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PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN TRANSFER OF TRAINING, PHASE I. MORE INFORMATION--CUES OR PRINCIPLE. TECHNICAL REPORT 5.

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DESCRIPTORS- *PROMPTING, *CONCEPT FORMATION, *LEARNING THEORIES, *TRANSFER OF TRAINING, TEACHING TECHNIQUES, EXPERIMENTAL GROUPS, PSYCHOEDUCATIONAL PROCESSES, COMPARATIVE ANALYSIS, *PROBLEM SOLVING,

THIS EXPERIMENT WAS DESIGNED TO INVESTIGATE (1) THE AMOUNTS OF INFORMATION COMMUNICATED BY THE KNOWLEDGE OF A PRINCIPLE AS OPPOSED TO THE KNOWLEDGE OF CUES AND (2) THE EFFECTIVENESS OF THE KNOWLEDGE OF A PRINCIPLE AS OPPOSED TO THE KNOWLEDGE OF CUES AT DIFFERENT STAGES OF LEARNING. THE FOUR GROUPS MAKING UP THE EXPERIMENTAL DESIGN WERE A CUE GROUP WHO KNEW THE SET OF FOUR POSSIBLE CUES AND THE NUMBER OF REQUIRED CUES, A PRINCIPLE GROUP WHO KNEW ONLY THE PRINCIPLE, A FULL INFORMATION GROUP WHO KNEW BOTH CUES AND PRINCIPLE, AND A NO INFORMATION GROUP WHO KNEW NEITHER CUES NOR PRINCIPLE. EACH OF THE FOUR GROUPS CONTAINED 13 UNDERGRADUATE PSYCHOLOGY STUDENTS. A BOOKLET OF STIMULUS PRESENTATIONS, ANSWER SHEETS, AND A QUESTIONNAIRE WERE DISTRIBUTED TO ALL SUBJECTS BEFORE INSTRUCTIONS WERE GIVEN. DEPENDING UPON THE GROUP TO WHICH THE SUBJECT BELONGED, ONE OF FOUR SETS OF INSTRUCTIONS WAS THEN READ BY EACH SUBJECT. WHILE IT WAS CONCLUDED THAT THE CUE GROUP PERFORMED BETTER THAN THE PRINCIPLE GROUP, THE DIFFERENCES BETWEEN THE TWO GROUPS WERE NOT SIGNIFICANT. THE SUBJECTS IN THE PRINCIPLE GROUP WHO REACHED AN ARBITRARY LEVEL OF SUCCESS LEARNED THE RELATIVE IMPORTANCE OF RELEVANT CUES BETTER THAN COMPARABLE SUBJECTS IN THE CUE GROUP. (GD)

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MORE INFORMATION -- CUES OR PRINCIPLE?

Thomas J. McHale and Lawrence M. Stolurow

Technical Report No. 5

Psychological and Educational Factors
in Transfer of Training
Phase I

May, 1964

U. S. Office of Education
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MORE INFORMATION -- CUES OR PRINCIPLE?

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Concern for the importance of stimulus factors in concept formation can be traced to Hull's classic study (1920). Later Smoke (1933) studied the relative importance of positive and negative instances, and Hovland (1952) re-examined this problem in terms of information theory. More recently, the work of Brunswik (1956) stimulated renewed interest in the problem. Bruner, Goodnow, & Austin (1956) report a series of studies concerned with the way in which S learns to select and utilize cues. These authors coined the term "criteriality" as a measure of the degree to which the S uses a particular cue in forming his responses; however, since they used two-valued cue and response categories (e.g., swept-back wing or delta wing, an X plane or a non-X plane), they were unable to infer from S's responses the nature of the mediating construct or principle being used. These should not be interpreted as the defining conditions for the use of the

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term, however, since another investigator, Smedslund (1955), utilized scaled cue and scaled response categories so that E could give scaled feedback rather than mere confirmation or disconfirmation. He analyzed his data in terms of the criterialities of each of the various cues in order to determine the use that was being made of various hypotheses or principles. Since his task was quite complex, the likelihood of success for the S was limited and little information was gleaned from the procedure.

Azuma (1960), recognizing the intention of this approach and the shortcomings of these efforts to implement it, developed a task with metrically multi-valued cue and response categories based on a multiple-correlation model which, although complex, could be mastered more easily than the task used by Smedslund. Azuma's study compared two task models: (a) a multiple-correlation model and (b) a decision theory model involving probability learning conditions. Both tasks were specifically designed to reveal the nature of the mediating principle, used by S, through an analysis of the various cues' criterialities. There were four cues, two relevant and two irrelevant. With the proper linear combination of the two relevent cues, an S could always determine the value of k on every trial. S had to determine which cues were relevant and the proper linear combination to weight them to arrive at the value of k, the unknown. The data from this study were submitted to further analyses (Azuma & Cronbach, 1961, 1962; Cronbach & Azuma, 1961).

