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TRANSFER IN PRODUCTION AND JUDGMENT
WITH INPUT INFORMATION VARIED

Thesis for the Degree of Ph. D.
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This is to certify that the
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TRANSFER IN PRODUCTION AND JUDGMENT WITH
INPUT INFORMATION VARIED

By

Manuel Gordon Howat

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ABSTRACT

TRANSFER IN PRODUCTION AND JUDGMENT WITH INPUT INFORMATION VARIED

by Manuel Gordon Howat

Transfer of production and judging activities at two levels of input information was studied for the first known time in this experiment using 128 Ss each training for a total of 16 trials. Transfer was measured by the traditional comparisons. Training in both the control and experimental groups was divided equally into two units. A new piece of apparatus, a pair of compound pendulums with recording devices, provided the task viz. to produce or judge the maximum arc attained by one pendulum with variable momentum that could be supplied by the other.

Pre-training in production led to positive transfer in judging. Likewise pre-training in either complete or incomplete information input gave positive transfer over their control groups. The highly significant main differences and interactions demonstrated a means of improving predictions of transfer by a consideration of input information and activity or degree of motor participation. The inadequacy of predicting transfer solely on the basis of generalization gradients, the difficulty of the task and motivational factors stimulated by a mere change in activity

Manuel Gordon Howat

was also demonstrated. In the choice of activities for this experiment evidence also points toward the value of attending to the degree of active (motor) participation for transfer.

Approved Donald M. Johnson

Date September 21, 1962

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TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
II. PROCEDURE	7
Equipment	7
Task	13
Design	15
III. RESULTS	20
Main Effects	20
Traditional Transfer Comparisons	26
Transfer for Activity by Input Information	
Interaction	27
Comparison of Alternate Orders of Training	28
Comparisons of Proficiency in the First	
Half of Training	29
Interaction of Conditions with Stimulus Value	29
Results for the Predicted Ratio on Positive	
Transfer	30
IV. DISCUSSION	31
Main Effects	31
Traditional Transfer Comparisons	32
Transfer in Activity by Input Information	
Transfer	36
Comparison of Alternate Sequences on the	
Last Half of Training	36
Comparison of Learning on the First Half of	
Training	37
Incidental Observations	37
V. SUMMARY	38
REFERENCES	40

LIST OF TABLES

Table	Page
1. The Design of the Major Unit	15
2. Design Layout of Each Sequence in Terms of Block and Order (Letter) of the Presentation of Stimulus Values Called Latin Square I	17
3. The Design of Block 1, Table 2, to Show Four Latin Squares of Set II in One Arrangement. The Design Shown in Table 2 Determines the Arrangement of All Latin Squares, Set II, Within Other Blocks	18
4. Stimulus Value and Corresponding Arc Length in Producing and Judging. Variance of Stimulus Value E Attained and Mean Difference between Activities	19
5. Comparison of Alternative Training Procedure .	21

LIST OF FIGURES

Figure		Page
1.	Diagram of the equipment which provided the task with side view, endview and two inserts of the recording equipment, the guide and recording wire, lower left	9
2.	Transfer as a Function of Pre-training with Complete Input Information. Curves in this and succeeding grafts are drawn by eye to approximate the function	22
3.	Transfer as a Function of Pre-training with Incomplete Input Information	22
4.	Transfer as a Function of Pre-training with the Activities of Producing	23
5.	Transfer as a Function of Pre-training with the Activities of Judging	23
6.	Transfer Due to Pre-training under Pi Versus Jc Conditions	24
7.	Transfer Due to Pre-training under Ji Versus Pc Conditions	24
8.	Transfer Due to Pre-training under Pc Versus Ji Conditions	25
9.	Transfer Due to Pre-training under Jc Versus Pi Conditions	25

LIST OF APPENDICES

Appendix	Page
A The Instructions Read to the Subjects Who Served According to The Stage and Condition	41
B Record Sheets	45
C Mean Absolute Error in Inches on Each Trial of Training in U_1 , First 8 Trials, and U_2 , Last Eight Trials of Training	46
D Comparisons of Alternative Sequences for Over- all Proficiency in Training, $U_1 + U_2$	47
E Mean Squares Used in Evaluating Hypotheses as Listed in Table 5	48

CHAPTER I

INTRODUCTION

This experiment is unusual in studying the transfer of training in judgment and production as two alternative activities. Typically studies of judgment or psychophysical tasks have excluded from the published results the early learning trials or measures of transfer. Transfer of training at two amounts of input information about the task was also investigated.

The term input information was used here to avoid any confusion that manipulations of independent variables in this experiment coincide with the output information or knowledge of results from a response (R). Input information is defined as the information which is available to the organism from the stimuli provided by the task situation up to the moment the discrete R cannot be reversed. The contribution of the input information on any specific trial in the chosen task is integrated and weighed by the S in his individual manner between trials containing considerable intervening activity different from the Rs measured.

The evidence on input information before a response (R) for discrete tasks is almost non-existent except in concept formation. The evidence on information feedback in continuous tasks indicates uniformly marked deterioration

when there is a delay in the usual time of obtaining useful information (Bilodeau, et al., 1960). Manipulations of information feedback have shown non-significant improvement in transfer (Archer, et al., 1958; Archer, et al., 1956; Bilodeau, 1959) as well as findings of significant transfer (Reynolds and Adams, 1953; and Smode, 1958).

Three alternative procedures are commonly used in training proficiency about one problem situation with variable input and output. Arranged on a continuum from that requiring the least to the most active participation three are listed: (1) A trained person demonstrates various states and evaluates the input in terms of expected output, and Ss are not required to make a commitment or evaluation of output from the given input. (2) The instructor arranges for various states or input conditions and Ss are required to commit themselves to a prediction which has been named judgment or estimation. (3) The Ss are required to manipulate the input state to achieve certain specified output. Acceptable descriptive terms for these three in the order given may be the procedures of demonstration, judgment and production. The labelling of each is merely a matter of convenience. The point made is that there is a continuum for the degree of active participation in learning how to meet problem situations. Degree of active participation may be at least behaviorally defined as the amount of motor involvement along with the decision making process.

The task for this experiment requires (2) above called judgment (J) and (3) called production (P). These two tasks

or activities also must be available in the same problem situation and be as comparable as possible. Differences between activities do arise from the input information rather than the output information. The task required simple manipulation of the amount of input information without change in output information or without alteration of knowledge or results, here called output information. Lastly, the results of the training should provide a sensitive measure of transfer.

Tasks were tested in pilot studies to determine if the slope of the learning curve was marked as well as continuous over a number of trials of training in an effort to obtain a sensitive measure of transfer. This task was chosen in the expectation of obtaining a sensitive measure of transfer. Since transfer is based on learning, one criterion was to choose a task which would give marked evidence of learning (mastery) over a sufficient number of trials to achieve a powerful test with a moderate number of Ss. Also a prerequisite was that one stimulus complex could provide for learning via J (judging) or P (producing) in an isomorphic manner, differing only in the variable of input information and degree of active participation. A number of tasks which approximately met the preceding requirements were tried. Often the rate of improvement was marked for only the first two to three trials. Perhaps these trials provided the set or frame of reference necessary to instigate prior learning. More assurance was desired that an appreciable amount of new learning was taking place. This was why the

pendulum was chosen to provide the task.

The tasks tested are listed in the order of rapidity at which the learning curve approached an asymptote followed by the number of physical dimensions left to vary as follows: (1) water volume in a common beaker (one-height) (2) area of a circle (one-radius) (3) water volume in a funnel (two-radius and height) (4) momentum to strike a pendulum to attain a specified maximum swing (three-mass, velocity and gravity or radius) (5) projection of points separated by A cm. distance so a line T cm. distance long will leave Y cm. separation at the ends (two-length and width) (6) the number of pages in a section of a book under blindfolded conditions (one-thickness). In view of the power of the above tests the above ordering need not be taken an absolute but as suggestive of the novelty or degree of complexity required in order to have reasonable assurance that new learning will take place and last for over five discrete trials.

Of the two procedures labelled J and P a distinction can be made on the basis of the input information before the final or committing R is made. We illustrate with the tasks used in this experiment. It is to judge the maximum arc of swing of a pendulum after a variable impact or to produce the particular momentum which will result in a specified maximum arc of swing. First, we classify the available feedback loops used into internal (proprioceptive) and external neural sensory systems. Here J excludes the internal while P always includes it. In this experiment J included the input information available for the time interval up to the

rebound from the collision which E caught in his hand without noise. I.e. the input information in judgment, if complete, can include sight of velocity of the striker and sounds resulting from the initial impact which is excluded from production. The differences between J and P are then considered to be qualitative, and these differences were thought best evaluated in terms of input information, the second major variable studied.

The concept of stimulus discrimination and response differentiation suggests that it is best to practice a task in exactly the form that is to be later utilized for the most efficient or effective training procedure. When factors of economy enter in it is desirable to know the quantitative difference which exists between practice in different forms in order to determine a minimum cost solution. E.g. in the activity of P, a machine may be required for each S while this is not necessarily so for J. Again with the other variable usually all additions of information are at a cost.

On the basis of the preceding classification of input information it is hypothesized that the differences in transfer from the control for that variable will be proportional to the main difference between task conditions. In this experiment it leads to a prediction that the ratio of positive transfer in the activity over positive transfer in input information would be proportional to the differences between activities over the differences between conditions of input information. Notationally this may be expressed as follows:

$$\frac{+\text{Transfer (J-P)}}{+\text{Transfer (I-C)}} :: \frac{\text{J-P}}{\text{I-C}}$$

where J = judgment, P = production, I = incomplete information and C = complete input information.

With differing sequences of task conditions one approach is to predict e.g. greater transfer from the most difficult pretraining to the easier than from the sequence easy-difficult. Goldstein and Newton (1962); Lordahl and Archer (1958) obtained positive results while Ritchie and Michael (1955) obtained the reverse.

CHAPTER II

PROCEDURE

Subjects

Ss were young male college students enrolled at Michigan State University.

