DOCUMENT RESUME

ED 050 236 VT 012 051

AUTHOR	Earle, Timothy C.
TITLE	Task Learning, Interpersonal Learning and Cognitive Complexity.
INSTITUTION	Colorado Univ., Boulder. Inst. of Behavioral Science.; Oregon Research Inst., Eugene.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Research Programs Office.
REPORT NO	ORIB-Bull-Vol-10-No-2
PUB DATE	May 70
NOTE	83p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	Complexity Level, Decision Making, *Interaction Process Analysis, Intergroup Relations, Interpersonal Relationship, *Learning Activities, Learning Difficulties, *Learning Experience, *Learning Theories, *Paired Associate Learning

ABSTRACT

The study of human learning has neglected interpersonal learning, mainly because of its complexity. However, with the recent development of a new methodology and research paradigm, empirical studies have been initiated. This is a report on one such study, involving 40 male University of Oregon students divided into two groups of 10 pairs of subjects. The task learning (TL) group and the interpersonal learning (IPL) group were trained for 60 trials to predict a numerical criterion on the basis of two numerical cues (X1 and X2). For the TL group, pairs of subjects were trained to use the same cue according to the same rule. For half the pairs, X1 was linearly related to the criterion, while for the rest, X1 was a nonlinear cue. In the IPL group, each pair was differentially trained, with one using X1 as a linear cue, and the other using X2 as a nonlinear cue. When the pairs were combined for a task involving two equally valid linear and nonlinear cues, the IPL group adapted significantly better to the task due to the linear subjects' inability to learn to use the nonlinear cue on the basis of task learning alone. (BH)

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University of Colorado

Institute of Behavioral Science

and

Oregon Research Institute

Task Learning, Interpersonal Learning and Cognitive Complexity[1]

by

Timothy C. Earle[2]

This paper is issued jointly as Oregon Research Institute Research Bulletin, Vol. 10, No. 2, 1970, and Program on Cognitive Processes Report No. 129, Institute of Behavioral Science, University of Colorado

Sponsorship for this study comes from the Personnel and Training Research Programs, Psychological Sciences Division, Office of Naval Research, under Contract No. N00014-68-C-0431, Contract Authority Ident. No. NR 153-311, and from Grants MH-15414 and MH-16437 from the United States Public Health Service.

ED050236

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Oregon Research Institute	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP NA
3. REPORT TITLE Task Learning, Interpersonal Learning and Cognitive Complexity	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Technical Report	
5. AUTHOR(S) (First name, middle initial, last name) Timothy C. Earle	

6. REPORT DATE May, 1970	7a. TOTAL NO. OF PAGES 71	7b. NO. OF REFS 20
8a. CONTRACT OR GRANT NO. N00014-68-C-0431 b. PROJECT NO c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Oregon Research Institute Research Bull. Vol. 10, No. 2, 1970 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale. Its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office of Naval Research Personnel and Training Research Branch Washington, D. C. 20360

13. ABSTRACT

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DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified

Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Task Learning						
Interpersonal Learning						
Decision Processes						
Cognitive Complexity						
Judgment						
Information Processing						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

Task Learning, Interpersonal Learning

and Cognitive Complexity

Abstract

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INTRODUCTION

All human learning consists of certain changes in the relations between a person and his environment. These changes can be as simple and individual as an eyeblink or as complex and interpersonal as 'falling in love'. Both general types of human learning, individual and interpersonal, are, of course, essential to human existence and normally not independent. The scientific study of human learning, however, has concentrated almost exclusively on individual learning (see: Melton, 1964), to the neglect of interpersonal learning. The study of interpersonal learning has been ignored not because interpersonal learning is any less important than individual learning, but because it is more complex; theoretically and methodologically interpersonal learning is more difficult to handle than individual learning. Recently, however, some preliminary efforts toward an understanding of interpersonal learning have been taken; a new methodology and research paradigm have been developed, and empirical studies are underway. The present paper reports one such study of interpersonal learning. The introduction to that study consists of two parts. First, the nature of the study of interpersonal learning is discussed. Second, interpersonal learning is contrasted with task learning and the study of the effects of cognitive complexity on these two types of learning is considered.