McHale & Stolurow (1962), in a replication of one part of the Azuma study, attempted to determine how information about the number of relevant cues improves performance. The information was not effectively presented and the number of subjects was small; the resulting trend, while in the right direction, did not reach significance. This suggested the need for a more complete investigation of the amounts of information carried by various parts of the mediating construct. Thus, they shifted the problem to the question of the amount of information conveyed to S by different parts of the mediating construct presumably used by S in arriving at the correct k values.

Problem

The present study was designed to investigate the amounts of information communicated by two components of a quantitative task: (a) knowledge of a principle, and (b) knowledge of the number of critical cues. It also investigated the relative effectiveness of knowledge of principle as opposed to knowledge of cues at different stages of learning. Since there was some question as to whether or not complete knowledge of the task solution would lead to perfect performance, a full information group was included; in addition, a no information group was included to determine the lower boundary of performance.

Design

The study was a 2 x 2 design generated by two dichotomized variables (presence or absence of information about cues, and presence or absence of information about principles).

The four groups consisted of (a) a cue group, who knew the set of four possible cues and the number of required cues; (b) a principle group, who knew only the principle; (c) a full information group, who knew both cues and principle; and (4) a no information group, who knew neither cues nor principle.

Hypotheses

An analysis of the task relative to the possible hypotheses which S could consider led to the following specific hypotheses which were tested:

1. Knowledge of the principle would be more beneficial than knowledge of the number of critical cues since there appear to be many more possible ways of weighting or combining cues than there are possible cues.

2. Knowledge of the number of critical cues would be more beneficial in the early stages of learning when the S must detect what is relevant, and knowledge of the principle would be more beneficial in the later stages of learning when the S must determine the appropriate weights to use in combining the relevant cues to determine k.

3. The rank order of performance of the four groups would be as follows: full information, principle information,

cue information, and no information.

Method

Subjects

Fifty-two undergraduate students in psychology at the University of Illinois participated in the experiment with 13 subjects in each of four groups. Thirty-eight subjects were administered the task during a regular class period; the other 14 subjects were obtained from a subject pool and were administered the task in small groups. Of the latter, 4 were in the cue group, 4 in the full information group, and 6 in the principle group.[2]

Materials and Procedure

A booklet of stimulus presentations, answer sheets, and a questionnaire were distributed to all Ss before instructions were given. Depending upon the group to which the S belonged, one of four sets of instructions was then read by each S.

The task stimuli. Each stimulus (trial) consisted of a 2.5 inch by 2.5 inch square outline with a small red cross

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[2]The classroom administration obviously was not an optimal situation since the data for eleven subjects from the undergraduate class who refused to cooperate had to be discarded.

and a small green cross drawn inside it. The left side and the bottom of the square represented coordinate axes. The location of each cross was specified by its coordinate distances from the left side and the bottom of the square, there were four possible positions along each coordinate.

Each of the crosses can be represented as a letter, x or y, and the four coordinate values can be represented by four variables, x', y', x", and y". Each variable could take on one of four values, .5, 1.0, 1.5, or 2.0 inches. The number of possible combinations of these values was 4^4, or 256; however, since the crosses were not allowed to occupy the same location in any stimulus presentation, only 240 (16 x 15) combinations were actually possible and not all of the possible displays were used.

Presentation of stimuli. Stimulus displays were presented in a booklet in which each page contained six different displays. The booklet consisted of 128 stimuli, or trials, to which Ss responded by marking one of ten possible response categories with an X. The answer sheet contained 10 circles for each trial, each circle was for one of the 10 possible numerical answers and S drew an X through the appropriate circle to indicate his response, i.e., what he thought was the value of k for the display. After each trial S was told the true value of k.

The 128 learning trials can be considered as 8 sets of 16 different presentations. Within each set, the 16 possible combinations of x' and x" appeared once each, which automatically made $r_{x'x"}$= .00. The distributions of y' and y" were very close to rectangular. Displays were prepared so that, for the set, $r_{x'y'}$, $r_{x'y"}$, $r_{x"y'}$, and $r_{x"y"}$ did not exceed .12 in any block. Thus, for practical purposes, these variables can be considered to be uncorrelated.