Equipment

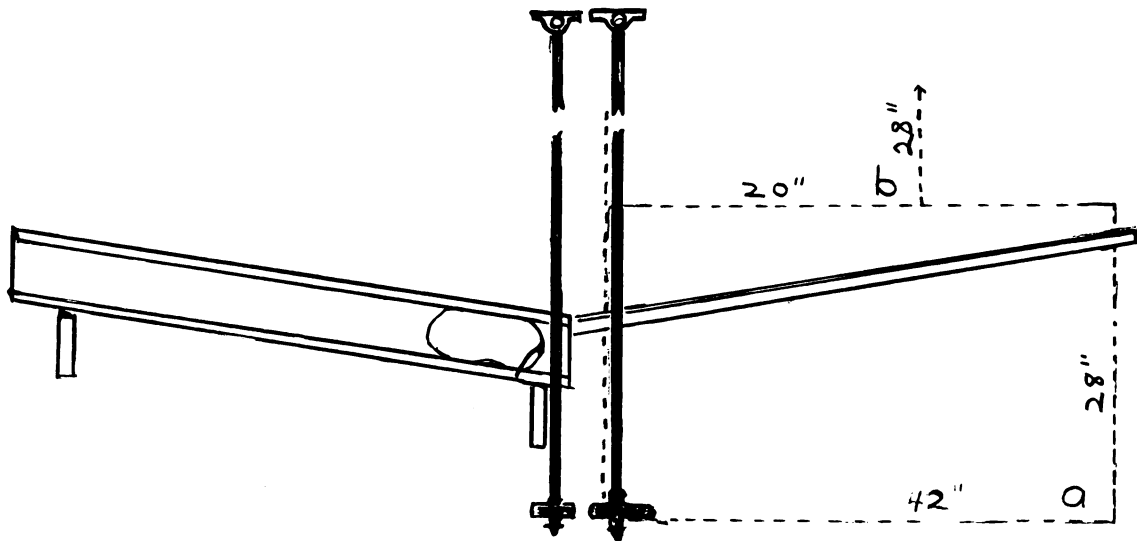
The equipment supplying the task consisted of four pairs of compound pendulums suspended on 1/4" cold rolled steel rods and mounted with the weights, round steel cylinders, facing each other endwise. One could be released from a point of displacement to strike the other like a hammer. The round cylinder weights, drilled before tempering, were securely clamped onto the suspending rod by sweating on nuts with solder. None loosened. The suspending rod extended one inch below the cylinder and this portion was threaded. This allowed a 1" wide by 2½" long strap piece to be clamped with an additional lock-nut to the bottom of the pendulums. These straps, all cut identically, were clamped cross-wise to the pendulums' line of rotation. At each end an eye-bolt was bolted into place. Guy wires extended from the eye-bolts to the ends of the rotating axle at the set screws. Piano wire was used and placed under

tension by lowering the eye-bolts. This imparted enough rigidity so that a striker pendulum could be released without missing its mate or making a near miss. The criteria used to tighten the piano wire on all pendulums to the same degree were (a) pitch of the wire plucked at the same point and (b) the extent of bow, viz. one inch, produced in the suspending rod. The radius of each pendulum was 61 in.

The supporting axle was an 8" by 1/2" cold rolled steel shaft supported by "Paffnir" sealed pillow-block roller bearings separated by 5 in. All bearings were dipped in gasoline for 1.5 minutes then rotated about an axle on a drill press for one minute each at a rapid speed to insure uniform seating of the seals before installation. Bearings were secured firmly via lag screws into spruce 2" x 4" so that all vibration from the pendulums was uniformly and effectively dampened at this point.

The pendulum weights were steel cylinders of 1 inch diameter. After machining each pair consisted of one shaft 133 c.m. for the striker pendulum and 82 c.m. in length for the recorder pendulum. The corresponding weights were 339 gr. and 179.5 gr. All sets were matched by machining to within .02 grams of each other. Machining produced identical levelled faces on all ends of the cylinders. Tempering was done in oil under conditions which achieved 42 Rc hardness on the surface, which is similar to that found in common hammers.

The recording pendulum carried the smaller cylinder; the striker pendulum carried the larger. Figure 1 illustrates



Side view of a pair of compound pendulums plus auxillary equipment and cardboard background drawn to scale

End view of one pendulum and recorder

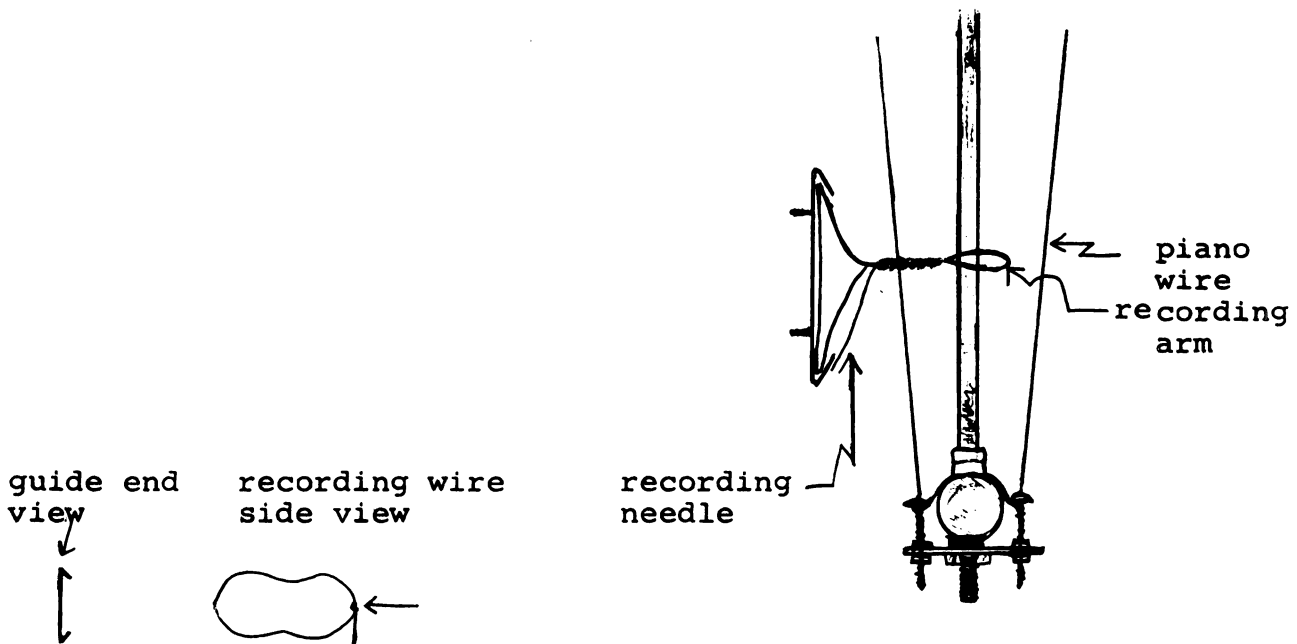


Figure 1.--Diagram of the equipment which provided the task with side view, endview and two inserts of the recording equipment, the guide and recording wire, lower left.

the recording equipment, mounted 2.5 inches behind the arc path of the recording pendulum, and indicates the wall background behind the striker pendulum. Figure 1 diagrams the arrangement for any one of the four pendulum pairs.

Between the rotating plane of the pendulums and wall there was space for mounting accessory equipment. Three wall brackets, 3.75 inches in depth, were attached at positions (1) behind the resting recording pendulum (2) behind an outside point on the arc of the recording pendulum and (3) behind an equivalent outside point on the arc of the striker pendulum. These three brackets were positioned at points which outlined a flat V. From both end points, which were separated by some six feet, galvanized, #28, metal fixtures were attached and supported together at the middle point. Behind the striker pendulum, Figure 1, was a 48 inch double V-shaped trough. This trough contained the marks E used to sight from to release the striker. Behind the recorder pendulum was a galvanized metal guide, 6 inches wide, 48 inches long, which contained the sliding recording marker. The shape of the recording guide is shown by the insert in Figure 1, lower left-hand corner. The shape of the recording pointer, front-view, is shown to the immediate right. The end-view of the protruding arm and pointer is with the end-view of the entire pendulum pair, lower right. Galvanized stove pipe wire, No. 19, had the required properties for construction of the recording marker in this system. The protruding arm which was caught by the pendulum, moving with increased displacement only, comprised the tightly twisted

pair of wires, one being folded back in a loop and the other folded over and extending back to just clear the marked edge of the guide and act as the indicator needle. This enabled readings to be made with little parallax error. E checked all readings at a point at a right angle from the guide at the position of the pointer.

The wire allowed continuous adjustment to equate the friction for all four pendulums. Equating frictions was done by adjusting the curvature of equivalent lengths of wire formed into markers until all would just slide down an angle of 28° under the influence of its own weight in each guide. Guides were next mounted at a smaller angle, viz. 8.7° . The friction was enough to prevent any slippage.

Line marking on the lower edge of the recording guide indicated the inches of arc travelled on the circumference of the recording pendulums. Readings were made to the nearest tenth of an inch by interpolation.

The double V-shaped trough, called the striker guide, situated behind the striker pendulum had marks only inside the V. This meant that no markings were available to the Ss and the E had to stand on an ordinary bench in order to use the two guy wires to sight opposite these marks for the correct release point of the striker. Such marks were predetermined by trial and adjustment to produce the desired arc swing in the recording pendulum. The variability in the arc E attained, the stimulus value, is recorded in Table 4.

Hanging from a wire close to the ceiling was a curtain mounted about 30 inches from the wall and running



parallel to it. Nothing could be seen behind the drawn curtain. It was possible to draw the curtain one-half of the way to cover the recording pendulum or to draw the curtain entirely across to cover both pendulums to leave nothing exposed from 3 inches above the bench to within 10 inches of the ceiling. With the curtain pulled all the way across visual information was so limited that it appeared to be ignored. This enabled input information level to be kept essentially constant for Ss.

Behind the striker pendulum mounted on the wall over the brackets were two panels of cardboard, a and b, of dimensions 28" x 42" and 20" x 28" respectively, as scaled in Figure 1, top. This presented a uniform background providing no markings from which sighting or reference could be made within this area. Below these were two 30 inch strips of wrapping paper side by side to present a further uniform but less expensive background below the path of the pendulums to ensure that no reference points would be left for use.