The Study of Interpersonal Learning

Interpersonal learning (as studied here) is the process whereby one person learns from another person information about an environmental task common to both. The study of interpersonal learning, then, includes the investigation of (at least) three interacting systems -- two subjects and their common environment. An experimental paradigm for the study of interpersonal learning must thus provide methods for the measurement of changes in and among these three systems. Such an experimental paradigm, the lens model paradigm, has recently been described by Earle and Miller (1969). Based on the theoretical and methodological ideas of Egon Brunswik (1952, 1956) and on the extensions of Brunswik's work by Hammond and his associates (Hammond, 1965; Hammond, Wilkens & Todd, 1966; Hammond & Summers, 1965; Hammond, Hursch & Todd, 1964; Peterson, Hammond, & Summers, 1965; Summers & Hammond, 1966; Todd & Hammond, 1965) the lens model paradigm for the study of interpersonal learning provides detailed quantitative descriptions of the two subjects and their common environment prior to and during interpersonal learning. Both of these stages of investigation are briefly discussed below.

The lens model paradigm for the study of interpersonal learning is presented graphically in Figure 1. The two subjects, S_1 & S_2, are individually trained on different two-cue probabilistic learning tasks. S_1 is trained on a task in which cue X_2 is highly correlated with the criterion, Y, and cue X_1 is uncorrelated with Y. S_2, on the other hand, is trained on a task in which cue X_1 is highly

INTERPERSONAL LEARNING

THE LENS MODEL PARADIGM

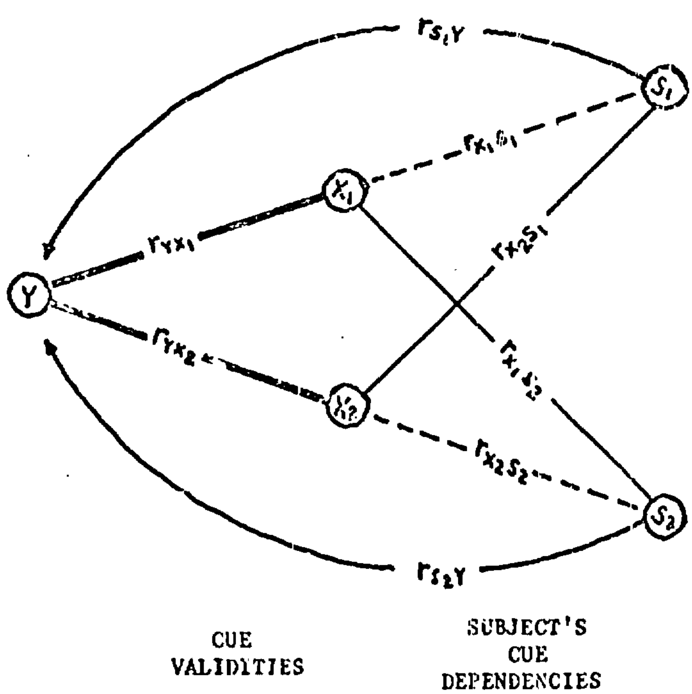


Figure 1

correlated with the criterion, Y, and cue X_2 is uncorrelated with Y. S_1 and S_2 are trained equally well on their different tasks.

The joint task (common environment) is formed of elements from both training tasks -- i.e., cues X_1 and X_2. The joint task differs from each of the individual tasks, however, in that X_1 and X_2 are equally and moderately correlated with Y. S_1 and S_2 thus bring to the joint task equally valid information concerning the use of one of the task cues. Each subject must then learn from the other subject (and from the task) the importance of the task cue which he had been trained to ignore and the other subject had been trained to use. In addition to learning to pay attention to another task cue, each subject may have to learn a new rule (function form) relating that cue to the criterion. Rule learning would occur if X_1 is related to Y according to a different rule from that relating X_2 to Y. Whether cue learning, rule learning or complete learning (see: Summers, 1967, 1969) is required for adaptation by S_1 and S_2 to the joint task, information can be obtained both from the other subject and from the task. These two types of learning -- interpersonal learning (from the other subject) and task learning (from the task feedback) -- occur concurrently and are indicated by the same measures -- the cue dependencies, achievement correlations and other parameters of the lens model. These measures will be discussed in detail in the methods section.

