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THE EFFECT OF CUE-CRITERION CORRELATIONS, CUE INTER-
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ON PERFORMANCE IN SUPPRESSOR VARIABLE TASKS

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THE EFFECT OF CUE-CRITERION CORRELATIONS, CUE INTER-CORRELATIONS AND THE SIGN OF THE CUE INTERCORRELATION ON PERFORMANCE IN SUPPRESSOR VARIABLE TASKS

Armeliu, K., and Armeliu, B. The effect of cue-criterion correlations, cue intercorrelations and the sign of the cue intercorrelation on performance in suppressor variable tasks. Umeå Psychological Reports No. 81, 1975. - The subjects' performance was investigated in a two-cue MCPL-experiment with a 2 (Cue-criterion correlations, $r_{ei} = .60$ and $.80$) a 2 (Total task predictability, $R_e^2 = 1.00$ and $.70$) x 2 (Sign of r_{ij}) x 5 (Blocks) factorial design. The difference in R_e^2 was due entirely to an increase in the cue intercorrelation, r_{ij} . Effects of R_e^2 on performance were therefore interpreted as effects of the cue intercorrelation. Two control conditions, with orthogonal cues and the same values of r_{ei} as in the experimental conditions, were included in the design. Subject consistency was directly related to the cue-criterion correlations and the cue-judgment beta-weights were directly related to the magnitude of the cue intercorrelation. The sign of r_{ij} determined the level of consistency.

In multiple-cue probability learning (MCPL) tasks the subjects are required to make predictions about a criterion variable from the state of a number of cue variables. When cues are orthogonal the only source of information about the validity of a cue is the cue-criterion correlations, r_{ei} . It is well known that the subjects are able to learn to utilize the cue-criterion correlations in orthogonal MCPL-tasks, when they make their predictions (see e.g., Dudycha & Naylor, 1966).

In MCPL-tasks with intercorrelated cues two aspects of the task have to be considered to ascertain the predictive value of a cue: the cue-criterion correlations and the cue intercorrelation, r_{ij} . For these tasks total task predictability, R_e^2 , is a function of both r_{ei} and r_{ij} . For given values of r_{ei} the task predictability is a U-shaped function of r_{ij} (see Dudycha, Dudycha & Schmitt, 1974, for a detailed discussion of the relations among R_e^2 , r_{ei} , and r_{ij} in MCPL-tasks).

The relations among r_{ei} , r_{ij} and R_e^2 have made it difficult to study the effect of r_{ij} on performance without confounding the effects of changes in r_{ij} with the effects of concomitant changes in r_{ei} and R_e^2 . This is clearly illustrated in the studies by Naylor and Schenk (1968) and Knowles, Hammond, Stewart and Summers (1972). Both studies investigated the effect of r_{ij} on performance in tasks where R_e^2 was kept constant. The results were that performance was a positive function of r_{ij} . It is, however, not possible to interpret these results in terms of r_{ij} , since changes in r_{ij} were directly related to changes in r_{ei} . The relation between performance and r_{ij} could therefore be the result of an increase in the cue-criterion correlations rather than in the cue intercorrelation.

Armeliuss and Armeliuss (1975b) made an attempt to separate the effects of r_{ei} and r_{ij} by means of tasks where one cue was a suppressor cue, i.e., a cue with low or zero correlation with the criterion but a negative beta-weight in the regression equation (Darlington, 1968). In that study the magnitude of r_{ei} and r_{ij} were inversely related to each other and R_e^2 was kept constant. They found that the subjects performance was positively related to the cue-criterion correlations but not to the cue-criterion beta-weights or r_{ij} . It is not possible to conclude that the cue intercorrelations had no effect whatsoever on performance, however, since there were no adequate control tasks for each level of cue-criterion correlation.

In another study by Armeliuss and Armeliuss (1975a) the performance of individual subjects was compared to the level of performance that would be expected if the cue intercorrelation had no effect, i.e. the level expected if the subjects used only the cue-criterion correlations to determine cue validity. The results showed that some subjects were able

to reach an optimal level of performance, whereas others were unable to do so. On the average, performance was higher than that expected if the cue intercorrelation had no effect and the subjects had utilized only the cue-criterion correlations.

Schmitt and Dudycha (1974) used three tasks with different levels of R_e^2 , where the cue intercorrelation was varied while both the cue-criterion correlations and total task predictability was constant. They found that achievement was impaired by the cue intercorrelation at the highest level of R_e^2 but not at the other levels. The subjects' matching of the ecological regression weights was impaired by the cue intercorrelation at all three levels of R_e^2 . Changes in the cue intercorrelation had no effect on subject consistency. In this study the increase in cue intercorrelation at all levels of R_e^2 meant that one cue received a large negative beta-weight, although the cue-criterion correlations were positive. There is reason to believe that the negative effect of the cue intercorrelation on achievement and matching of regression weights is a result of the difficulty of learning a large negative beta-weight. It is known that negative relations between variables are more difficult to handle than positive (e.g., Naylor & Clark, 1968). In addition, r_{ij} was not a source of information about the criterion, i.e. the cue intercorrelation did not increase total task predictability compared to an orthogonal task with the same cue-criterion correlations.