Criterion k. The formula used by the E to define the correct response, k, was (2x' + x")/3. Since x', y', x" and y" were uncorrelated with each other, the definition of k, in terms of the zero order correlations, determined their validities as follows: $r_{x'k}$=.89, $r_{x"k}$=.45, $r_{y'k}$=.00, $r_{y"k}$=.00. Though the actual correlations of x' and x" with k were exactly .89 and .45, respectively, in each block, the actual correlations of y' and y" with k varied between -.12 and +.12. Since the 10 discreet response categories were exact (except for rounding in the second decimal place), the Ss had to use precisely a 2:1 weighting in order to be correct 100% of the time.

Measures of Performance

The dependent variables used as measures of performance were the criterialities of the individual cues, computed over blocks of trials, and the value given the construct k .

Product-moment correlation coefficients were computed for each S's actual responses with the Ss possible responses, based upon the assumption that he made judgments solely in terms of x', x", y', y", or k. This yielded a 5 x 4 matrix of correlations for each subject (rows for x', x", y', y", and k; columns for each block of 32 trials) which was analyzed separately. Correlations to determine criterialities were computed over nonoverlapping blocks of 32 trials: 1-32, 33-64, 65-96, and 97-128. These blocks will be referred to as blocks 1, 2, 3, and 4 respectively.

A questionnaire which attempted to get S to verbalize his principle or mediating construct and to assign a number to his relative weighting of the two relevant cues was administered to all Ss in all groups after the learning session was completed. The verbalizations are informative, although one question about the relative weighting was not understood by Ss (See discussion).

Results

In order to determine representative values for each group, the following steps were taken:

1. Criterialities were converted into z' scores and group means for the z' scores were calculated. All statistical tests used the z' transformations as raw scores since they roughly approximated a normal distribution.

2. The mean *z'* values were reconverted into the corresponding *r* values. These mean *r* values were taken as the representative criterialities for each group in each block of trials (mean criterialities). Table 1 contains the mean criterialities on all coordinates for each experimental group on each of the four trial blocks. Figures 1, 2, and 3 are graphical representations of the data in Table 1 (graphical representations of the mean criterialities of y' and y" are not presented because the values are close to .00, as predicted). Note that, in general, an asymptote for the learning curves of *k* has not been reached.

A 2 x 2 analysis of variance was used for x', x", and *k* to detect the significant effects of principle, cues, or their interactions for each of the 4 trial blocks. In addition, Duncan's Multiple Range Test (1955) was used to test for significant differences between the means of the groups in each of the 4 blocks. Tables 2 through 6 contain the results of these tests.

Table 1

Mean Criterialities ($\underline{r}$) for Each Group in All Blocks of Trials

Group[a]	Block	Mean criterialities[b]				
		x'	y'	x"	y"	$\underline{k}$
No Information	1	.38	-.03	.22	.03	.42
	2	.64	.00	.31	.07	.71
	3	.64	-.12	.33	.08	.74
	4	.69	.04	.36	.06	.78
Cue Information	1	.40	-.03	.26	.15	.49
	2	.56	.07	.43	.05	.73
	3	.66	-.08	.52	.09	.86
	4	.66	.10	.53	.09	.88
Principle Information	1	.38	.00	.31	.03	.51
	2	.54	.04	.45	.01	.71
	3	.68	-.09	.35	.00	.83
	4	.66	-.01	.36	-.04	.79
Full Information (cue and principle)	1	.69	-.04	.44	.08	.85
	2	.78	.11	.35	-.03	.92
	3	.77	-.04	.40	.11	.94
	4	.79	.04	.38	.00	.95

[a]N was 13 per group; therefore any r which was greater than .55 exceeded the .05 level of significance (two-tailed test).

[b]Criterion criterialities are $r_{x'\underline{k}}=.89$; $r_{x''\underline{k}}=.45$, $r_{y'\underline{k}}=.00$, and $r_{y''\underline{k}}=.00$.