Two studies using the general lens model framework described above have recently been reported. The first of these, Miller & Hammond (1969), investigated the effects of two independent variables on interpersonal learning: (1) differences in the complexity of the cognitive systems of the learner and the person learned from, and (2) variations in the explanatory context in which these differences were communicated. Two levels of cognitive complexity were used: (1) Simple: A subject was trained to depend heavily on a cue related to the criterion by a rule with a positive linear form, (2) Complex: A subject was trained to depend heavily on a cue related by a rule with an inverted U-shaped form. Six levels of explanatory context were used: (1) Individual subjects with no feedback from the task; (2) Individual subjects with outcome feedback; (3) Individual subjects with outcome feedback and with the judgment of another, oppositely trained subject; (4) As in (3), but with both subjects present and with free discussion between them; (5) As in (4), but also with cue-dependency information; and (6) As in (5), but with discussion focused on cue-dependencies.

The results of the Miller & Hammond paper were these: Cognitively simple (linear) subjects adapted to the joint task in explanatory context conditions #4, #5, & #6, but not in conditions #1, #2 or #3. Cognitively complex (nonlinear) subjects, on the other hand, showed adaptation to the joint task starting with condition #2. The cognitively complex subjects, in other words, learned to use the newly important cue (the cue they weren't trained on) and the newly important rule (positive linear relation) on the basis of task learning alone; the addition of linearly trained subjects to the explanatory context (Condition #4) did not significantly improve the performance of the complex subjects. The cognitively simple subjects did not learn to use the newly important cue and the newly important rule (inverted U-shaped relation) until the addition of nonlinearly trained subjects to the explanatory context (Condition #4); simple (linear) subjects required interpersonal learning in order to adapt to the joint task. In sum, Miller & Hammond showed that in a joint task including both a simple (linear) and a complex (nonlinear) rule, subjects trained to use the complex rule could adapt to the joint task (learn to use the simple rule) on the basis of task learning alone, whereas subjects trained to use the simple rule could adapt to the joint task (learn to use the complex rule) only with the aid of information learned from subjects trained to use the complex rule: cognitive complexity affects interpersonal learning.

A result related to those described above was also reported by Miller & Hammond: In those groups in which simple linear subjects were paired with complex nonlinear subjects (Conditions #4, #5, #6), the complex subjects generally adapted better to the joint task than did the simple subjects (No difference in #4, better in #5 & #6). But it was reported above that the complex subjects successfully adapted to the task in all conditions except #1, whereas the simple subjects successfully adapted to the task only when they were paired with complex subjects (#4, #5, #6). The simple subjects therefore benefited more from the interpersonal interaction than did the complex subjects: Although the complex subjects adapted better to the task, the simple subjects learned more from the complex subjects than _vice versa_.

The second lens model study of interpersonal learning was conducted by Earle & Miller (1969). Carrying a step further the finding of Miller & Hammond that cognitive complexity affects interpersonal learning, Earle & Miller investigated interpersonal learning in pairs of subjects trained to use the 10 combinations of 4 different cue-criterion function forms (rules). The four rules were these: (1) positive linear; (2) negative linear; (3) U-shaped; (4) inverted U-shaped. Ten experiments were run, with 10 pairs of subjects in each experiment -- a total of 200 subjects. A typical experiment, for example (Exp. #1), involved pairs of subjects the members of which were trained to depend on different cues; both cues, however, were related to the criterion by identical positive linear rules. The joint task for these subjects was composed of the two positive linear cues on which they were trained. Other experiments involved pairs of subjects one member of which was trained on a positive linear cue and the other on a negative linear cue (Exp. #2), or pairs of subjects both members of which were trained on negative linear cues (Exp. #3), and so on for the 10 combinations of the 4 function forms. The purpose of the 10 experiments was to investigate the effects of differential cognitive complexity on the adaptation by subjects to an interpersonal learning task.