The experiment used in addition four standard clipboards, four jointed cardboard covers and four padded blindfolds. The blindfolds were made of heavy black felt with cloth contoured around the nose with a one inch wide elastic band to secure the position. Under the felt eyepiece a stuffed pad was sewn which ensured that the eyelids would be closed when the blindfolds were in place. The cardboard cover allowed one piece to be secured under the clip of the clipboard and the other folded piece would rest over the

hand and pencil of the S covering one-half of the page. It meant that Ss were unable to see another's record without greatly changing head position in a manner that would be obvious to all. It also meant that E could observe the records by simply walking behind the bench to read. This E did regularly.

Task

The task was described as one of learning the proper amount of momentum as supplied by release of the striker pendulum which would result in a specific length of arc movement of the recorder pendulum. The specific instructions read to the subjects are given in Appendix A as follows: 1, introduction to the equipment, 2 to 5 instructions for specific conditions, and 6, general orientation of Ss to the entire experiment, including Es role in the experiment. Instruction always involved the following sequence of events: introduction, a set of specific instructions for the conditions they would first train under, general orientation, actual participation in the first 8 trials of training (U_1), and lastly instructions for the second half of training (U_2).

The production (P) activity required Ss to record to the nearest tenth of an inch the stimulus value they were to try for before each trial, get the striker pendulum poised as instructed, and release when E said, "go". The preparation for the strike in the incomplete information input (I) condition was without vision from the time the S took a standing position until after the strike or collision. Lowering

and raising padded blindfolds to the forehead with the left hand accomplished this easily. Because blindfolds were raised after release and before Ss caught the return swing of the pendulums the output information or knowledge of results was alike or constant for either input information condition.

In the judgment (J) activity Ss were seated on a bench facing pendulum pair B. Cardboard hoods, which covered their hand, pencil and upper half of their record sheets, were clamped in place on their clipboard. E called "ready" after obtaining a correct sighting at least two seconds before the strike. Ss were to record their estimate, to the nearest one-tenth of an inch, within 10 seconds after the collision. If an S had not recorded he was asked to do so at this time. For complete input information (C) the curtain was drawn far enough so that no S could see the recording pendulum more than three inches from rest. Since the suspending rod was straight and extended upward from a point 54" above the floor, Ss could project from the rod to decide where the pendulum weight was positioned no matter how the E's body covered the bottom of the striker pendulum. For incomplete input information (I) the curtain was drawn all across the wall section to cover all the pendulum apparatus from S's vision.

Ss aimed for the lowest error score possible. The same stimulus values were given in different random orders balanced over groups (blocks) in a latin square arrangement as detailed below for both activities, P and J, or units,

U_1 and U_2 of training, each of 8 trials.

Design

Basically the design was to allow a comparison of the transfer of training in one activity or under one condition with training involving two activities or conditions. For one variable, activity, the paradigm may be JJ vs. PJ or PP vs. JP. For input information the designation would be CC vs. IC or II vs. CI. This experiment compared both orders. The overall design is best described as two experiments or stages I and II which complement each other. Each reciprocally contains the control sequences for the variable which has the experimental sequence in the other stage. The arrangement of the 16 basic cells which accomplished this is indicated by the labelling below, where activity is used for column headings in both stages.

Table 1.--The Design of the Major Units

Stage	I				II			
Unit	1	2	1	2	1	2	1	2
Activity	P	P	J	J	P	J	J	P
Input in- formation level	C	I	C	I	I	I	I	I
	I	C	I	C	C	C	C	C

Every one of the 8 sequences above, or 16 cells paired into training sequences, can be described by the four orders of a set of stimulus values given twice per unit of 8 trials

or a total of four times. The second presentation was modified to prevent recognition of the specific stimulus. These four orders constitute four columns of a Latin square. The four rows comprise the four possible sequences of orders for presentation of the stimulus values to a group of four Ss at one time. Each row is one of the four blocks used in the experiment. The arrangement is illustrated in Table 2 where the orders are designated by letters.

The first row of Table 2 helps to relate this breakdown to the 8 sequences or 16 cells previously described. The second row helps relate Latin Square I to the further breakdown into trials using Latin Square II.

The final breakdown of design specifies the arrangement of particular stimulus values within trials. A group of four stimulus values comprise an order designated by a letter in Table 2. Every order occurs then only once in each of the four segments of training (columns in Table 2 and in each row (block)). The specific values per order are shown in Table 3 by reproducing all those occurring in the top row, Block 1. The four orders in one block, a row of Latin Square I, comprises an entire Latin Square II where stimulus values (St.) are columns and each segment of four trials is one row.

Table 2.--Design Layout of Each Sequence in Terms of Block and Order (Letter) of the Presentation of Stimulus Values Called Latin Square I.

Unit	First		Second	
Trial Nos.	1-4	5-8	9-12	13-16
Block 1	D	C	B	A
Block 2	A	B	C	D
Block 3	B	A	D	C
Block 4	C	D	A	B

The eight stimulus values used once in each half of training actually comprise four values (1, 2, 3, 4) plus four of the same slightly modified (1', 2', 3', 4') by the addition of a constant height increment, viz. 0.1 inches, Table 3. Since all communication was in inches of arc traversed, the increment on the dimension of height was changing as some non-linear function. No Ss expressed recognition of a constant increment in the pertinent independent variable of height displacement. The tabular values in height for each of the arc distances requested in production are given in Table 3. It can be seen that the spread in height of displacement is a minimum of 1.0 between the four distinct stimulus values. This is ten times the distance between the second slightly modified second of four stimulus values indicated with a prime.

Table 3.--The Design of Block 1, Table 2, to Show Four Latin Squares of Set II in One Arrangement. The Design Shown in Table 2 Determines the Arrangement of All Latin Squares, Set II, Within Other Blocks.

Order	Trial number	Stimulus value number	Inches of height displacement	Inches of arc length
D	1	2	2.3	16.8
	2	4	4.5	23.6
	3	3	3.4	20.5
	4	1	1.2	12.1
C	5	1'	1.3	12.6
	6	3'	3.5	20.8
	7	2'	2.4	17.2
	8	4'	4.6	23.8
B	9	4	4.5	23.6
	10	2	2.3	16.8
	11	1	1.2	12.1
	12	3	3.4	20.5
A	13	3'	3.5	20.8
	14	1'	1.3	12.6
	15	4'	4.6	23.8
	16	2'	2.4	17.2

Column 4 of Table 4 shows small variance values and clearly indicates that the stimuli for judging can be treated as independent variables for purposes of regression with the relaxation which allows relatively slight variability without marked alteration of the probability statements (Acton, 1959). Column 5, Table 4, indicates that the difference between the stimuli for producing and the mean used in judging was nil, and can for practical purposes be equated in the context of this task.

Table 4.--Stimulus Value and Corresponding Arc Length, Variance and Mean Arc Length in Producing and Judging. Variance of Stimulus Value E Attained and Mean Difference between Activities.

Stimulus Value Number	Arc Length in inches			Difference P - J
	Asked to Produce	Attained in Judgment Mean	Variance	
1	12.1	12.00	.09	-.10
2	16.8	16.66	.52	-.14
3	20.5	20.43	.10	-.07
4	23.6	23.5	.06	-.10
1'	12.6	12.52	.10	-.08
2'	17.2	17.11	.05	-.09
3'	20.8	20.82	.06	-.02
4'	23.8	23.84	.08	-.04

Pilot data confirmed the expectation that the standard deviations increased as the mean of the trials increased. The Log_{10} transformation of this data adequately eliminated the dependence. A second reason a logarithm transformation was adopted is that previous studies indicate that the logarithm of the stimulus values is a suitable transformation for describing the behavior of organisms.



CHAPTER III

RESULTS

Main Effects

In view of the design and power reflected in the overall standard error of $.00064 \log_{10}$ in. it is of interest that the difference among the four pendulums, the four blocks and four orders did not attain significance even at a P criterion of 0.10.

The grand mean of all the conditions combined showed an underestimation of 1.035 inches of arc and an absolute error of 1.076 in. of arc.

All differences between levels of the main three variables were highly significant, $P .0005$. The absolute error for the P activity was 0.22 in. of arc more than the J activity. Likewise, there was 0.51 in. more error in the I level of input information than at the C level. The first half of training called U_1 contained 1.21 in. more error than the last half of training U_2 . These means can be obtained from Table 5. Appendix E contains all mean squares for Table 5.

The functions for U_1 and U_2 over eight trials each differed significantly for all three components as shown in the last three columns of Section A, Table 5. Mean Values for each trial are in Appendix C. Evaluated over Stage I with



Table 5. Comparisons of Alternative Training Procedure.

Comparisons of Groups with Absolute Error in Inches					Statistics on Transformed Data				
Grp.	M.	Grp.	M.	Diff.	P for diff.	Ref. to fig.	P for Components of the functions		
							c*	l*	q*
A. Units of Training, First Eight Versus Second Eight.									
U ₁	3.77	U ₂	2.55	+1.21	.001		.001	.001	.05
B. Traditional Evaluation of Transfer on the Last Eight Trials.									
1. Input Information Level.									
CI	2.62	II	3.00	+ .38	.001	2	.01	.08	.05
IC	2.22	CC	2.34	+ .12	.001	3	.075	-	***
2. Activity Level.									
PJ	2.38	JJ	2.49	+ .11	.001	4	-	-	-
JP	3.00	PP	2.34	- .66	.001	5	.05	-	-
C. Transfer of Activity by Input Information Interaction.									
PiJi	2.64	JcJi	2.69	+ .05	.001	6	-	.05	.15
JiPi	3.44	PcPi	2.55	- .89		7	.02	.01	.06
PcJc	2.12	JiJc	2.30	+ .18		8	.01	.02	-
JcPc	2.56	PiPc	2.14	- .42		9	.03	.01	.09
D. Comparisons of Alternate Sequences on Last Eight Trials.									
JiJc	2.30	JcJi	2.69	+ .39	.001	8,6	-	.04	-
PiPc	2.14	PcPi	2.55	+ .41		9,7	.04	.04	-
JiPi	3.44	PiJi	2.64	- .20		7,6	.08	.03	-
JcPc	2.56	PcJc	2.12	- .44		9,8	.03	-	-
E. Comparisons of Learning on the First Half of Training.									
Jc	2.73	Ji	3.37	+ .65	.001	9,8	.03	-	-
Pc	3.08	Pi	3.46	+ .38	.001	8,6	-	-	-
Pi	3.46	Ji	3.37	- .09		6,7	x	x	x
Pc	3.08	Jc	2.73	- .35		8,9	x	x	x