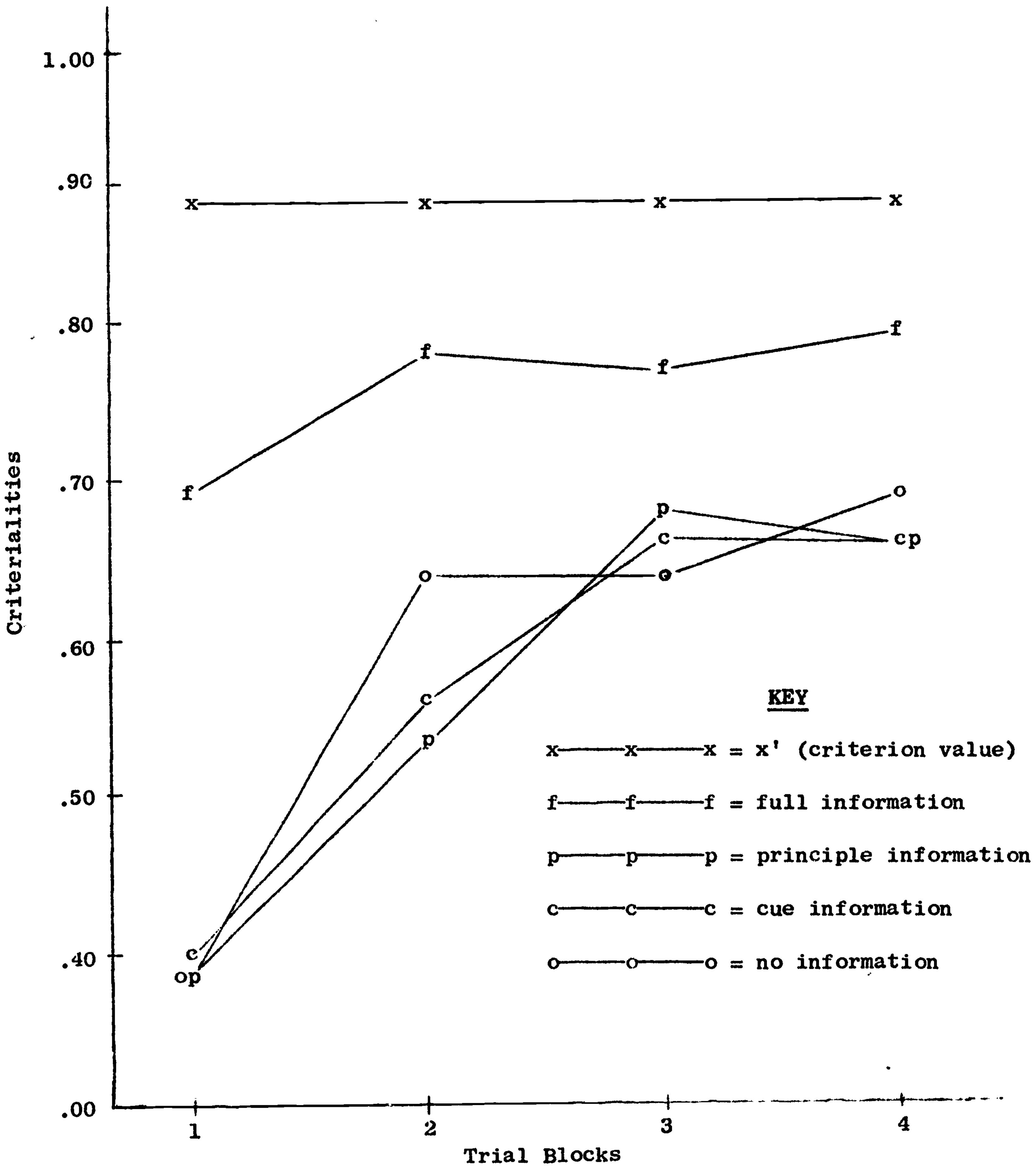

Figure 1. Mean criterialities of x' for each of the four experimental groups and criterion value of x'.