The primary finding by Earle & Miller was that differences in cognitive complexity affected the task adaptation within pairs composed of a simple subject (trained to use a linear rule) and a complex subject (trained to use a nonlinear rule) (Exps. #7, #8, #9, #10): The complex nonlinear subjects adapted better to the joint interpersonal learning task than did the simple linear subjects. Other results indicated that simple linear subjects who were paired with other linear subjects (Exps. #1, #2, #3) showed as much task adaptation as complex nonlinear subjects paired with other nonlinear subjects (Exps. #4, #5, #6). Further, there were no differences in the interpersonal learning task adaptation of positive vs. negative linear subjects or U-shaped vs. inverted U-shaped subjects.

The results of the Earle & Miller study are ambiguous concerning the effects of cognitive complexity on interpersonal learning: In pairs composed of one complex and one simple subject the complex subject adapts better to the task than does the simple subject. But is this result due to superior interpersonal learning on the part of the complex subject -- or is it due to superior task learning? Does the nonlinear subject learn to use the linear rule through communication with the linear subject, or simply through 'communication' (feedback) from the task? The results of the Miller & Hammond study suggest that the nonlinear subject would have adapted as well to the interpersonal learning task with or without communication from the linear subject. In other words, task learning alone is probably sufficient to account for the superior performance of the nonlinear subjects over the linear subjects. Miller & Hammond's results suggest further that the linear subjects would not have adapted as well as they did to the interpersonal learning task if they had not had communication with the nonlinear subjects: Interpersonal learning _and_ task learning are probably both necessary to account for the performance of the linear subjects. The results of the Earle &

Miller study, in sum, seem to indicate that, while the nonlinear subjects when paired with linear subjects show superior task adaptation, the linear subjects in these pairs probably show superior interpersonal learning. This conclusion is similar to that arrived at by Miller & Hammond.

The key distinction here is the one stated at the beginning of this paper -- between individual (task) learning and interpersonal learning. In the Miller & Hammond study this distinction was inherent in the design -- subjects who worked individually on the task were compared with subjects who paired with other differently trained subjects. Earle & Miller, however, did not control for task learning. The authors showed that cognitive complexity does indeed affect task adaptation, but they failed to indicate what part of that task adaptation was due to information learned from the other subject; they did not show the effects of cognitive complexity on interpersonal learning, *per se*.

The effects of differential cognitive complexity on the interpersonal learning between two persons is clearly an important problem, a first step toward an understanding of the process of interpersonal learning. The studies by Miller & Hammond and Earle & Miller have demonstrated some of the effects of cognitive complexity on individual and interpersonal learning and they have shown that the lens model paradigm is adequate to the requirements of the study of interpersonal learning. The purpose of the present study is to use the lens model paradigm toward two ends in the study of dyadic interactions: (1)

To clearly separate dyadic task learning (learning together) from dyadic interpersonal learning and to investigate the effects of cognitive complexity on both types of learning. (2) To determine what information is learned by one person from another person in relation to a particular interpersonal interaction task. A discussion of the three important concepts used in this study -- task learning, interpersonal learning and cognitive complexity -- is given below.