* c = constant, l = linear, q = quadratic

-*** not significant at any acceptable level

x not tested for significance

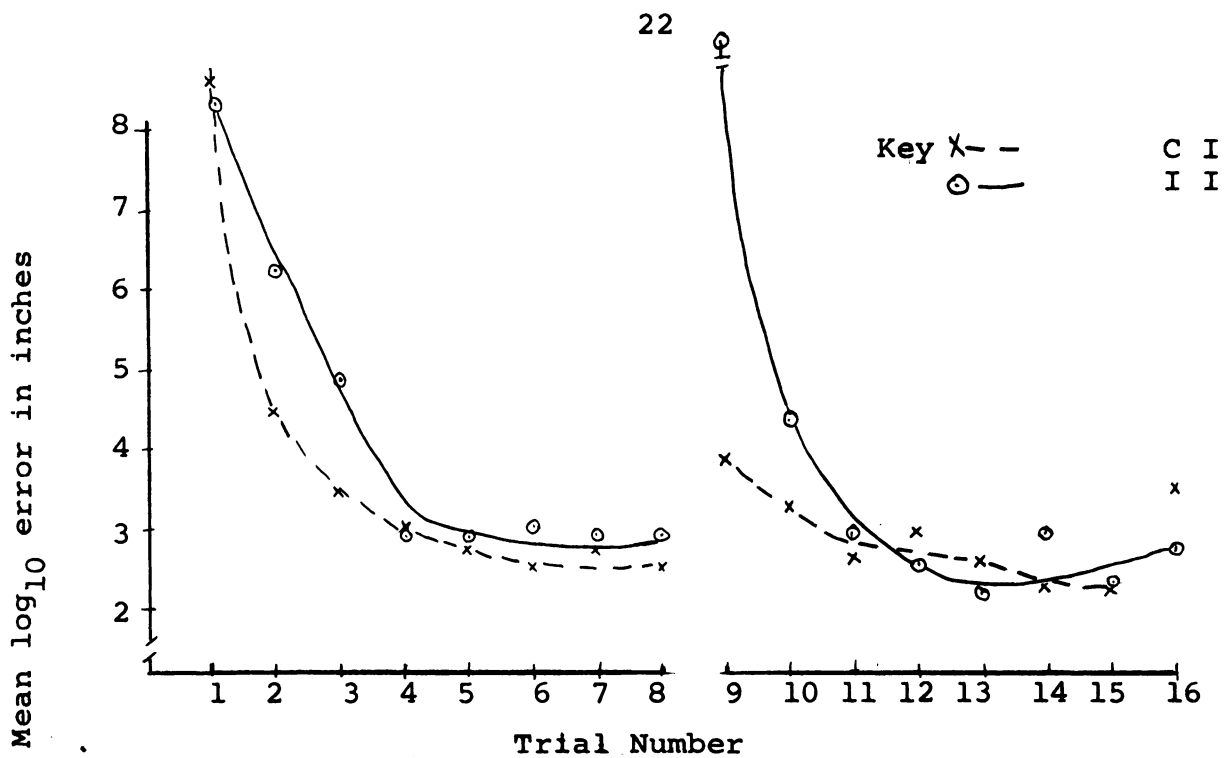


Figure 2.--Transfer as a function of Pre-training with Complete Input Information. Curves in this and succeeding graphs are drawn by eye to approximate the function.

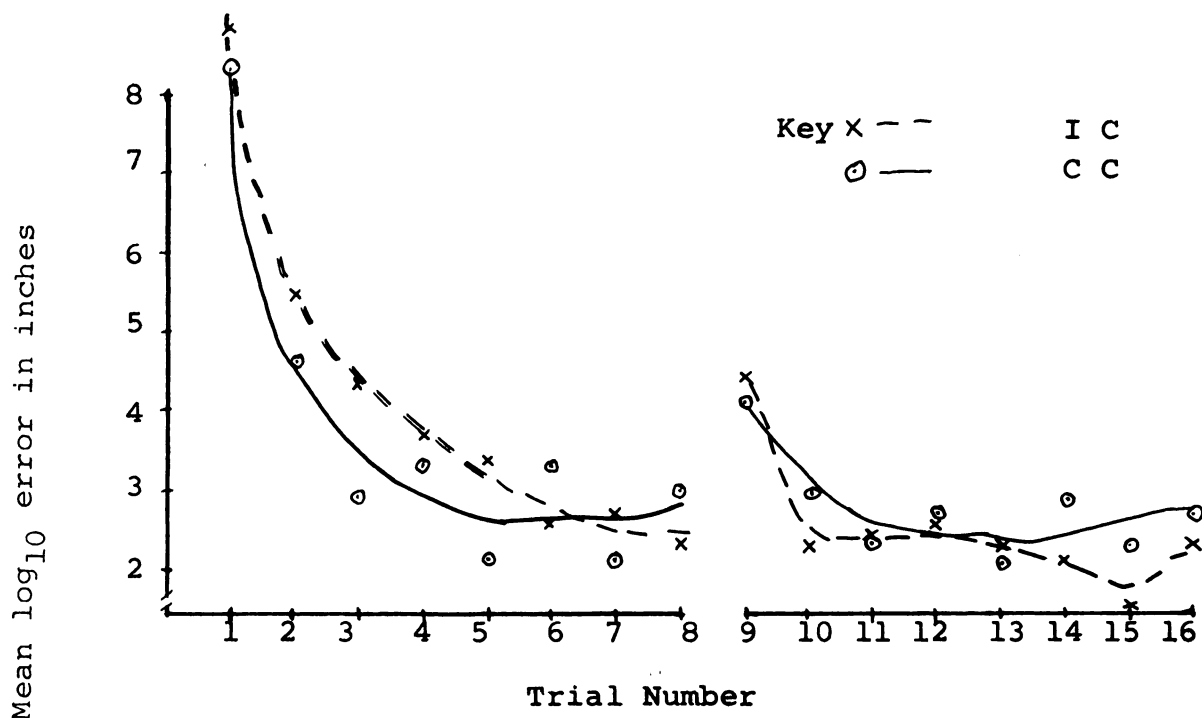


Figure 3.--Transfer as a Function of Pre-training with Incomplete Input Information.

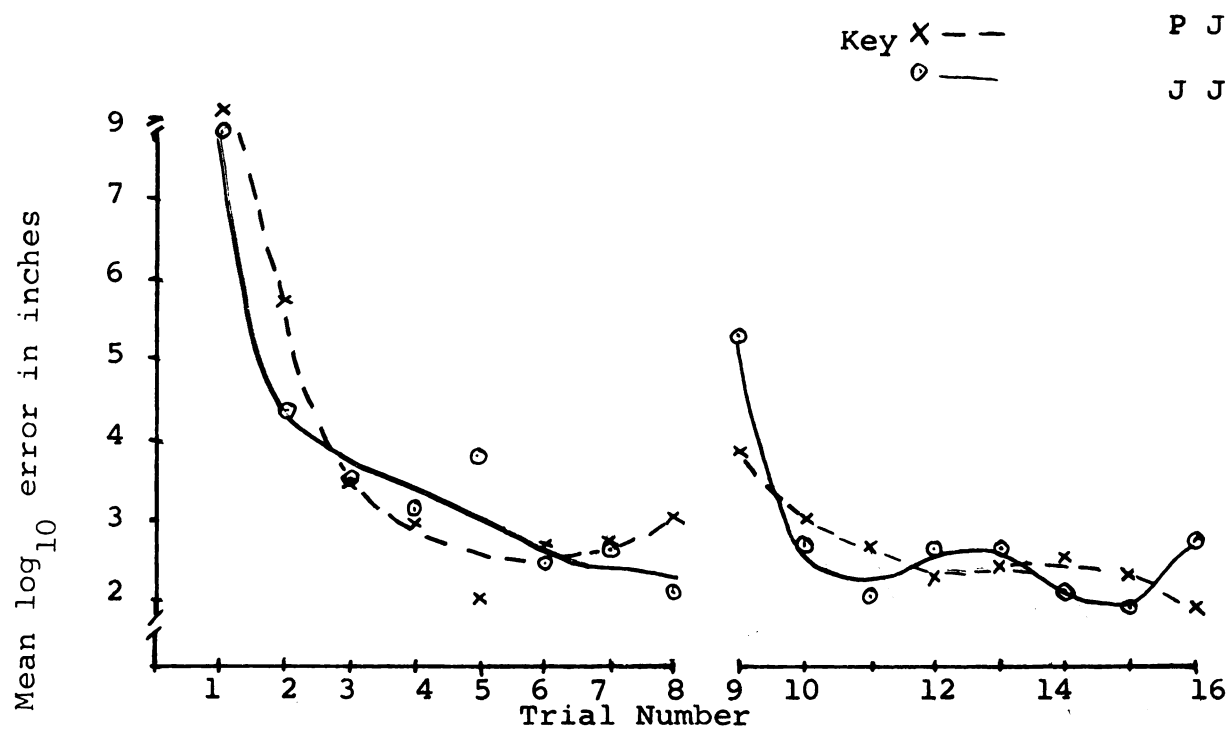


Figure 4.--Transfer as a Function of Pre-training with the Activity of Producing.