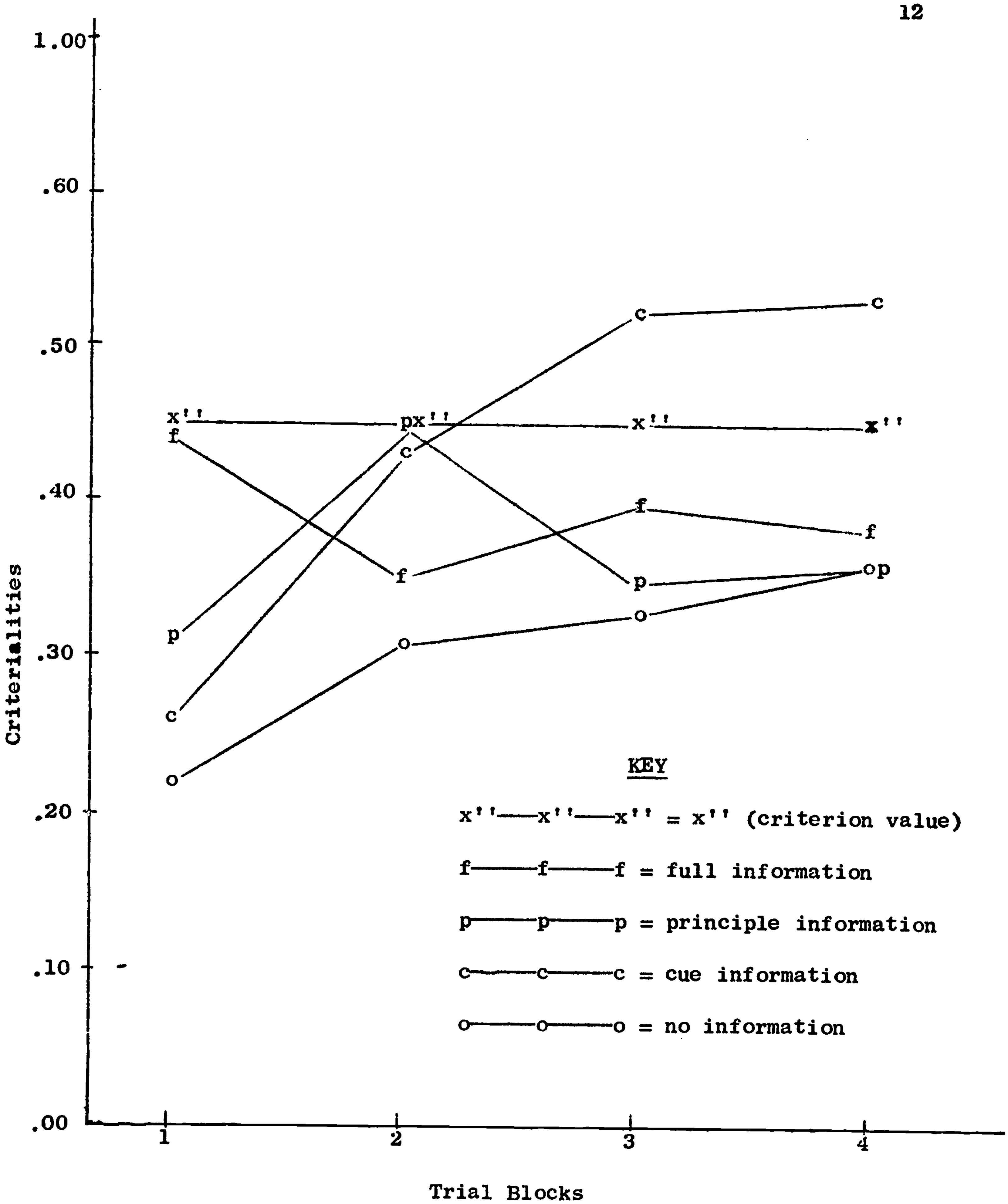

Figure 2. Mean criterialities of x'' for each of the four experimental groups and the criterion value of x''.