The purpose of the present study is to investigate the effects of r_{ei} and r_{ij} on performance in a two-cue MCPL-task, where total task predictability is increased by the cue intercorrelation, i.e. under conditions where r_{ij} is an important source of information about the task. So far, there is very little evidence that the cue intercorrelation in itself has a positive effect on the subjects' performance in MCPL-tasks. Instead, the important factor seems to be the cue-criterion correlations. However, the tasks used in earlier studies makes it hard to draw any firm conclusions with respect to this problem. The design of the present experiment makes it possible to evaluate the effects of r_{ij} independently of those of r_{ei} . In addition, the sign of r_{ij} will be varied to see if the effects of the cue intercorrelation is dependent on the sign of r_{ij} . This will

also make it possible to study the important question of whether it is more difficult to learn a task with negative beta-weights than a task with only positive beta-weights.

Method

Subjects: Eighty-two undergraduate psychology students from the University of Umeå participated in the experiment to fulfill a course requirement and 18 educational students from the University of Umeå were paid to participate in the experiment.

Learning tasks and design. The experimental_m tasks were two-cue MCPL-tasks with intercorrelated cues. One cue was uncorrelated with the criterion variable, $r_{e2} = .00$ for all experimental conditions. The design was a 2 (Sign of the cue intercorrelation) x 2 (Levels of cue-criterion correlations for cue 1: $r_{e1} = .60$ and $.80$) x 2 (Levels of task predictability: $R_e^2 = 1.00$ and $.70$) x 5 (Blocks of 20 trials) factorial design with repeated measures on the last factor.

In addition to these eight experimental conditions, two control conditions were included in the experiment. In the control conditions the tasks were orthogonal two-cue MCPL-tasks with the same levels of the cue-criterion correlations as those in the experimental tasks: $r_{e1} = .60$ and $.80$, and $r_{e2} = .00$. Table 1 gives the task characteristics for the experimental and control tasks.

If the cue intercorrelation has any effect on the subjects' performance, this will show up as a significant main effect for task predictability, since the increase in R_e^2 is due only to an increase in r_{ij} . The control conditions were included to answer the question whether the effect of the cue intercorrelation was to improve the performance beyond the level expected if the subjects utilize only the cue-criterion correlations as a source of information. If the cue intercorrelation has a positive effect on performance there will be a significant difference between the control tasks and the experimental tasks, since the increase in R_e^2 in the experimental tasks compared to the control tasks is due only to an increase in r_{ij} .

Table 1. Task characteristics for the experimental and control tasks.

Experimental tasks	r_{ij}	r_{e1}	r_{e2}	beta_{e1}	beta_{e2}	R_e^2
1	.80	.60	.00	1.67	-1.33	1.00
2	.70	.60	.00	1.18	-.82	.70
3	.60	.80	.00	1.25	-.75	1.00
4	.30	.80	.00	.88	-.26	.70
5	-.80	.60	.00	1.67	1.33	1.00
6	-.70	.60	.00	1.18	.82	.70
7	-.60	.80	.00	1.25	.75	1.00
8	-.30	.80	.00	.88	.26	.70
Control tasks						
1	.00	.60	.00	.60	.00	.36
2	.00	.80	.00	.80	.00	.64

Procedure. The learning tasks were presented in booklets. On the face of each page in the booklet the cues were presented as two bars numbered from one through twenty. The value of each cue was represented as the shaded part of the bar. The criterion value was presented as a number between one and thirty on the other side of the page. On each of the 100 training trials, the subjects (a) observed the two cue values, (b) gave their prediction of the criterion value on their answer sheets and (c) observed the correct criterion value. The subjects were allowed to work at their own pace. They were not informed of the structure of the tasks. They were told to base their predictions on the values of the cues, and it was emphasised that due to the nature of the task they should not expect to be perfectly correct on each trial.

Results

For each subject and block the correlation between his judgments and the correct criterion values, r_a , the squared multiple correlation between cues and judgments, R_s^2 , the cue-judgment beta-weights, β_{si} , and the correlation between the linearly predictable variance in the task system and that in the subject system, G , were computed. The correlation measures r_a and G were transformed to Fisher's Z -values before the statistical analysis.

