muscular tension and to the introduction of motivational instructions, and
- b) to investigate the effects of varying amounts of experimentally-induced muscular tension and the frequency of the introduction of motivational instructions on pursuit rotor performance.

¹A recent study by Noble in the L.S.U. laboratory (personal communication) included paired scores on the pursuit rotor and Taylor's anxiety test (13). In two samples the correlations were $-.102$ ($n = 103$) and $.062$ ($n = 106$), neither of which is significantly different from zero. For this reason, the anxiety index of D was considered irrelevant to the present study.

METHOD

Apparatus--The apparatus used in this experiment consisted of four USAF pursuit rotors, Model B-2 (10), that revolved at 60 rpm, four hinged styli, four 0.01 Model S-1 Standard Electric time clocks, four 5-lb. dumbbells, four 10-lb. dumbbells, and a stop watch. The apparatus was so arranged that trials of a standard length were automatically presented on all four rotors that operated simultaneously. The basic time intervals employed throughout the experiment consisted of 20-sec. trials separated by 10-sec. rests. Scores were recorded to the nearest 0.01 sec. at the end of each block of five 20-sec. trials.

Subjects--The Ss used in this experiment were both graduate and undergraduate male students enrolled during the 1956 summer session at Louisiana State University. None of the Ss had had previous experience with the pursuit rotor, and no pretraining or trial runs were given. A total of 216 Ss were used, 24 being assigned to each of the nine experimental conditions. They were tested in subgroups of from one to four in a simple counter-balanced order.

4.

Procedure--The design employed was a Lindquist (8) Type III, 5 x 3 x 3 factorial design, with 24 cases per group. Each of the two motivational variables was varied in the following three ways: high, medium, and no muscular tension; and maximum, minimum, and zero frequency of instructions. Prior to the instructions designed to motivate, all SS were given operating instructions modified from Melton (10):

"This apparatus is called a pursuit rotor. Your problem is to keep this stylus in contact with the target as the turntable rotates. Hold the stylus lightly in your preferred hand and place the tip on the target. Since the handle operates on a hinge, constant pressure is easily maintained. Keep your fingers behind the guard at all times. Do not press down on the stylus, but follow the target with a relaxed, swinging movement of the arm. There will be no practice period.

"Whenever the stylus touches the metal target, an electrical circuit is completed which records time on one of these clocks. Your job is to score as much time on the target as you can while the rotor is in operation. When the buzzer sounds, get on the target and try to stay on it. When the buzzer sounds at the end of the trial, the rotor will stop. Lift the stylus and hold it up until

the rotor starts again.

"First, there will be a number of trials separated by short rest periods. Then will come a longer rest period during which you will continue to stand by your rotors. Then there will be another series of trials separated by short rest periods, etc. The entire experiment will take about 25 min. Do the very best you can. Ready?"

All Ss were given six blocks of five 20-sec. trials with a 60-sec. rest interpolated between blocks to allow time for recording and for E to give the instructions to the instructions groups. Furthermore, since the experimental conditions were not introduced until the second block of trials, all Ss were treated the same on the first block of five trials.

The verbal instructions designed to motivate the groups differentially are defined in terms of the frequency of the introduction of these instructions during the experimental session. More specifically, the maximum frequency groups received verbal instructions between each 20-sec. trial and between each block of five 20-sec. trials. The minimum frequency groups received verbal instructions only between each block of five 20-sec. trials. Between the five-trial blocks the instructions were begun

exactly 10 sec. before the beginning of the next trial in the next five-trial block and ended just as this trial began. The following comments that were intended to manipulate motivation are as follows: "Remember, your job is to score as much time on the target as you can. When the buzzer sounds, get on the target and try to stay on it. Do the very best you can."

The muscular tension groups were required to hold a 5-lb. (medium tension) or a 10-lb. (high tension) dumbbell in the non-preferred hand in a vertical position with the arm extended toward the floor. The Ss in the weight groups were told to "pick up your weight in the non-preferred hand" between Blocks I and II, and were required to hold their weights throughout the duration of the experimental session. The no-tension groups held no weight at all, but kept the non-preferred hand extended toward the floor.

RESULTS

The following names and their symbols were given to the nine groups in this experiment: No Instructions-No Weight (NI-0), No Instructions-5-lb. Weight (NI-5), No Instructions-10-lb. Weight (NI-10), Minimum Frequency Instructions-No Weight (Min I-0), Minimum Frequency Instructions-5-lb. Weight (Min I-5), Minimum Frequency Instructions-10 lb. Weight (Min I-10), Maximum Frequency Instructions-No Weight (Max I-0), Maximum Frequency Instructions-5-lb. Weight (Max I-5), Maximum Frequency Instructions-10-lb. Weight (Max I-10). The mean time on target for each of the nine groups on the first block of five trials, before the introduction of the experimental variables, is given in Table I. These scores were obtained by summing all the scores in block I and dividing by 24, the N for each group. It will be observed that the range of performance extends from a mean of 14.43 sec. to a mean of 24.10 sec., the overall mean which is 19.00 sec.