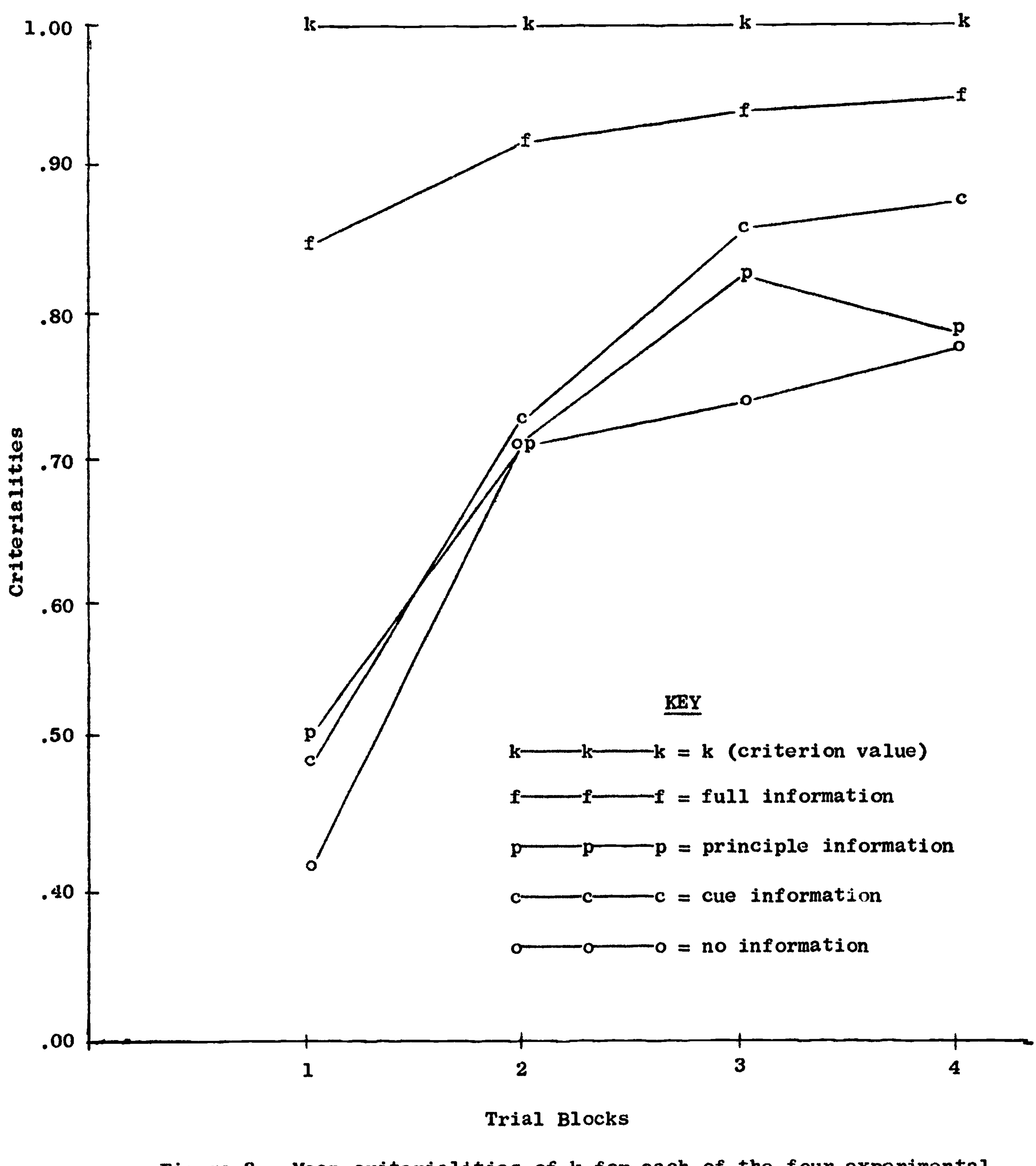

Figure 3. Mean criterialities of k for each of the four experimental groups and the criterion value of k.

Table 2

Analyses of Variance of x', x" and k for Trial Block 1

Variable	Source of variation[a]	Sum of squares	d.f.	Mean squares	F
x'	Knowledge of Principle	.58	1	.58	4.14*
	Knowledge of Cues	.82	1	.82	5.86*
	Interaction	.49	1	.49	3.50
	Within	6.56	48	.14	
	Total	8.45	51		
x"	Knowledge of Principle	.32	1	.32	8.00**
	Knowledge of Cues	.14	1	.14	3.50
	Interaction	.02	1	.02	.50
	Within	1.93	48	1.93	
	Total	2.41	51		
k	Knowledge of Principle	2.12	1	2.12	10.10***
	Knowledge of Cues	1.96	1	1.96	9.33***
	Interaction	1.20	1	1.20	5.71*
	Within	10.23	48	.21	
	Total	15.51	51		

*Significant at .05 level.
**Significant at .01 level.
***Significant at .005 level.

[a] The principle and full information groups were told the principle; cue and full information groups were told the number of the cues.

Table 3

Analyses of Variance of x', x" and k for Trial Block 2

Variable	Source of variation[a]	Sum of squares	d.f.	Mean square	F
x'	Knowledge of Principle	1.23	1	.23	1.44
	Knowledge of Cues	.34	1	.34	2.12
	Interaction	1.03	1	1.03	6.44*
	Within	7.70	48	.16	
	Total	10.30	51		
x"	Knowledge of Principle	.02	1	.02	.33
	Knowledge of Cues	.00	1	.00	.00
	Interaction	.25	1	.25	4.17*
	Within	2.82	48	.06	
	Total	3.09	51		
k	Knowledge of Principle	1.41	1	1.41	4.08
	Knowledge of Cues	1.81	1	1.81	5.17*
	Interaction	1.30	1	1.30	3.71
	Within	16.73	48	.35	
	Total	21.25	51		

*Significant at the .05 level.

[a]The principle and full information groups were told the principle; the cue and full information groups were told the number of cues.

Table 4

Analyses of Variance of x', x"
and k for Trial Block 3

Variable	Source of variation[a]	Sum of squares	d.f.	Mean square	F
x'	Knowledge of Principle	.27	1	.27	1.08
	Knowledge of Cues	.13	1	.13	.05
	Interaction	.07	1	.07	.03
	Within	12.13	48	.25	
	Total	12.60	51		
x"	Knowledge of Principle	.05	1	.05	1.00
	Knowledge of Cues	.27	1	.27	5.49*
	Interaction	.10	1	.10	2.00
	Within	2.24	48	.05	
	Total	2.66	51		
k	Knowledge of Principle	1.39	1	1.39	2.24
	Knowledge of Cues	2.38	1	2.38	3.84
	Interaction	.11	1	.11	.18
	Within	29.75	48		
	Total	34.63	51		

*Significant at the .05 level.