All performance measures were subjected to two sets of ANOVAs. The purpose of first set of ANOVAs was to investigate whether performance was affected by the task parameters r_{ei} , R_e^2 and sign of r_{ij} . All performance measures were therefore subjected to a 2 (Sign of cue intercorrelation) $\times$ 2 (Levels of r_{ei}) $\times$ 2 (Levels of R_e^2) $\times$ 5 (Blocks) ANOVA with repeated measures on the blocks factor. Effects for R_e^2 will be interpreted as effects for r_{ij} since the changes in levels of R_e^2 are due entirely to changes in r_{ij} . Since the cell variances tended to be correlated with the cell means, the performance measures were subjected to a square-root transformation (Wiener, 1962).

The second set of ANOVAs was performed to answer the question whether the effects of the cue intercorrelation was to improve the performance in the intercorrelated tasks. This was done by means of a comparison between the experimental tasks and the control tasks. The comparison was for the last block only, and the performance measures were subjected to a 2 (Levels of r_{ei}) $\times$ 3 (Levels of R_e^2) ANOVA. When no interaction effects with the sign of r_{ij} was obtained in the first ANOVA, the design was collapsed over sign in the second ANOVA. Otherwise a separate ANOVA was made for each sign. The post hoc tests were made according to the Newman-Keul's procedure.

Achievement. Significant effects for r_{ei} were obtained on r_a ($F_{1/72} = 11.73$, $p < .01$). Achievement was higher when $r_{ei} = .80$ than when $r_{ei} = .60$. The effects for R_e^2 on r_a were also significant ($F_{1/72} = 9.19$, $p < .01$). r_a was higher when $R_e^2 = 1.00$ than when $R_e^2 = .70$. In addition,

r_a increased significantly over blocks ($F_{4/288} = 7.26, p < .01$). The results for r_a are shown in Figure 1.

Fig. 1. The effects of total task predictability, cue-criterion correlations and blocks on r_a in the experimental and control conditions.

The comparison with the control conditions yielded significant effects for cue-criterion correlations ($F_{1/94} = 4.37, p < .01$), and for R_e^2 ($F_{2/94} = 4.37, p < .01$). r_a was higher when $r_{el} = .80$ than when $r_{el} = .60$. The post hoc tests for the effect of R_e^2 showed that achievement was higher when $R_e^2 = 1.00$ than in the other two R_e^2 conditions. The difference between the $R_e^2 = .70$ and the control conditions was not significant, see Figure 1.

The effects on r_a may be due either to variations in subject consistency, R_e^2 or to variations in the subjects' matching of the regression weights, G_s , or to both of these factors, since $r_a = R_s \cdot R_e \cdot G_s$ (Tucker, 1964). The different components of r_a are analyzed below.

Subject consistency. Significant effects for the cue-criterion correlations ($F_{1/72} = 5.56, p < .05$) and for the sign of the cue intercorrelation ($F_{1/72} = 4.29, p < .05$) were obtained on subject consistency. R_s^2 was higher when the cue-criterion correlation was .80 than when it was .60, and higher when the sign of the cue intercorrelation was positive than when it was negative. In addition, the subjects became significantly more consistent over blocks ($F_{4/288} = 8.67, p < .01$) Task predictability had no effect on subject consistency.

The comparison with the control conditions shows only a significant main effect for cue-criterion correlations ($F_{1/94} = 15.41, p < .01$). The results for subject consistency are shown in Figure 2.

Fig. 2. The effects of cue-criterion correlations, the sign of the cue intercorrelation and blocks on subject consistency in the experimental and control conditions.

The lack of effects for R_e^2 on R_s^2 means that changes in the magnitude of the cue intercorrelation had no effect on subject consistency. The variables that influence the subjects' consistency seem to be the cue-criterion correlations and the sign of r_{ij} .

Cue-judgment beta-weights. For cue 1 significant effects were obtained for task predictability ($F_{1/72} = 8.14, p < .01$) and for blocks ($F_{4/288} = 5.66, p < .01$). In Figure 3 (a) it can be seen that β_{s1} is higher when $R_e^2 = 1.00$ than when $R_e^2 = .70$. This difference corresponds to the difference in β_{e1} of the tasks with low and high R_e^2 . The β_{s1} values are lower than the β_{e1} values, indicating that the learning of β_{e1} is not optimal.

The comparison with the control conditions shows that β_{s1} is higher in the $R_e^2 = 1.00$ condition than in both the $R_e^2 = .70$ and the control conditions, but there is no difference between the last two conditions. The results can be seen in Figure 3 (a).

For cue 2, a significant effect for the sign of the cue intercorrelation ($F_{1/72} = 25.30, p < .01$) shows that the sign of the beta-weight is of importance for determining the subject beta-weights. However, β_{s2} is negative only in the $R_e^2 = 1.00$ condition.