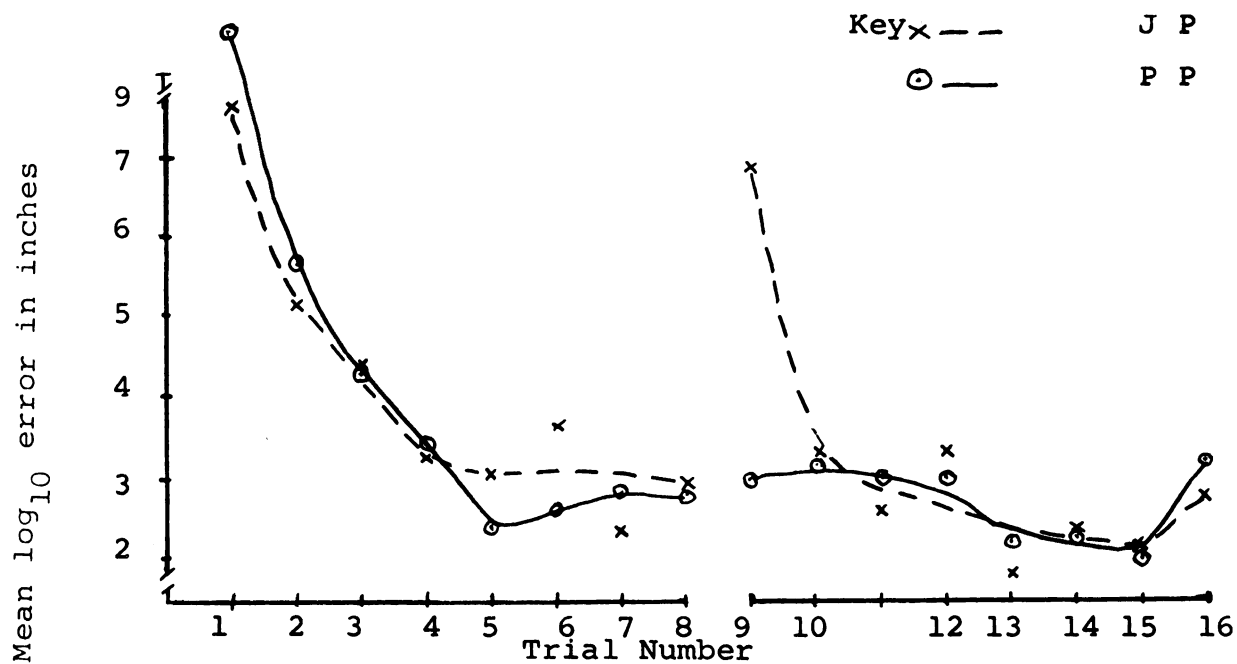


Figure 5.--Transfer as a Function of Pre-training with the Activity of Judging.



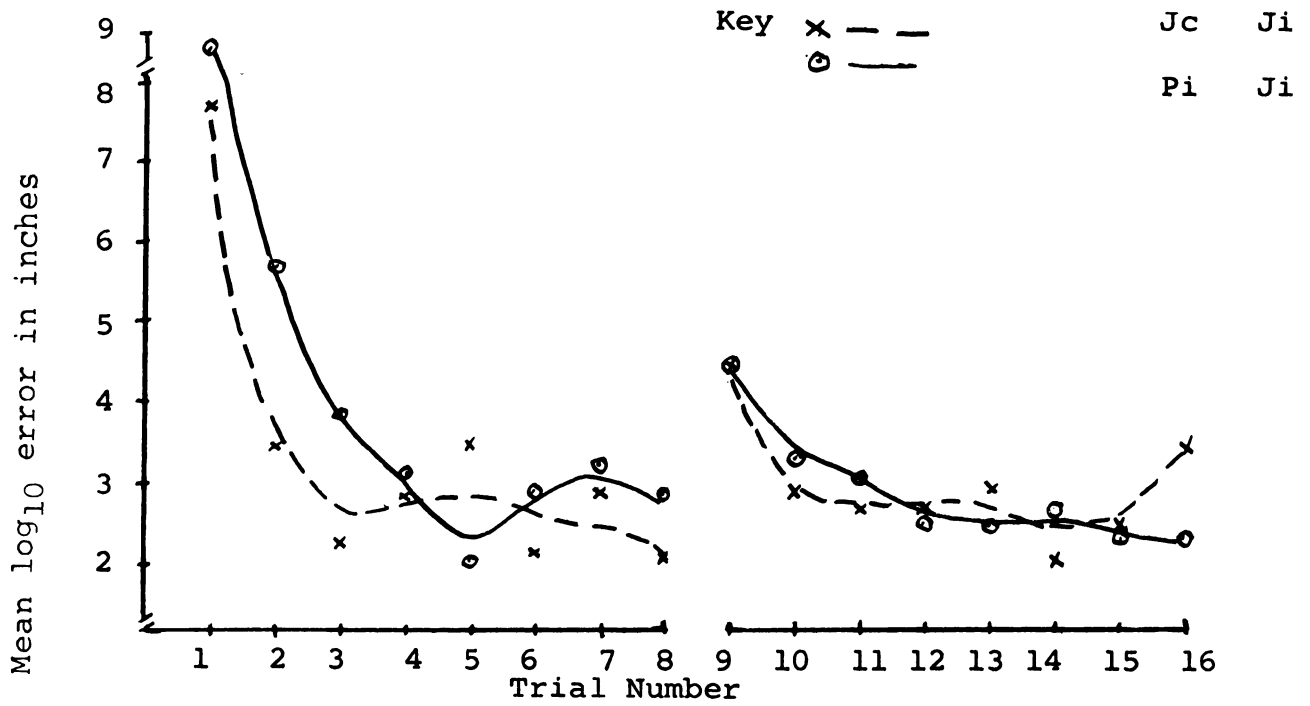


Figure 6.--Transfer Due to Pre-training under Pi Versus Jc Conditions.

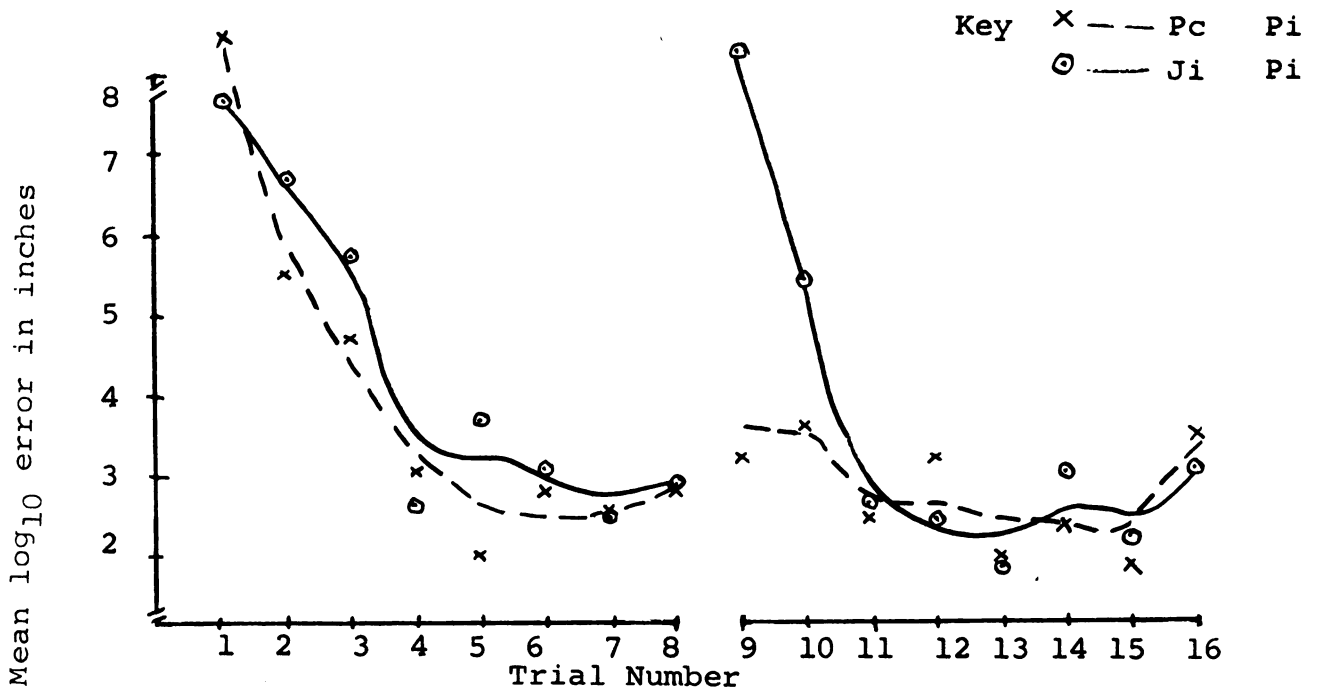


Figure 7.--Transfer due to Pre-training under Ji versus Pc Conditions.



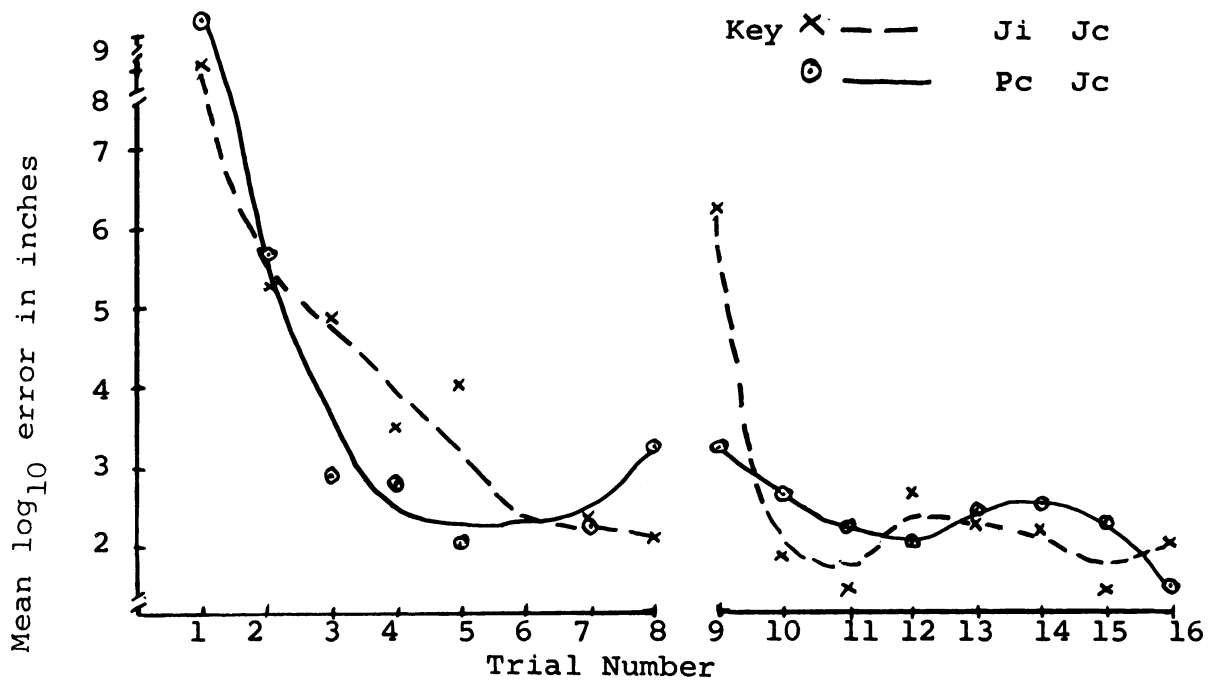


Figure 8.--Transfer due to Pre-training under Pc Versus Ji Conditions.