[a]The principle and full information groups were told the principle; the cue and full information groups were told the number of cues.

Table 5

Analyses of Variance of x', x"
and k for Trial Block 4

Variable	Source of variation[a]	Sum of squares	d.f.	Mean square	F
x'	Knowledge of Principle	.20	1	.20	.91
	Knowledge of Cues	.19	1	.19	.86
	Interaction	.36	1	.36	1.64
	Within	10.45	48	.22	
	Total	11.20	51		
x"	Knowledge of Principle	.13	1	.13	2.60
	Knowledge of Cues	.16	1	.16	3.20
	Interaction	.12	1	.12	2.40
	Within	2.56	48	.05	
	Total	2.97	51		
k	Knowledge of Principle	.76	1	.76	1.29
	Knowledge of Cues	4.05	1	4.05	6.86*
	Interaction	.67	1	.67	1.14
	Within	28.48	48	.59	
	Total	33.96	51		

*Significant at the .05 level.

[a]The principle and full information groups were told the principle; the cue and full information groups were told the number of cues.

Table 6

Results of Duncan's Multiple Range Tests for x', x" and k for Each Block of Trials

Variable	Block	Groups	Probability
x'	1	Full > No Information, Principle, Cues	< .01
	2	Full > Principle, Cues	< .05
	3	None	
	4	None	
x"	1	Full > No Information Full > Cues	< .005 < .05
	2	None	
	3	Cues > No Information, Principle	< .05
	4	Cues > Full, No Information, Principle	< .05
k	1	Full > No Information, Principle, Cues	< .005
	2	Full > No Information, Principle, Cues	< .01
	3	Full > No Information	< .05
	4	Full > No Information, Principle	< .05

An analysis of variance was run for three variables, x', x" and k, using data from the first block of trials (See Table 2). Using S's k values as the dependent variable, knowledge of the principle and knowledge of the number of cues produced a significant effect on performance at the .005 level, and a significant interaction between these variables at the .05 level. These results can be explained by the superior performance of the full information group, which is significantly better than that of all other groups at the .005 level. Using the criterialities, it is clear that the full information group learned the most relevant cue (x') better (criteriality was .69) than any other group, and learned the less relevant cue (x") better (criteriality was .44) than any of the other groups (no information, .22; cue information, .26; principle information, .13).

In the second block of trials, knowledge of the number of cues continues to produce a significant effect at the .05 level. The superior performance of the full information group again accounts for the significant difference in performance. Since an F of 4.04 is necessary for significance at the .05 level, the F relating to knowledge of the principle (4.03) is slightly less than significant. The full information group's criteriality for x' is still significantly better (.78) than that of either the principle (.54) or cue groups (.56); interestingly enough, although better, it is not significantly better than the value for the no information group (.64). For both relevant cues (x' and x") the interaction effect was significant on the second block of trials.

In the third block of trials, neither knowledge of the principle nor knowledge of the number of cues is significant. The performance of the full information group was significantly superior to the performance of the no information group, but it was not superior to that of the other groups. The mean criteriality of the cue group for x" (.52) is significantly higher than that of either the no information (.33) or principle group (.45). This difference is accounted for by the fact that the cue group tends to weight the relevant cues more evenly. In fact, the cue group's mean criteriality for x" is greater than the criterion criteriality for x".

In the fourth block of trials, it appears that having knowledge of the number of cues results in significantly superior performance at the .05 level. The full information group performed significantly better than either the no information or principle groups. The mean criteriality of k for the principle group dropped unexpectedly from .83 in block 3 to .79 in the fourth block. The mean criteriality for the cue group (.88) is approximately midway between that of the full information group (.95) and that of the no information (.78) and principle groups (.79). The mean criterialities for the latter two are almost identical. The mean criteriality for x" of the cue group (.53) is significantly greater than that of the other groups, including the full information group (.38), which is the highest of the other groups. Even as late as the fourth block of trials, the cue group tends to weight relevant cues more evenly (x' criteriality is .66 and x" criteriality is .53). Table 7 gives the mean relative weights of relevant cues for each group.

The relative weighting of the two relevant cues can be found for each S by dividing his criteriality for x' by his criteriality for x". Although the criterion weighting is 2:1, rounding errors make the criterion weighting 1.98:1 in the computations. Since relative weightings are uninterpretable when the criterialities are small or negative, the mean weightings for groups were computed only for the last block of trials. Only those subjects whose criteriality for k surpassed .70 were included in the analysis; Ss whose criteriality was less than .70 were considered to be non-solvers since less than half of the variance of their responses could be accounted for by E's criterion values.