A summary of a simple randomized analysis of variance design (8) for the nine groups during Block I is given in Table II. It may be observed that for 8 and 207 degrees of freedom, the obtained F value of 1.14

TABLE I

Mean Time on Target in Sec. for the Nine Groups
During Block I

GROUP	MEAN
No Instructions-No Weight	24.10
No Instructions-5-lb. Weight	16.37
No Instructions-10-lb. Weight	14.43
Min. Freq. Inst.-No Weight	17.42
Min. Freq. Inst.-5-lb. Weight	19.27
Min. Freq. Inst.-10-lb. Weight	22.05
Max. Freq. Inst.-No Weight	19.34
Max. Freq. Inst.-5-lb. Weight	18.71
Max. Freq. Inst.-10-lb. Weight	19.27

TABLE II

Simple Analysis of Variance for Nine Conditions
During Block I

<u>Source</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between <u>Ss</u>	1581.8029	8	197.72	1.14
Within <u>Ss</u>	35916.0066	207	172.67	
Total	37497.8095	215		

is not significant at the five per cent level of confidence. Although these data may yield significant differences between particular pairs of groups, it may be inferred from the non-significant F obtained from the overall analysis that no significant initial differences were observed among the groups.

A Type III analysis of variance was next performed to evaluate the differences obtained among the various experimental groups. The total sum of squares was partitioned into the following sources of variance: Within Effects--Trials, Trials x Instructions, Trials x Weight, Trials x Instructions x Weight, and Error (pooled S_s x Trials); Between Effects--Instructions, Weight, Instructions x Weight, and Error (between S_s). A summary of this analysis is given in Table III. It should be noted that this analysis was performed on the last five blocks of trials since the experimental conditions were not introduced until the second block of trials. Individual performance scores are presented in Appendix A.

It will be noted in Table III that neither the Instructions nor the Weight variable is significant. Both mean squares are obviously smaller than the error term. There is a slight effect with the Instructions x

TABLE III
Analysis of Variance of Scores Obtained from
Nine Groups of Ss Tested Under Different
Experimental Conditions

<u>Source</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Instructions	184.2196	2	92.1098	1.00
Weight	391.6449	2	195.8224	1.00
Instr. x Weight	4070.2120	4	1017.5530	1.023
Error (between <u>Ss</u>)	208806.8838	107	1944.2362	
Trial Blocks	90426.7731	4	22606.6932	982.386*
Trials x Instr.	173.1690	2	86.5845	1.00
Trials x Weight	175.8400	2	87.9200	1.00
Trials x Instr. x Weight	174.8125	4	43.7031	1.00
Error (pooled <u>Ss</u> x Trials)	19083.7499	828	23.0359	
Total	320647.1098	1079		

*Significant beyond the .001 level

Weight source of variance, but not large enough to approach significance. The Trials variable was found to be significant beyond the .001 level of confidence. No other significant differences were obtained, although where both Instructions and Weight were involved in the Trials x Instructions x Weight interaction, a slight effect was found.

Figure 1 shows the mean per cent time on target for the control and experimental groups at the six stages of practice. The calculated means may be found in Appendix A. All nine curves show a negatively accelerated increasing function of the number of trials presented, an expected outcome in motor learning experiments of this type. Some crossing over appears at each successive stage of practice, but there also appears to be two distinct sets of curves. The apparently superior set would include the conditions Min I-5, Max I-10, NI-0 (control), and Min I-10. Note that all of these groups except the control contain both instructions and weights. The apparently inferior set would include the conditions NI-10, Max I-5, Min I-0, NI-5, and Max I-0. Note that in this set each of the conditions except Max I-5 includes a control factor, i.e., the absence of either instructions or weight.

Figure 2 shows more clearly the course of learning

FIG. 1 Mean per cent time on target for the nine conditions of the six stages of practice.

FIG. 2 Mean percent gain of the six categories of different stages of practice.

for each of the experimental categories. These six curves represent the mean per cent gain of each of the experimental categories as a function of successive stages of practice, i.e., between each block of five trials. It should be noted that the symbols are different from those shown in Fig. 1 because they represent different combinations of groups rather than single groups. The value for the first point between blocks I and II for the No Instructions (NI) category was obtained by subtracting the mean of Block I from the mean of Block II in the NI-0, NI-5, and NI-10 conditions. A mean of these three differences was obtained and recorded. Similar operations were performed for the other five categories, namely, for Minimum Instructions (Min I), Maximum Instructions (Max I), No Weight (O-WT), 5-lb. Weight (5-WT), and 10-lb. Weight (10-WT). This procedure was repeated between Blocks II and III, III and IV, etc. These values are presented in Appendix B.