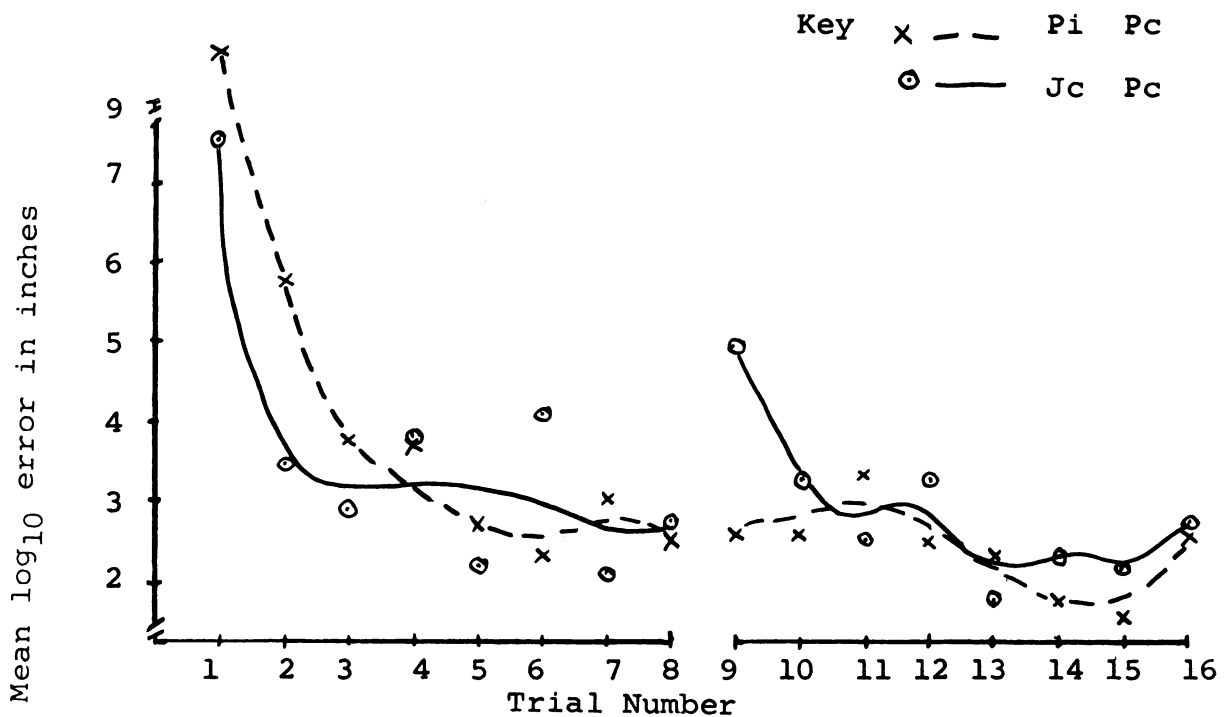


Figure 9.--Transfer Due to Pre-training under Jc Versus Pi Conditions.

64 Ss the functions for P and J did not differ significantly in any of the three components and for this reason were not included in Table 5.

Traditional Transfer Comparisons

Here evaluation is made of transfer by comparison on the last half of practice using the classical paradigm of the experimental group B-A versus A-A. Table 5 contains the identification of these comparisons, using abbreviations previously introduced followed by the absolute mean error of each, the difference in absolute error attributable to transfer or other comparisons with sign and the P value obtained for the hypotheses of no overall differences among groups covered. Next reference is made to the most relevant figure illustrating the function which will help the reader to visualize difference between functions of the pair for the constant, linear and quadratic components. These P values are given in the last three columns of Table 5. Only the first three columns of data in Table 5 use raw values. The figures and statistical analyses use absolute error transformed to $\log_{10}$. The rows of Table 5 list, A. Units of Training, B. 1 input information level, and 2 activity level, C. Transfer of activity by input information interaction, D. Comparisons of alternate sequences, E. Comparisons of learning on the first half of training.

The first six columns of Section B, Table 5, reveal that heterogeneous training was superior in transfer to homogeneous training for these variables with one exception,



viz. JP was 0.66 inches inferior to PP. Not only did P show 0.22 more error than J over all 16 trials, but P showed a larger margin of mean error over J in the last 8 trials, viz. 0.47 inches. This, with Figures 4 and 5, offers empirical evidence that the rate of learning in activity P was less rapid than in J.

The three components that were evaluated for the function over trials for the CI vs. II comparison differ significantly at acceptable P levels as shown in the last three columns. Only the constant component approached significance for the IC vs. CC comparison. For the variable activity, B2, the only significant difference was between the constant terms for the JP vs. PP comparison. The magnitude of these differences is best estimated from Figures 2 to 9 using a best visual fit for the function to the observed data points. The exact trial means are recorded in Appendix C for all classifications of the independent variables in sections ordered similarly to those in Table 5.

Transfer for Activity by Input Information Interaction

In this category the interaction of input information and activity is reported. Due to the design of the experiment any group homogeneous on one variable is heterogeneous on the other as was specified in the procedure, Table 1. Useful comparisons on U_2 shown in Section C are possible which indicate how, e.g., differences between $PiJi$ and $JcJi$ compare when contrasted with the same sequence of activity under complete

input information, e.g. PcJc and JiJc. This reflects the effect of the position in training for insertion of activity by input information combination.

The superiority of PJ over JJ was very small and non-significant under the I level but a significant 0.18 inches under the C level of input information. The inferiority of JP compared to PP (0.89 in.) was twice as large under the I level as under the C level of input information and significant.

For the three components evaluated significant differences were obtained in the constant term for all except PiJi versus JcJi, Table 5. Refer to Figures 6 and 7. All the linear components differed significantly between pairs. The differences between pairs in quadratic components approached significance at around the .10 level for all comparisons except PcJc vs. JiJc, which did not show a significant difference.

Comparison of Alternate Orders of Training

The comparisons shown in Part D of Table 5 supply evidence as to whether proficiency in the last eight trials of training was better for the IC sequence or the CI sequence on both J and P activities. Among these four comparisons differences were highly significant. The IC sequence was superior to the CI sequence for both J and P activities by about the same amount. The JP order was inferior to the PJ order but over twice as much so under the C level as under the

I level of input information.

As a by-product of studying transfer some results are available on the proficiency over all training trials. These means of $U_1 + U_2$ are shown in Appendix D. The CI sequence was 0.21 in. superior to IC with J, but the IC sequence was almost equally inferior, 0.19 in., to the CI sequence with P. The PJ sequence was considerably superior, 0.55 in., to the JP sequence with I throughout. But with C throughout this superiority of PJ was trivial, viz. 0.08 in.

Comparisons of Proficiency in the First Half of Training

The learning curve for the first half of training is considered here. Table 5, E, indicates that the superiority of C over I was 0.65 inches in J but only 0.38 inches of arc in P in the first 8 trials of training. Pi was only slightly inferior, 0.09 inches, to Ji. However, Pc was as much inferior to Jc as was Pi to Pc. This is the evidence that the reduction in level of input information, from C to I caused less deterioration for the P activity than it did for the J. Clearly, the reductions in input information were not equivalent.

Interaction of Conditions with Stimulus Value

Ten major comparisons between conditions which differed significantly when evaluated as a function of trials were evaluated as a function of the stimulus value for both raw absolute error and $\log_{10}$ of arc length. All of these



uniformly showed no significant differences between comparisons which are included in Table 5. I.e. there was no evidence of any interaction between treatment conditions and stimulus values.

Results for the Predicted Ratio on Positive Transfer

All the positive transfer attributable to input information or activity, when compared to the difference in the variables and put in the form predicted in the introduction, gives the following ratios:

$$\frac{+ \text{ Transfer Activity}}{+ \text{ Transfer II}} :: \frac{P-J}{I-C} = + \frac{.11}{.50} :: \frac{.22}{.51}$$

It is hard to specify the universe of possibilities out of which such a prediction could be made. Furthermore, as formulated, a test of significance would be aimed at acceptance of the null hypothesis rather than rejection. The predicted outcome was in the right direction.

Another way to state the outcome is to evaluate the difference between numerators with denominators equated. Here the predicted ratio was about 22 per cent and the observed 44 per cent.