Although the standard deviation of the weights of those in the principle group is quite large, their mean weighting and that of the full information group are very close to the criterion weighting. The no information group tends to overweight the more relevant cue; however, the variance in this group is the largest of the four groups. The cue group tends to underweight x', and overweight x". Except for one S whose weighting was perfect, all Ss in this group had a weighting below 1.98:1.

Table 7

The Mean Relative Weight of Relevant Cues (x' and x"), and S.D. of Ratio for Each Group in Trial Block 4[a]

Group	$\underline{N}$[b]	Relative weights of x' and x"	S.D. of ratio
Full Information	11	2.04	.31
Principle Information	10	2.02	.83
Cue Information	9	1.32	.44
No Information	8	2.46	1.62

[a]Relative weights for trial blocks 1, 2 and 3 were uninterpretable (criterialities small or negative.)

[b]Only those subjects were included whose criteriality for $\underline{k}$ was .70 or greater.

Conclusions

The following conclusions about the experimental hypotheses were drawn:

1. The rank order of performance for the four groups is not as predicted, since the group given information about the number of relevant cues performed better than the group given the solution principle. The difference between these two groups, however, is not significant.

2. A knowledge of the principle (principle group) is not more beneficial than a knowledge of the number of cues (cue group), although a knowledge of the principle together with a knowledge of the cues (full information group) leads to better performance; however, the final level of performance for the full information group is not statistically better than that of the cue group.

3. When the principle and cue groups are compared, a knowledge of the cues does not seem to be more beneficial initially, nor does a knowledge of the principle seem to be more beneficial later in learning; however, the groups who knew the principle (full information and principle groups) did learn the relative importance of the two relevant cues better than the other groups.

Discussion

Since it is difficult to administer a task of this kind in large groups, unless the cooperation of Ss is guaranteed, the data reported here must be regarded as a pilot study. E must know that the Ss whose data are included are actually answering before the verbal feedback is given. In this experiment, the only criteria for eliminating Ss from the analyses was if they failed to answer a significant number of questions or if they gave the same answers for a long series of trials. Furthermore, since the instructions were exceedingly complicated and, at times, obscure to Ss, some clarifying verbal instructions were needed, though not included.

In their instructions, the cue information group was told that there were four cues, two relevant and two irrelevant, while the principle group was told the proper weighting of the two relevant cues. In order to make the cue group comparable to the full information group, they should have been told which were the two relevant cues so that the cue group would have had to learn only the proper weighting. If these more informative instructions had been given, the hypothesis that a knowledge of cues will be beneficial in the initial blocks of trials might have been born out.

The fact that the groups did not reach an asymptote of performance at the end of four blocks of trials suggests that more trials should be added. Four blocks of trials were convenient in that the whole experimental procedure was accomplished in one hour; however, the time should be increased.

A further difficulty was revealed by the first question of the questionnaire, particularly as answered by the no information group. E defines k in terms of stimulus parameters with an algebraic equation; however, S may arrive at the same solution with a geometric model. He may, for example, draw a line between the two colored crosses, pick a point on this line, drop a perpendicular from it to the bottom of the square, and then use the bottom of the square as a scale for k. By so doing he will arrive at the correct answer, even though his model of the task differs from that employed by E. If this is an easier solution, as it appears to be, and if this is the usual method that would be employed by S. if he approached the task with no information, then the principle information given in algebraic terms might make the task unnecessarily complicated. This might account for the failure of the principle group to reach a final level of performance that exceeded that of the no information group. It would also make generalizations from the data suspect.

Cronbach & Azuma (1961) reported that S need not have only one hypothesis about k; he may have a different hypothesis for different subsets of stimulus presentations. For example, S may have one solution if the two crosses are in the same column, another if they are one column apart, and so on. This is a factor to be examined, although this seems less likely in the task presented here since it included ten response categories with exact numerical feedback, whereas Cronbach and Azuma's task used four response categories represented by four standard stimuli. On the other hand, this factor would not vitiate an analysis of overall group success in terms of the criteriality of *k*, but generalizations about the criterialities of x' and x" would have to be made cautiously since *S* might not be using them in the same combination on every trial.

Summary

An attempt was made to determine the relative importance of a knowledge of the solution principle or a knowledge of the number of relevant cues in a concept-attainment task. The overall success of the cue group was better (though not significantly) than that of the principle group; however, *Ss* in the principle group who reached an arbitrary level of success did learn the relative weighting of the two relevant cues better than did comparable *Ss* in the cue group.

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