It may be seen in Fig. 2 that the NI and O-WT groups appear to be superior and inferior respectively to the other groups at the beginning stages of practice. Between Blocks II and III both the NI and O-WT groups fall below the other groups. At the next stage (between Blocks III and IV), both the NI and O-WT groups are superior, with the 5-WT and Min I groups next highest, and

the 10-WT and Max I groups the lowest. Toward the end of the session all of the groups tend to converge upon a common mean.

Figure 3 shows the mean per cent gain of each of the nine conditions as a function of successive stages of practice. These curves describe in a little more detail than in Fig. 2 the course of learning for each condition. Of particular interest is the curve describing the control group (N1-C). Note that although this group's initial gain is about the average for all groups, the gain is lowest in the final stage. The mean per cent gain values may be found in Appendix C.

FIG.3 Mean percent gain of the nine conditions of the five stages of practice.

DISCUSSION

In the present experiment motivation has been defined in terms of two operations, namely, induced muscular tension and motivational instructions. Muscular tension was varied by the amount of weight the Ss were required to hold in their non-preferred hand; motivational instructions were varied by the frequency of the introduction of instructions to improve during the experimental session. If it is assumed, then, that the greater the weight, the greater the muscular tension thus the greater the irrelevant drive, and the more frequent the introduction of the instructions, the greater the relevant drive, according to Hull (7), the combination of these drives should result in an increase in performance. Such a prediction did not hold up under the conditions studied in this experiment.

It should be pointed out, however, that the foregoing prediction could be made only if it is assumed that generalized D is not already operating at or near its maximum strength. The hypothesis offered is that the negative results obtained in this experiment may be accounted for by the Ss initially high motivational state due to the incentive provided by this particular

perceptual-motor task. A diminishing returns principle is assumed in Hull's drive summation formula, which is not inconsistent with the hypothesis of initial high level of generalized D. Presumably, then, Ss were already functioning near their maximum drive strength due to the incentive properties of the task, thus rendering ineffective the introduction of other motivational factors.

On the basis of Courts' (5) study it might have been predicted that the weight variable would produce an inflected performance function. One might also speculate that the instructions variable would also have an inflected function. Thus one might hypothesize that No Instructions and No Weight would have the least effect upon performance, Minimum Frequency Instructions and 5-lb. Weight the greatest effect, and Maximum Frequency Instructions and 10-lb. Weight near the No Weight and No Instructions level. The results from the present experiment show that such was not the case. Perhaps the discrepancy observed between the results obtained in the present experiment and the Courts study could be explained in terms of the difference in the method used to induce muscular tension. Courts utilized a dynamometer, whereas in the present experiment dumbbells were employed. There probably was

some distraction involved in maintaining a given pressure in Courts' study because his Ss were given a light signal if uniform pressure was not maintained.

Implicit in the design of the present study was the assumption that maximum attention to the task at hand would facilitate performance more than partial or interrupted attention. This desideratum was accomplished by having Ss merely hold a weight in the non-preferred hand, rather than requiring Ss to be constantly aware of the possibility of the occurrence of a flashing light that would be a signal for some sort of additional activity (e.g., squeezing harder on a dynamometer), thus resulting in apparently divided attention. It is this latter situation that the present study attempted to avoid. The foregoing presentation leads to the seemingly paradoxical conclusion that the facilitation resulting from muscular tension requires an attentional component.

Meyer (11) has recently developed a theory that attempts an interpretation of the Courts experiments from a physiological point of view. Within his framework the interaction of simultaneous responses is attributed to "a convergence of impulse patterns upon the motor pathways of the central nervous system" (p. 216). He bases his theory on the classical concepts of spatial

summation in addition to the details of organization within the motor system. When Ss squeeze the dynamometer a motor channel is activated, resulting in excitation that is distributed to other parts of the body. Small amounts of additional excitation trips-off appropriate neurons, and facilitation occurs up to a certain point. Finally, performance decreases because more and more inappropriate than appropriate neurons are fired.

Turning attention toward the motivational instructions, the results showing a non-facilitating effect are consistent with Noble's (17) experiment but inconsistent with the Atkinson-Ammons (2) study. In the latter experiment it is felt that most of the differences obtained between the so-called "motivated" and "non-motivated" conditions could be accounted for in terms of associational factors in the instructions. For example, this may be likened to the situation whereby one of two track men in a hundred yard dash is instructed to run as fast as he can, and his opponent is told not to run so fast. The outcome would most likely be in favor of the former, but is more attributable to the learning factor than to the drive factor.

Although no significant differences were obtained

in the present experiment except for the Trials variable, some interesting trends may be observed by inspection of Fig. 2. Noteworthy are the effects obtained at the various stages of practice. In general, when the weights and the instructions are combined they produce a facilitating effect early in practice and an inhibiting effect in the middle stages of practice. At the last stage of practice all of the groups perform at about the same level. Freeman (6) and Courts (5) also report similar findings at the beginning stages of practice. In the present experiment the results suggest that late in practice the instructions became monotonous and irritating to Ss, especially those in the zero weight groups, resulting in a minimum of facilitating effects. Reports from many of the Ss are in agreement with this suggested hypothesis. With regard to the weights, fatigue effects may have been operating to produce a decremental effect in the middle stages of practice. At the end of practice the weight groups appear to recover their advantage somewhat, as if the instructions were not so effective with the no-weight groups, who had less work decrement effects to overcome.