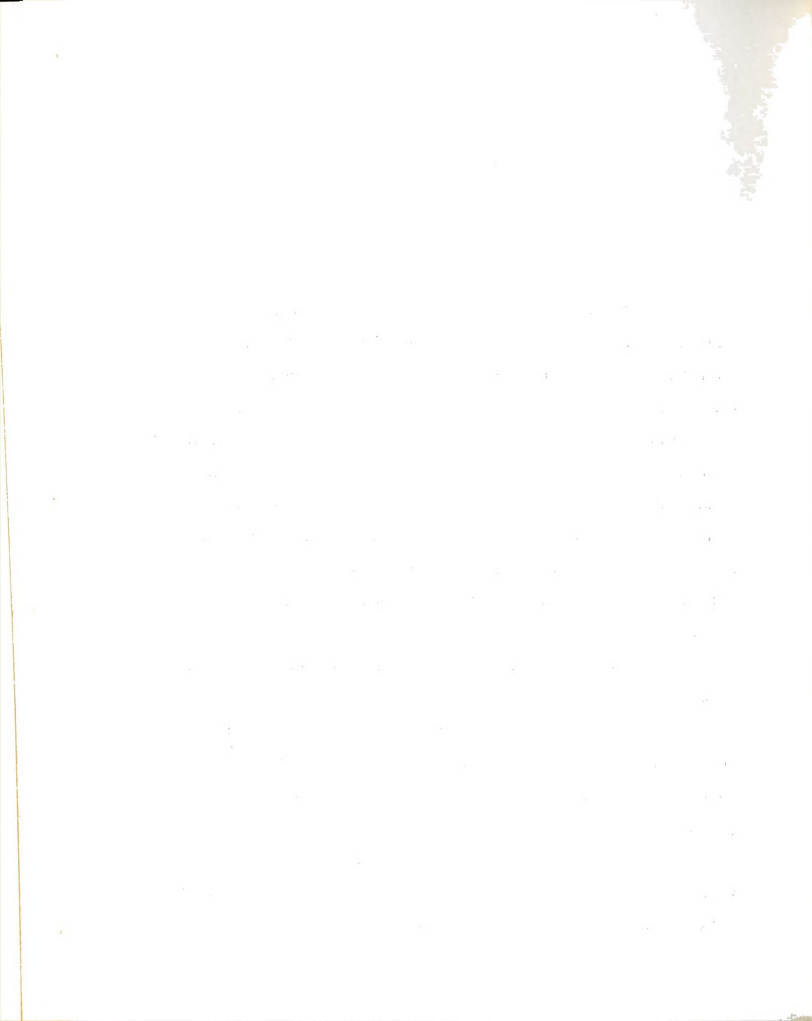
CHAPTER IV

DISCUSSION

Main Effects

Of the differences between the three main effects the difference between P and J may be related to input information as well as degree of active participation. As commented on earlier J included input information from sound for a longer duration per trial than does P from either sight or the proprioceptive sense. Thus, if the activities happened to be equated in every other respect except the one commented on above, the extra input information available should favor J. Empirically it can be said that J is an activity in which learning to a criterion requires less practice than for P.

It is of interest that the task and design chosen permitted the variable of practice U_1 vs. U_2 to give the highest difference, input information to rank intermediate and activity to give the least difference. Fortunately, although P involved more active participation than J the former provided a more difficult task. Thus, the chief objectives were accomplished, viz., to obtain sensitivity to learning, to select an ample range of input information, and to have activities approximately comparable.



Traditional Transfer Comparisons

It is noteworthy that IC was superior to CC, that PJ was superior to JJ, and also of interest that CI was superior to II in transfer. At least the former two observations are in opposition to the common recommendation that it is better to devote all training to practice in the manner that is exactly like that required for the final evaluation, e.g. Deese, 1952. This recommendation follows from the assumption that training in any dissimilar way will benefit only to the extent generalization can take place. Generalization from any similar task cannot be as good as training on the task itself, which would be perfect generalization. These results have demonstrated that more should be considered than the principle of generalization in making recommendations on the most efficient kind of pretraining.

The predictions that have been made of positive transfer obtained from a difficult-to-easy sequence of training or the reverse may be considered. Positive transfer in this experiment was greater in one of the four main comparisons for the CI versus II sequence, where C could be empirically defined as the easier task. In two other comparisons IC vs. CC and PJ vs. JJ, positive transfer was greater in what likewise could be considered as the difficult-easy sequence. In the other comparison there was negative transfer, or the easy-difficult sequence JP was inferior to the difficult-difficult sequence PP. These results then both contradict and support findings of which sequence gives better transfer, e.g. Goldstein and Newton (1962) on complex tracking and Lordahl,

et al., (1958) on rotary pursuit tracking, and Ritchie, et al., (1955) for instrument and contact flight training.

The design of this experiment effectively eliminates any possibility that the above superiority of mixed training over homogeneous training is due to the motivational or arousal aspect from any change in the task. The design always involves a change in one or the other variable and then if IC is compared with CC the latter group experienced a change in activity. Thus, the occurrence of a change in form of participation is always present.

It is possible that pretraining on I induces Ss to make better use of their other senses. Then when sight is available, as in C, Ss are able to benefit from their increased proficiency in using the other senses as well.

Even more beneficial was CI over II. Using the same explanation it appears that there is greater transfer in using a sense as effective as sight in pretraining. The proficiency with sight, C, either is enduring or it facilitates learning later in the absence of sight.

Considering the alternative sequences of input information it was concluded that an initial abundance, CI vs. II was more effective in transfer than initial poverty, IC vs. CC. This is an expected outcome based on the assumption that transfer is limited by the amount of learning that can occur. Since input information is essential to any learning, then transfer should be higher from the abundant - poverty sequence because CI can allow more learning to be initiated early in training as compared to IC.

The superiority of PJ over JJ is explained as a situation comparable to that of CI over II. Regardless of the overall difference in difficulty between P and J activities, P by definition required more active participation. The proprioceptive sense must be included. Pretraining on P by involving the Ss more actively or intimately at the beginning may enable better learning of how to utilize available input information or result in a higher motivation to learn proficiency with the use of sight or of sound in activity J. The design used in this experiment does not allow the evidence to separate between these two possibilities. With the variable of activity one cannot be as precise in attributing the difference to an underlying or basic component as well as with the variable of input information. However, a sensible conclusion appears to be that training which improves the most active participation should come as early as possible if it cannot be continued throughout.

Where early training may involve active participation even in a more difficult task, the final proficiency may be higher than for continuous training on an easier task which involves less active participation.

Any comparisons with experiments on information feedback (output information) is done only because more related comparisons are not available. In tests of transfer for augmented output information Archer and Namikas (1958) obtained no significant difference in rotary pursuit tracking, but Smode (1958) did in one dimension compensatory tracking. The present experiment differs from many others in that here

it is known that the extra input information was beneficial to performance and was perceived as such by the Ss. Augmented output information, e.g. auditory feedback in a tracking task may add little to the Ss' proficiency and/or may be considered superfluous by the Ss.

Johnson and Zerbolio (1963) have completed perhaps the most closely related experiment. They found the highest significant positive transfer to the judgment of appropriate plot titles from pretraining in the production of plot titles rather than from the J-J sequence. Ss must put forth more motor activity or active participation to produce a plot title than to judge one into a few categories. Similarly, with the task of momentum Ss are predicted to be more consciously aware of their input information in P and their R to it than they are in J. The similar significant outcomes in the two experiments strongly suggests that active participation is a factor which may be isolated for further study of its influence on transfer.

It is concluded that considerations of input information and degree of active involvement are more vital approaches to the understanding of positive transfer than are considerations of sequence of difficulty level or of auxiliary output information. The inadequacy of the principle of generalization for a simple account of the reported findings was also demonstrated.

Transfer in Activity by Input Information Interaction

An answer is available to the question of whether PJ is superior to JJ at all combinations of input information. The answer is yes. In addition P as post-training was always superior to J as pretraining even for the JP versus PP sequence. This is evidence that the superiority of P over J arises from a factor independent of the quantity of input information. This factor is concluded to reside with the activity P and not be due to the length of time input information is available because it is available for a longer period of time in J than in P.

Comparison of Alternate Sequences on the Last Half of Training

The results led to the expected outcome that it is better to end up on C regardless of activity and it is better to end up on J regardless of level of input information as far as evaluating final performance. Where transfer is ignored and a change in sequence of training is necessary, comparison of alternative sequences over the entire training period is desired. The outcome of such comparisons showed that overall for activity and input information the situation was the reverse of that holding for the last half of training. The sequence which ended up the best, U_2 , was the easier one. The latter needs no explanation. But the conclusion can only be that overall learning equally divided into two forms of training was greater with the most difficult task first.

Comparison of Learning on the First Half of Training

In order of increasing error scores the combinations of training are ordered as follows: Jc, Pc, Ji, Pi. This order is exactly consistent with the other observations and the main effects. Therefore, no further discussion here is warranted.

Incidental Observations

Frequently the mean error on the last trial of training was higher than on previous trials. Reference to Appendix B indicates that there were spaces for ten trials on the sheet. Ss were not aware that U_1 would consist of eight trials, but they could assume that U_2 would consist of eight trials. After completing U_1 E told Ss they were half finished with their experiment. In view of this difference between U_1 and U_2 and that found between trial 3 and 16 the frequent rise on trial 16 has been termed the end effect. It could deserve further study in the context of other research on judging.

It appears appropriate to conclude that not only have unique variables been studied with new apparatus but unique results have also been obtained.

CHAPTER V

SUMMARY

The purpose of this study was to determine the influence on transfer of proficiency, due to activities producing (P) or judging (J) each at two levels of input information, incomplete (I) and complete (C). The design used was a double Linquist type V factorial design one-half containing the control on one of the two variables not controlled in the other half. Thus measures of transfer were made in the classical manner which could be termed comparisons of heterogeneous training with homogeneous training for each variable.

The task was to judge or produce the correct maximum arc length attained by a compound pendulum when struck by another compound pendulum with a considerably heavier weight. This required the learning of the effects of transmission of momentum in a situation new to the 128 Ss. All trained for two units (U_1 and U_2) each of 8 trials.

Highly significant differences between all comparisons of transfer made demonstrated that heterogeneous training led to more transfer than the control or homogeneous training with the exception of P, the most difficult task. The fact that transfer from J to P was inferior to transfer from P to P when P is more difficult than J provides a clue as to why PJ, and

CI gave better transfer than their respective controls. If a task involves a high degree of active (motor) participation then homogeneous training on a difficult task is best and if active participation can be involved in only part of the training it should come first. Some interactions of activity and input information were also significant. Many significant differences were obtained between the above comparisons for the three simplest components of the functions over trials. Over the range of stimulus values used there were no significant interactions with any treatment in both the raw or transformed data.



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APPENDIX A

The Instructions Read to the Subjects Who Served According to The Stage and Condition.

1. Introduction:

"We have four pairs of pendulums. The one with the longer cylinder (E points) is used to supply the momentum to its mate by striking it as a hammer. Therefore, it is called the striker. The skill or task to be learned is the proper momentum which will result in specific inches of arch on the circumference for the maximum swing of the other, recording pendulum (E points).