Task Learning, Interpersonal Learning and Cognitive Complexity

Task Learning

Task learning consists of certain changes in the relations between a person (or group of persons) and the environment, that are brought about through the communication of information from the environment to each person. Task learning, then includes the ordinary individual learning so well studied by psychologists, where a subject's responses to a task environment change over trials as a function of the feedback (information) provided by the task environment. Also included in task learning, however, are changes in the relations between members of a group and the common environment they share, if these changes result from communication of information from the environment (as opposed to communication of information among the members of the group). This multiperson interactive form of task learning can be called learning together since the members of a group are free to communicate but initially have nothing useful to say to one another -- all useful information comes from the task. A typical learning together situation would be one in which two persons, for example, are faced with a common problem about which neither of them knows anything, or about which they have the same knowledge. In other words, prior to the learning together process, the relations of the two persons to the problem are identical -- neither person initially has anything to learn from the other. As the two persons interact with the problem, their relations with the problem change; these changes are a result of feedback of one sort or another from the problem. Both persons learn about the problem as a result of information supplied by either of them to the other. This is the distinction between task learning (learning together) and interpersonal learning which is central to the study reported in this paper.

Interpersonal Learning

Interpersonal learning has been defined above as the process whereby one person learns from another person information about an environmental task common to both. In order for interpersonal learning to occur the relations between each of at least two persons and their common task must initially be different -- each person must possess useful information which can be learned by the other person. During their interpersonal interaction the information possessed by these cognitively different persons is exchanged in the process of interpersonal learning. A typical interpersonal learning situation would be one in which two persons are faced with a common problem about which they have different partially valid beliefs. Since both persons are initially partially correct for different reasons, the exchange of information through interpersonal learning will increase their overall knowledge of the problem. This increase in knowledge about the task is not due solely to interpersonal learning, however -- task learning (as discussed above) also occurs in the interpersonal interaction process. The problem in assessing the degree of interpersonal learning in an interaction situation is thus dependent on proper control of the degree of task learning. The control used in the present study consisted of pairs of subjects which could learn from the task, but not from each other. The task adaptation of these 'task learning pairs' was compared with that of 'interpersonal learning pairs' who could learn from both the task and from each other.

Cognitive Complexity

Cognitive complexity, as investigated in the present study, refers to the complexity of the policy which the individual subject brings to the interpersonal interaction situation. Within the lens model paradigm there are two main types of cognitive complexity. First, there is the number of cues used: In general, the larger the number of cues used by a subject, the more cognitively complex he is. Second, there is the form of the rule used by the subject to relate each of the cues to the criterion: The more nonlinear the rule used by the subject is, the more cognitively complex he is.

The first type of complexity, number of cues, has been investigated in individual multiple-cue prediction tasks (Uhl, 1963) and in changes of multiple cue tasks (Summers, Taliaferro & Fletcher, 1969); the effects of differences in the number of cues used in a dyadic interaction situation have not, however, been studied. The second type of complexity, rule nonlinearity (cognitive function form), has been studied in both individual (Hammond & Summers, 1965; Summers & Hammond, 1966; Summers, 1967; Summers, Taliaferro & Fletcher, 1969) and interactive (Miller & Hammond, 1969; Earle & Miller, 1969) situations. The results of the studies of the effects of cognitive complexity (linearity-nonlinearity) on interpersonal interaction have been reviewed above, and the limitations of those studies have been noted. In the present study, the effects of the second type of cognitive complexity, rule nonlinearity, are investigated in both task learning and interpersonal learning situations in order to assess the effects of differential cognitive complexity on interpersonal learning *per se*. Before detailing the method used in the study of interpersonal learning, the requirements which the method must satisfy are first considered.

Requirements of Method

The above discussions of task learning, interpersonal learning, and cognitive complexity argue that the study of the effects of cognitive complexity on interpersonal learning requires two sub-studies: (1) The effects of cognitive complexity on task learning; (2) The effects of cognitive complexity on task learning combined with interpersonal learning. A comparison of these two groups should reveal the effects of cognitive complexity on interpersonal learning.

Dyadic task learning has been termed learning together because both subjects initially learn exclusively from the task rather than from one another. The method for studying task learning, then, must provide two subjects who are initially identically related to the interaction task. As part of these identical relations, the two subjects must be cognitively equally complex. Furthermore, pairs of subjects differing in cognitive complexity (i.e., simple pairs vs. complex pairs) must be provided in order to assess the effects of that variable on task learning.