Under the conditions studied in this experiment the following conclusion may be drawn regarding part

(a) in the Statement of the Problem: Due to the absence of significant differences, the validity of ascribing motivational properties to experimentally-induced muscular tension and to the introduction of motivational instructions, is not supported by the results. Regarding part (b) of the Problem, the results show no effect of varying amounts of experimentally-induced muscular tension, as defined in terms of lifted weights, or the frequency of the introduction of motivational instructions on perceptual-motor performance.

SUMMARY

This study represents an attempt to manipulate motivational level in a pursuit rotor task in terms of the following two operations: (1) experimentally-induced muscular tension, and (2) the introduction of motivational instructions. Muscular tension was varied by the amount of weight the Ss were required to hold in their non-preferred hand; motivational instructions were varied by the frequency of introduction of instructions to improve during the experimental session.

The design employed was a Lindquist Type III, 5 x 3 x 3 factorial design. A total of 126 Ss were used, 24 being assigned to each of the nine experimental conditions.

It was found that neither the Instructions nor the Weight variable was significant. There was a slight effect with both the Instructions x Weight and Trials x Instructions x Weight interactions but not large enough to approach significance. The Trials variable was found to be significant beyond the .001 level of confidence. No other significant differences were obtained.

The results were discussed with regard to prior studies and to their implications for Hull's theory.

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APPENDIX

APPENDIX A
(NI-0)
Individual Performance Scores for the Six 5-Trial Blocks

	I	II	III	IV	V	VI	Sum
1	26.41	38.47	43.43	53.06	58.41	62.11	255.48
2	36.03	47.59	49.58	64.20	60.64	67.03	285.04
3	20.37	39.43	55.18	65.06	66.97	73.39	300.03
4	31.12	41.54	44.30	56.15	65.26	62.64	269.89
5	17.20	34.07	35.93	47.39	47.82	44.99	210.20
6	14.23	30.88	31.17	41.21	48.34	58.31	209.91
7	11.91	20.81	30.92	42.29	47.60	57.23	198.85
8	29.11	50.89	53.67	65.19	67.13	68.22	305.10
9	27.75	42.77	49.68	54.09	56.45	63.09	266.08
10	19.81	43.00	50.33	55.51	61.54	62.82	273.20
11	48.14	67.18	69.43	83.72	86.51	89.66	396.50
12	30.87	49.72	57.97	65.61	66.76	71.69	311.75
13	29.71	37.06	54.18	56.51	58.32	58.06	264.13
14	12.38	26.13	39.48	44.60	45.55	41.47	197.23
15	27.38	44.38	46.53	46.12	60.68	55.26	252.97
16	26.51	50.54	57.51	70.13	70.10	71.64	319.92
17	24.16	53.11	57.55	68.90	69.23	71.16	315.95
18	31.41	38.12	38.65	53.18	50.35	59.79	240.09
19	12.71	23.33	27.20	33.97	43.09	51.78	179.27
20	17.02	31.58	35.99	54.96	58.40	60.82	241.75
21	7.71	19.80	29.64	42.30	45.64	48.58	185.96
22	45.38	57.03	71.12	69.98	82.27	77.34	357.74
23	2.68	6.85	11.94	24.82	38.62	35.55	117.78
24	28.44	44.53	40.84	49.12	56.77	55.43	246.69
Sum	578.44	938.81	1082.22	1308.07	1412.45	1468.06	6209.61
Mean	24.10	39.12	45.09	54.50	58.85	61.17	

APPENDIX A Cont'd.
(NI-5)

S	I	II	III	IV	V	VI	Sum
1	14.34	48.51	51.89	60.31	62.70	62.03	285.44
2	14.33	35.04	35.95	42.82	41.68	45.07	200.56
3	18.47	38.85	46.20	47.90	53.02	55.11	241.08
4	11.66	30.45	40.66	52.04	52.11	56.54	231.80
5	29.74	45.88	52.66	61.03	65.29	66.61	291.47
6	21.53	40.32	50.91	58.45	67.04	70.69	287.41
7	24.05	33.10	41.27	52.89	59.89	63.61	250.76
8	5.70	15.23	27.53	43.36	43.80	53.83	183.75
9	19.98	46.09	47.62	62.90	74.17	67.52	298.30
10	20.17	36.64	47.70	55.04	61.04	66.89	267.31
11	15.46	29.08	42.40	46.84	56.93	61.62	236.87
12	25.78	33.34	44.44	41.85	57.80	59.21	236.64
13	17.47	38.25	43.65	53.47	59.95	61.83	257.15
14	15.98	26.27	37.50	46.35	53.95	59.63	223.70
15	9.59	21.90	40.03	51.25	47.87	55.13	216.18
16	10.40	28.97	42.44	52.48	49.93	55.91	229.73
17	2.40	16.16	24.16	35.91	39.68	46.59	162.50
18	5.15	21.87	34.10	25.61	35.28	32.46	149.32
19	37.40	56.23	73.04	76.79	73.84	80.28	360.18
20	26.08	34.09	46.85	51.45	60.35	62.09	254.83
21	13.71	33.99	39.53	47.06	56.74	59.64	236.96
22	11.69	28.31	29.74	39.94	44.96	46.75	189.70
23	7.30	17.76	20.06	33.36	41.48	41.72	154.38
24	14.48	27.53	37.64	55.19	59.14	62.72	242.22
Sum	392.86	783.86	997.97	1194.29	1318.64	1393.48	5688.24
Mean	16.37	32.66	41.58	49.76	54.94	58.06	