The wire in this guide (E points) was delicately adjusted to accurately record with low friction. It reads in inches of circumference traversed which you can all now visualize. Do not touch the cardboard please."

2. Production with Incomplete Information Input.

"To provide the correct momentum for impact hold the striker like this when I say ready (E demonstrates) and pull carefully straight back in the line of rotation to the desired amount and simply release. By not pushing in or out from the wall the rather delicate guide wires need not get strained causing the striker to get out of alignment. After the impact quickly raise the blindfolds and catch both pendulums carefully with your hands by the end of the cylinder.

This avoids misalignment due to one hammer striking a supporting wire. If the pendulums successively clash they will not continue to hit squarely but become misaligned or cause a broken support wire. Either would increase error. You will record the value I ask you to try to attain in row B, 'Try for'.

After I say 'ready' you are to pull your blindfold in place and get your striker poised. When I say 'go' release it, then catch the rebound. Next quickly lift your blindfold, stop the pendulums, pick up your clipboard, stand directly opposite the wire indicator and read at the metal edge to the nearest one-tenth and record in your sheet, row A. Do not move the indicator until I check your figure. But do go ahead to record the difference with the correct sign and check, because this difference is your knowledge of results. You may compare or check with your neighbor between trials.

Try to obtain as low a score as possible on each trial.

You are only allowed to use your one hand in preparing for each trial."

3. Production with Complete Information Input.

"To provide the correct momentum for impact hold the striker like this. When I say ready (E demonstrates) and pull carefully straight back in the line of rotation to the desired amount and simply release. By not pushing in or out from the wall the rather delicate guide wires need not get out of alignment. After the impact and swing catch both pendulums carefully with hands simply by the end of the cylinder.

This avoids misalignment due to one hammer striking a supporting wire. If the pendulums successively clash they will not continue to hit squarely but become misaligned or cause a broken support wire. Either would increase error.

After I say ready you are to get your striker poised. When I say "go" release it, then catch the rebound. Next pick up your clipboard, stand directly opposite the wire indicator and read the metal edge to the nearest one-tenth and record in row A. Do not move the indicator until I check your figure. But do go ahead to record the difference with the correct sign and check because this is your knowledge of results. You may compare or check with your neighbor between trials.

Try to obtain as low a score as possible on each trial."

4. Judgment with Incomplete Information Input.

"This means you will have sound only. I will simply release the striker from various positions and the maximum swing of the other pendulum will be recorded. Within ten seconds after the collision I wish you to very privately record your estimate to the nearest one-tenth of an inch of the maximum arc attained by the recorder pendulum under the proper trial number in the row headed, "Your estimate".

Privately means without a wisper or lip movement. To assist in the goal of privacy these shields should be put in place on your clipboard (E clips these on). After the time is up I will call out the actual reading for you all to record in

the row headed "actual". Now subtract row B from row A and record with sign in the last column. This part of the aspect need not be private, and you can compare with your neighbor to check your difference. It is very easy to use the wrong sign. Also expect me to check on all your moves. Before I release the pendulum on each trial I will call ready so you can focus your attention. Try to obtain as little error as possible on each trial."

5. Judgment with Complete Information Input.

"This means you will have vision as well as sound."

Note: The remaining instructions in this condition were identical to that immediately above.

6. Concluding Remarks all Ss received.

"It is my duty to check all your operations including figures during the experiment to detect any error or misunderstanding promptly. I know no one will deliberately risk questionable procedures, but it is worth striving for the most uniform procedure possible. Are there any questions?"

APPENDIX B

1. Record Sheet Used by S For The P Activity if In U₁

2. Record sheet provided for S

- a. Used for Activity J, if in U₁

b. Used for U₂ of Training Regardless of Activity

	1	2	3	4	Trial Number
1					5
2					4
3					3
4					2
5					1

A-8 with sign
IR 07

APPENDIX C

Mean Absolute Error in Inches on Each Trial of Training in U_1 , first 8 Trials, and U_2 , last Eight Trials of Training.

Trial:	1	2	3	4	5	6	7	8
1. For Activities P, Producing, and J, Judging.								
P, U_1	9.35	5.69	3.82	3.18	2.19	2.63	2.77	2.88
U_2	4.78	3.70	2.75	2.86	1.96	2.41	2.00	2.99
J, U_1	7.75	4.73	3.95	3.19	3.38	3.03	2.46	2.50
U_2	4.62	3.02	2.37	2.50	2.54	2.36	2.15	2.36
2. For C and I Levels of Input Information.								
C, U_1	8.50	4.57	3.19	3.11	2.45	2.88	2.45	2.74
U_2	4.27	2.60	2.36	2.62	2.18	2.22	1.89	2.23
I, U_1	8.61	5.86	4.58	3.26	3.13	2.78	2.79	2.63
U_2	6.69	3.81	2.76	2.74	2.33	2.55	2.26	3.12
3. For Sequences of I and C Levels of Input Information.								
C, U_1	8.61	4.52	3.45	2.93	2.77	2.48	2.75	2.49
I, U_2	3.86	3.24	2.60	2.96	2.48	2.23	2.20	3.52
I, U_1	8.38	6.24	4.83	2.89	2.88	3.01	2.88	2.91
I, U_2	9.53	4.38	2.92	2.51	2.17	2.87	2.32	2.73
I, U_1	8.84	5.47	4.33	3.63	3.38	2.55	2.70	2.34
C, U_2	4.41	2.23	2.36	2.57	2.29	2.07	1.58	2.35
C, U_1	8.38	4.61	2.93	3.30	2.12	3.27	2.14	2.99
C, U_2	4.12	2.97	2.36	2.67	2.07	2.38	2.20	2.11
4. For Sequences of P and J Activities.								
P, U_1	9.13	5.76	3.43	2.99	2.04	2.69	2.75	3.06
J, U_2	3.88	3.03	2.68	2.33	2.44	2.58	2.35	1.93
J, U_1	7.88	4.38	3.56	3.18	3.81	2.47	2.66	2.15
J, U_2	5.36	2.70	2.06	2.66	2.64	2.14	1.95	2.79
J, U_1	7.62	5.09	4.33	3.20	2.96	3.58	2.27	2.84
P, U_2	6.64	4.32	2.60	2.85	1.80	2.66	2.18	2.91
P, U_1	9.58	5.61	4.22	3.38	2.35	2.59	2.79	2.69
P, U_2	2.9.	3.08	2.90	2.87	2.13	2.16	1.83	3.08

5. For All Eight Sequences Used in the Experiment.

Jc, U ₁	7.69	3.49	2.26	2.81	3.52	2.15	2.93	2.12
Ji, U ₂	4.45	2.86	2.66	2.68	2.96	2.05	2.47	3.44
Ji, U ₁	8.07	5.27	4.87	3.56	4.09	2.79	2.39	2.18
Jc, U ₂	6.27	1.92	1.46	2.64	2.32	2.23	1.44	2.13
Pc, U ₁	9.54	5.55	4.65	3.04	2.02	2.82	2.58	2.87
Pi, U ₂	3.28	3.63	2.53	3.25	2.01	2.42	1.93	3.59
Pi, U ₁	9.61	5.68	3.79	3.71	2.68	2.30	3.01	2.51
Pc, U ₂	2.55	2.53	3.27	2.49	2.26	1.91	1.73	2.56
Ji, U ₁	7.71	6.75	5.78	2.61	3.73	3.11	2.52	2.99
Pi, U ₂	8.34	5.41	2.74	2.48	1.88	3.07	2.25	3.14
Jc, U ₁	7.53	3.43	2.89	3.79	2.19	4.05	2.01	2.70
Pc, U ₂	4.93	3.23	2.47	3.22	1.72	2.26	2.10	2.68
Pi, U ₁	9.04	5.73	3.82	3.17	2.03	2.90	3.24	2.84
Ji, U ₂	4.46	3.35	3.12	2.54	2.46	2.66	2.39	2.32
Pc, U ₁	9.23	5.79	2.98	2.81	2.06	2.49	2.27	3.29
Jc, U ₂	3.31	2.71	2.25	2.12	2.42	2.51	2.31	1.54

APPENDIX D

Comparisons of Alternative Sequences for Overall Proficiency in Training, U₁ + U₂.

Groups Compared	<u>JiJc vs. JcJi</u>		<u>PiPc vs. PcPi</u>	
Mean Error in Inches	3.12	2.91	3.05	3.24
Difference	+0.21		-0.19	
Groups Compared	<u>JiPi vs. PiJi</u>		<u>JcPc vs. PcJc</u>	
Mean Error in Inches	3.82	3.27	2.97	2.89
Difference	+0.55		+0.08	

APPENDIX E.

Mean Squares Used in Evaluating Hypotheses as Listed in Table 5.

Groups Compared	Between Means		Between Groups on Three Components of Functions Over Trials				
	Error	Treatment	Error	Treatment			
				c.*	l.*	q.*	
A. Units of Training.							
U ₁	U ₂	1.27	91.06	.254	13.29	3.67	1.16
B. Traditional Evaluation of Transfer on the Last Eight Trials.							
1. Input Information Level.							
CI	II	9.08	66.95	.222	1.80	.71	.91
IC	CC	9.20	66.68	.205	-	-	-
2. Activity							
PJ	JJ	8.40	68.37	.205	-	-	-
JP	PP	10.20	64.60	.249	1.03	.41	-
C. Transfer of Activity by Input Information Interaction.							
PiJi	JcJi				.37	.94	.48
JiPi	PcPi	9.83	63.27	.209	1.39	1.47	.81
PcJc	JiJc				2.11	1.36	-
JcPc	PiPc				1.09	1.81	.61
D. Comparisons of Alternate Sequences on Last Eight Trials.							
JiJc	JcJi				-	.95	.28
PiPc	PcPi	9.83	63.27	.209	.99	.93	.47
JiPi	PiJi				.65	1.06	.40
JcPc	PcJc				1.10	-	-
E. Comparisons of Learning on the First Half of Training.							
Jc	Ji	7.23	70.84	.176	3.85	-	-
Pc	Pi	8.32	63.56	.203	-	-	-

* c = constant, l = linear, q = quadratic

- obviously too small to attain significance and not calculated

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