As shown by a significant interaction between the sign of r_{ij} and R_e^2 ($F_{1/72} = 7.34, p < .01$) there is a difference in β_{s2} between the high and low R_e^2 conditions only when β_{e2} is negative. When β_{e2} is positive, β_{s2} is equal in the two R_e^2 conditions. No other effects for cue 2 were significant.

Fig. 3. The effects of task predictability and blocks on β_{s1} in the experimental and control conditions (a), and the effects of task predictability, the sign of the cue intercorrelation and blocks on β_{s2} in the experimental and control conditions (b).

The comparison with the control conditions was made separately for each sign of r_{ij} since the interaction between the sign of r_{ij} and R_e^2 was significant. As expected, the only significant difference was that between the $R_e^2 = 1.00$ condition where β_{e1} was negative on one hand, and $R_e^2 = .70$ and the control conditions on the other hand. In Figure 3 (b) it can be seen that in the $R_e^2 = 1.00$ condition, the subjects have learned the value of the negative beta-weight almost as well as the value of the positive beta-weight, although the values of β_{s2} in both cases are far below the values of β_{e2} .

In summary, the results for the beta-weights show that the subjects have learned something about the regression weights of the task. The subject beta-weights are higher and cue 2 receives a greater negative weight in the high R_e^2 conditions than in the low R_e^2 conditions and the orthogonal conditions. The cue-criterion correlations do not affect the cue-judgment beta-weights. There is no difference in the cue-judgment beta-weights for the high and low levels of r_{ei} , although the differences in the beta-weights of the tasks are as large as for the high and low R_e^2 conditions. Together with the fact that the beta-weights of the tasks are underestimated, this means that learning of the regression weights in the $r_{e1} = .60$ condition is poorer than in the $r_{e1} = .80$ condition, which should show up in the analysis of G.

Matching of regression weights. As expected, there were significant effects for cue-criterion correlations on G ($F_{1/72} = 4.81, p < .05$). Matching was better when $r_{e1} = .80$ than when $r_{e1} = .60$. The comparison with the control condition shows no significant effect. In the last learning block the average value of G was .97 and .89 for the high and low values of r_{e1} respectively.

Discussion

The results of the present study are that differences in the cue-criterion correlations are accompanied by differences in subject consistency but not by differences in the cue-judgment beta-weights. The opposite seems to be true for the cue intercorrelation, as shown by the effects for R_e^2 . Thus, both the cue-criterion correlations and the cue intercorrelation are of importance for achievement. The sign of r_{ij} , finally, is of importance for the level of subject consistency, and for the learning of the regression weight of the suppressor cue.

The results of the present study, then, show that both the cue-criterion correlations and the cue intercorrelation are of importance for the subjects' achievement in MCPL-tasks, but that they affect r_a in different ways. Subject consistency is a direct function of r_{ei} and the cue-judgment beta-weights are directly related to the magnitude of r_{ij} . This indicates that r_{ei} and r_{ij} independently determine the value of r_a .

The effects for r_{ei} on performance in MCPL-tasks with intercorrelated cues seem to be quite stable and have also been clearly demonstrated in previous studies (Armeliu & Armeliu, 1975b; Miller & Sarafino, 1972). In the studies where r_{ei} and r_{ij} are positively related the facilitating effect on performance has been interpreted in terms of r_{ij} (Naylor & Schenk, 1968; Knowles, et al., 1972). In view of the present results it is quite clear that the effect should be interpreted as, at least in part, due to r_{ei} .

The present results also show that the subjects are able to learn a task where the cues are highly intercorrelated better than a task with orthogonal cues. This is somewhat surprising in view of previous results (see Armeliu & Armeliu, 1975b; Dudycha, et al., 1975), which have been interpreted to mean that learning is impaired by cue intercorrelations. However, these earlier studies did not include control conditions which made it possible to evaluate the effects of r_{ij} independently of those of r_{ei} .

The results indicate that learning a negative beta-weight is no more difficult than learning a positive beta-weight. This rules out the hypothesis that suppressor variable tasks are difficult to learn because of the negative relation between the suppressor cue and the criterion, as might have been expected from results on single cue probability learning (SPL) (e.g., Naylor & Clark, 1968). There are, however, important differences between SPL and MCPL. In MCPL-tasks the subjects have to integrate the values of the cues to make their predictions. As shown by Armelius and Armelius (1975a) the same regression equation may result from different integration rules. A negative beta-weight in the regression equation, therefore, does not necessarily correspond to a negative relation in the integration rules used by the subjects. The question of the effects of the sign of the beta-weights cannot be isolated from the broader question of what the subjects actually do when they learn a MCPL-task with intercorrelated cues. This question, however, cannot be answered only through the use of paramorphic representations of the subjects' strategies by means of regression equations but requires other forms of data (see Armelius & Armelius, 1975a).

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