APPENDIX A Cont'd.
(NI-10)

S	I	II	III	IV	V	VI	Sum
1	5.39	25.27	33.17	29.59	29.77	32.15	144.97
2	23.31	38.59	45.38	52.37	58.92	64.14	259.40
3	11.34	29.01	42.68	52.40	60.02	71.45	255.56
4	17.80	24.45	37.97	44.59	49.21	54.08	210.30
5	15.94	34.78	41.60	41.85	41.13	53.04	212.40
6	11.99	20.19	33.56	47.60	55.94	61.83	219.12
7	8.55	26.31	42.29	53.76	49.74	64.24	236.34
8	30.01	41.00	53.16	68.26	68.51	70.40	301.33
9	52.75	76.21	80.48	86.65	87.40	87.83	418.57
10	15.87	40.24	46.99	50.54	54.13	62.33	254.23
11	6.11	34.73	43.00	55.08	58.59	61.62	253.02
12	5.03	16.29	24.99	34.94	37.03	45.99	159.24
13	34.86	60.63	69.64	75.64	84.46	86.32	376.69
14	19.62	38.71	40.40	42.26	50.74	54.33	226.44
15	22.90	39.59	46.87	54.27	54.21	53.87	248.81
16	11.11	42.09	50.57	61.91	60.31	61.65	276.53
17	24.91	63.01	72.04	78.90	85.29	87.35	386.59
18	10.50	34.78	49.53	57.07	57.77	70.73	269.88
19	4.07	18.81	30.77	37.62	42.35	43.59	173.14
20	.25	2.10	12.32	15.64	34.36	36.54	100.96
21	2.08	11.94	32.04	47.96	53.43	60.29	205.66
22	1.31	1.71	12.03	13.52	25.63	43.60	96.49
23	1.83	4.58	8.72	20.02	28.98	40.42	102.72
24	10.86	30.28	50.02	50.49	50.11	67.44	258.34
Sum	346.39	755.30	1000.22	1172.93	1288.05	1435.23	5651.73
Mean	14.43	31.47	41.68	48.87	53.67	59.80	

APPENDIX A Cont'd.
(NI-10)

S	I	II	III	IV	V	VI	Sum
1	4.39	25.27	33.17	29.59	29.79	32.15	144.97
2	23.31	38.59	45.38	52.37	58.92	64.14	259.40
3	11.34	29.01	42.68	52.40	60.02	71.45	255.56
4	17.80	24.45	37.97	44.59	49.21	54.08	210.90
5	15.94	34.78	41.60	41.85	41.13	53.04	212.40
6	11.99	20.19	33.56	47.60	55.94	61.83	219.12
7	8.55	26.31	42.29	53.76	49.74	64.24	236.34
8	30.01	41.00	53.16	68.26	68.51	70.40	301.33
9	52.75	76.21	80.48	86.65	87.40	87.83	418.57
10	15.87	40.24	46.99	50.54	54.13	62.33	254.23
11	6.11	34.73	43.00	55.08	58.59	61.62	253.02
12	5.03	16.29	24.99	34.94	37.03	45.99	159.24
13	34.86	60.63	69.64	75.64	84.46	86.32	376.69
14	19.62	38.71	40.40	42.26	50.74	54.33	226.44
15	22.90	39.59	46.87	54.27	54.21	53.87	248.81
16	11.11	42.09	50.57	61.91	60.31	61.65	276.53
17	24.91	63.01	72.04	78.90	85.29	87.35	386.59
18	10.50	34.78	49.53	57.07	57.77	70.73	269.88
19	4.07	18.81	30.77	37.62	42.35	43.59	173.14
20	.25	2.10	12.32	15.64	34.36	36.54	100.96
21	2.08	11.94	32.04	47.96	53.43	60.29	205.66
22	1.31	1.71	12.03	13.52	25.63	43.60	96.49
23	1.83	4.58	8.72	20.02	28.98	40.42	102.72
24	10.86	30.28	50.02	50.49	60.11	67.44	258.34
Sum	346.39	755.30	1000.22	1172.93	1288.05	1435.23	5651.73
Mean	14.43	31.47	41.68	48.87	53.67	59.80	

APPENDIX A Cont'd.
(Min I-0)

S	I	II	III	IV	V	VI	Sum
1	40.20	64.01	71.11	76.19	83.19	85.88	380.38
2	24.08	47.95	60.49	58.23	67.69	73.87	308.23
3	28.48	44.01	54.67	61.55	64.25	72.57	297.05
4	5.88	21.96	35.62	41.45	42.46	57.22	198.71
5	11.54	25.75	29.85	45.22	34.96	47.07	182.85
6	5.85	28.63	36.88	50.67	56.02	60.94	233.14
7	15.59	35.34	48.14	59.84	62.15	64.00	269.47
8	21.49	34.36	50.80	58.24	66.05	70.07	279.52
9	38.82	50.88	58.62	59.04	68.41	75.47	312.42
10	4.29	14.86	33.88	53.88	52.80	50.59	206.01
11	2.79	12.89	25.38	35.33	45.72	47.84	167.16
12	3.78	14.50	24.49	38.41	44.70	53.18	175.28
13	28.97	32.77	43.46	52.15	66.40	55.60	250.38
14	6.06	17.37	30.02	34.73	37.79	42.66	162.57
15	39.41	53.06	64.73	66.52	69.88	73.00	327.19
16	15.29	20.17	37.92	50.05	60.62	63.60	232.36
17	26.43	37.66	46.32	41.06	51.24	54.21	230.49
18	3.47	11.10	26.08	33.60	37.46	44.19	152.43
19	15.64	41.74	49.17	49.77	54.59	46.47	241.74
20	8.70	14.16	26.31	35.22	41.67	42.75	160.11
21	18.09	24.06	39.48	46.66	55.34	66.39	231.93
22	15.37	21.76	44.52	54.77	57.66	59.43	238.14
23	37.61	53.40	59.45	65.58	60.03	64.04	302.50
24	0.38	3.61	14.42	21.52	29.09	28.75	97.39
Sum	418.21	726.00	1011.81	1189.68	1310.17	1399.79	5637.45
Mean	17.42	30.25	42.16	49.57	54.59	58.32	

APPENDIX A Cont'd.
(MIN I-5)

S	I	II	III	IV	V	VI	Sum
1	15.42	36.15	38.30	49.98	56.08	49.61	230.12
2	16.58	20.22	32.07	41.95	48.55	59.03	201.82
3	9.33	33.36	45.16	58.84	64.22	65.21	266.79
4	33.14	42.59	58.54	63.77	61.76	73.98	300.64
5	26.40	50.21	61.81	61.42	68.45	69.02	310.91
6	19.65	26.81	45.48	56.14	64.92	70.62	263.97
7	27.23	51.13	52.80	62.01	72.37	68.40	306.71
8	24.15	48.91	63.64	61.33	66.31	70.69	310.88
9	19.87	36.81	55.45	63.38	67.33	68.94	291.91
10	15.84	25.11	32.20	45.36	45.64	52.49	200.80
11	40.45	58.40	60.25	65.15	74.41	83.37	341.58
12	33.75	55.70	60.63	72.84	78.16	79.83	347.16
13	17.93	30.36	52.01	62.40	66.06	74.69	285.52
14	13.37	35.26	49.67	48.73	57.79	59.41	250.86
15	12.12	17.46	39.45	50.05	49.09	55.70	211.75
16	2.40	5.86	20.76	30.06	31.09	52.93	140.70
17	6.96	28.69	38.30	50.71	54.94	63.90	236.54
18	43.48	55.25	56.15	67.08	65.02	69.00	312.50
19	4.11	10.36	15.91	26.10	29.89	48.20	130.46
20	40.04	54.88	57.63	67.65	67.85	62.69	310.70
21	5.68	20.87	37.71	43.78	51.84	56.66	210.86
22	0.65	13.66	34.46	36.70	38.43	40.95	164.20
23	26.78	38.85	40.24	52.61	51.60	49.93	233.23
24	7.22	20.11	38.77	41.90	51.90	66.34	219.02
Sum	462.55	817.01	1087.39	1279.94	1383.70	1511.59	6079.63
Mean	19.27	34.04	45.31	53.33	57.65	62.98	

APPENDIX A Cont'd.
(MIN I-10)

S	I	II	III	IV	V	VI	Sum
1	12.68	31.37	43.17	54.41	61.92	70.05	260.92
2	40.60	51.84	59.59	59.83	60.33	57.44	289.03
3	20.79	32.11	42.19	58.21	51.70	56.40	240.61
4	41.18	43.75	47.33	50.14	59.83	56.68	257.73
5	18.71	27.33	34.15	42.23	38.10	43.26	185.07
6	44.36	57.86	67.28	72.42	80.77	78.74	357.07
7	10.72	17.03	23.69	20.61	29.15	30.59	121.07
8	16.52	36.84	49.95	57.94	60.73	65.85	271.31
9	12.86	25.46	33.47	43.79	50.79	52.24	205.75
10	7.54	24.45	31.94	38.42	46.55	53.49	194.85
11	41.60	54.20	63.06	66.96	69.27	78.40	331.89
12	34.43	51.98	61.18	65.50	74.87	78.38	331.91
13	41.69	60.42	70.50	76.17	77.74	77.90	362.73
14	13.24	25.68	39.25	42.03	55.23	54.93	217.12
15	10.72	27.51	43.34	44.95	58.57	65.17	239.54
16	7.65	19.35	35.94	48.41	49.67	52.29	205.66
17	51.63	69.96	70.24	78.71	72.69	76.31	367.91
18	5.25	15.54	31.08	32.00	38.78	47.54	164.94
19	16.20	36.25	43.80	54.45	59.03	53.84	247.37
20	6.52	38.77	45.34	60.69	66.50	74.97	286.27
21	4.75	15.83	23.40	29.04	29.75	35.65	133.67
22	32.33	48.27	60.38	69.35	76.99	74.61	329.60
23	7.99	17.98	26.71	31.88	38.66	46.46	161.69
24	29.15	55.13	55.61	58.87	65.34	64.12	299.07
Sum	529.11	884.91	1102.59	1257.01	1372.96	1445.31	6062.78
Mean	22.05	36.87	45.94	52.38	57.21	60.22	

APPENDIX A Cont'd.
(MAX I-O)

S	I	II	III	IV	V	VI	Sum
1	7.86	23.19	32.42	45.08	54.63	55.52	210.83
2	40.74	62.47	63.80	67.91	77.64	80.44	352.26
3	9.41	21.71	47.48	43.59	51.13	64.63	228.54
4	19.78	33.62	31.76	48.76	40.55	51.03	205.72
5	8.65	44.35	47.90	56.62	54.36	58.80	262.03
6	4.45	5.01	11.14	15.05	21.05	21.42	73.67
7	55.82	66.06	66.00	73.99	73.45	75.14	354.64
8	31.25	43.03	58.90	67.09	71.37	74.89	315.28
9	24.32	47.78	55.02	56.23	68.54	66.85	294.32
10	6.40	18.04	23.19	17.17	32.41	36.81	127.62
11	15.39	33.93	38.79	53.02	55.69	63.84	245.27
12	31.23	35.88	45.39	50.56	52.56	63.81	248.20
13	34.46	45.13	48.18	49.94	59.30	69.55	272.10
14	28.55	41.95	52.77	62.76	63.92	64.28	285.68
15	24.72	31.05	34.74	41.31	50.61	48.99	206.70
16	21.54	24.45	29.72	34.76	34.56	41.41	164.90
17	5.58	23.16	31.31	42.41	36.15	46.08	179.11
18	4.44	16.51	26.68	28.09	28.08	41.07	140.43
19	8.63	19.52	29.66	48.93	56.10	58.71	212.92
20	11.29	37.90	57.32	69.84	68.12	66.02	299.20
21	1.75	5.16	17.83	27.51	35.55	44.63	130.68
22	36.84	56.33	55.46	66.29	69.36	68.34	315.78
23	23.55	39.64	47.45	62.43	57.56	56.38	263.46
24	7.46	18.59	25.22	27.84	28.89	35.87	136.41
Sum	464.11	794.46	978.13	1157.08	1241.58	1354.50	5525.75
Mean	19.34	33.10	40.76	48.25	51.73	56.44	

APPENDIX A Cont'd.
(MAX I-5)

S	I	II	III	IV	V	VI	Sum
1	18.47	40.11	62.29	60.29	56.24	70.99	289.92
2	36.77	43.53	47.32	51.01	65.21	62.77	269.84
3	3.37	18.84	41.31	44.94	49.16	48.75	203.00
4	6.54	17.81	29.69	31.19	51.27	49.38	179.34
5	23.97	45.24	48.80	61.62	65.51	64.66	285.87
6	5.74	16.64	22.59	21.86	32.51	43.89	137.49
7	51.84	56.92	67.16	68.45	69.84	73.02	335.39
8	20.01	35.94	43.98	57.99	59.83	53.13	250.87
9	20.78	39.20	51.68	66.42	73.26	81.09	311.58
10	5.53	14.31	18.56	22.38	29.24	33.33	117.82
11	69.64	84.61	90.85	91.69	93.96	93.14	454.25
12	3.39	3.46	8.35	20.76	35.80	42.98	111.35
13	22.76	38.52	38.61	41.81	48.18	52.78	219.90
14	35.53	60.28	57.24	58.16	69.59	62.46	307.73
15	36.81	55.56	68.39	65.97	67.09	71.58	328.59
16	9.48	28.82	51.71	62.47	65.30	69.51	277.81
17	33.79	51.28	50.94	61.20	64.71	64.19	292.32
18	6.15	29.04	46.31	54.68	54.11	53.26	237.40
19	5.49	13.68	30.89	42.23	48.02	54.37	189.19
20	7.16	16.41	26.68	33.60	39.55	42.43	158.67
21	1.84	6.94	13.61	27.62	34.96	47.81	130.94
22	5.29	14.96	26.95	39.73	41.49	41.92	165.05
23	10.87	39.55	51.16	57.46	65.51	73.89	287.57
24	7.90	26.70	24.68	36.23	46.89	51.17	185.67
Sum	449.12	798.35	1019.75	1179.76	1327.27	1402.43	5727.56
Mean	18.71	33.26	42.49	49.16	55.30	58.43	

APPENDIX A Cont'd.
(MAX I-10)

S	I	II	III	IV	V	VI	Sum
1	20.87	26.83	36.55	39.32	42.12	55.63	200.45
2	3.50	17.96	27.41	31.19	33.99	37.64	148.19
3	27.54	45.21	59.53	57.83	70.94	72.36	305.87
4	22.70	38.67	57.49	64.89	73.24	79.50	313.79
5	13.47	25.12	36.42	36.42	54.52	55.21	207.69
6	42.93	70.84	71.99	72.77	71.62	70.84	358.06
7	12.89	30.58	51.26	54.12	66.02	64.04	266.02
8	45.01	61.61	71.74	74.64	75.92	78.82	362.73
9	19.66	52.53	55.93	58.93	63.09	71.41	301.89
10	45.10	63.38	75.95	72.87	73.42	74.74	360.36
11	10.94	26.93	37.40	42.95	45.84	62.06	215.18
12	6.32	19.19	39.30	49.58	58.40	56.29	222.76
13	14.33	29.57	41.74	46.71	55.86	58.16	232.04
14	21.53	40.97	56.05	68.08	69.46	65.87	300.43
15	17.56	42.09	50.04	57.71	61.50	67.00	278.34
16	5.00	20.08	31.37	31.54	52.54	44.35	179.88
17	17.45	26.66	38.55	51.50	51.94	52.21	220.86
18	48.05	66.49	75.39	80.80	86.15	89.53	398.36
19	13.18	24.51	42.89	41.38	48.59	55.96	213.33
20	3.30	5.11	17.47	24.14	27.80	36.08	110.60
21	13.30	32.71	51.08	56.12	69.89	74.21	284.01
22	9.31	17.28	27.89	45.76	36.97	42.05	169.95
23	14.22	34.24	40.47	56.43	58.25	66.30	255.69
24	14.29	35.24	49.26	53.78	57.96	64.34	260.58
Sum	462.45	853.80	1143.17	1269.46	1406.03	1494.60	6167.06
Mean	19.27	35.58	47.63	52.89	58.58	62.28	

APPENDIX B

Mean Per Cent Gain of the Six Categories Between
5-Trial Blocks

CATEGORIES	I-II	II-III	III-IV	IV-V	V-VI
0 WT	13.87	8.51	8.10	4.28	3.59
5 WT	15.20	9.81	7.62	5.21	3.86
10 WT	16.06	10.44	6.30	5.11	4.28
NI	16.12	8.37	8.26	4.78	3.85
MIN I	14.14	10.75	7.29	4.72	4.02
MAX I	14.87	9.65	6.47	5.10	3.84

APPENDIX C

Mean Per Cent Gain of the Nine Groups Between
5-Trial Blocks

GROUPS	I-II	II-III	III-IV	IV-V	V-VI
NI-0	15.02	5.97	9.41	4.35	2.32
NI-5	16.29	8.92	8.18	5.18	3.12
NI-10	17.04	10.21	7.19	4.80	6.13
MIN I-0	12.83	11.91	7.41	5.02	2.73
MIN I-5	14.77	11.27	8.02	4.32	5.33
MIN I-10	14.82	9.07	6.44	4.83	3.01
MAX I-0	13.76	7.66	7.49	3.48	4.71
MAX I-5	14.55	9.23	6.67	6.14	3.13
MAX I-10	16.31	12.05	5.26	5.69	3.70

VITA

Albert Howard Bell was born February 15, 1924, in Hot Springs, Ark. He attended the Hot Springs public schools and Subiaco Academy, Subiaco, Ark., graduating from the latter in 1941. During the school-year 1941-42, he was a student at Hot Springs Junior College. Following three years naval service during World War II, he registered as a sophomore at Tulane University, receiving the B.S. degree in 1951 and the M.S. degree in 1955. In the meanwhile he registered in the clinical psychology program at Louisiana State University in 1954 and is presently a graduate assistant in the Department of Psychiatry and Neurology, L.S.U. Medical School, New Orleans, Louisiana.

EXAMINATION AND THESIS REPORT

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Major Field: Psychology

Title of Thesis: Effect of Experimental Alterations in the Frequency of
Repetition on the Retention of Material in the Memory
Approved: _____

W. Noble

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Date of Examination:

20 May 1957