In order to provide two subjects identically related to an admittedly 'unnatural' laboratory task, a training procedure is necessary. The elements (cues) of the two subjects' past environments (training tasks) must be the same. In other words, they must simply be trained on the same task. Differential cognitive complexity could be introduced by having some pairs train on a nonlinear task (one nonlinear cue and one random cue) and others train on a linear task (one linear cue and one random cue). The interaction task would consist, then, of one linear cue and one nonlinear cue: The linear subjects would have to learn together from the task how to use the nonlinear rule, while the nonlinear subjects would have to learn together from the task how to use the linear rule. Thus a two-stage training and interaction procedure is appropriate to the study of task learning. The method must provide quantitative measures of the changes in relations between the two subjects and the two tasks.

When interpersonal learning is combined with task learning in dyads, the two subjects can learn from both the task and each other.

The method for studying interpersonal learning combined with task learning, then, must provide two subjects who are initially differentially related to the interaction task. As part of these differing relations, the two subjects must be differentially cognitively complex, in order that the effects of that variable on interpersonal learning can be assessed.

The same two-stage training and interaction procedure that is appropriate to the study of dyadic task learning is appropriate to the study of interpersonal learning combined with task learning. In the present case, however, the elements (cues) of the two subjects' past environments (training tasks) must be different rather than the same. The two subjects must be trained on different tasks. Differential cognitive complexity is introduced by having one subject of a pair train on a nonlinear task while the other subject trains on a linear task. The interaction task would be identical to that used in task learning -- one linear cue and one nonlinear cue: The linear subjects would have to learn from the task and from their nonlinear partners how to use the nonlinear cue; conversely, the nonlinear subjects would have to learn from the task and from their linear partners how to use the linear cue. Again, as in task learning, the method must provide quantitative measures of the changes in relations between the two subjects and the two tasks.

METHOD

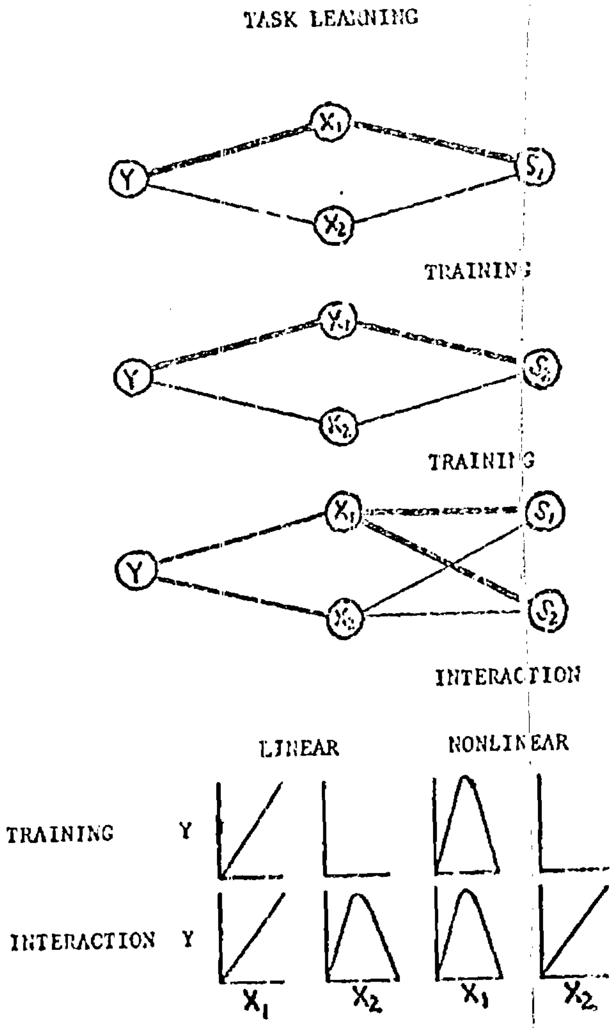
The Lens Model Paradigm

The lens model paradigm for the study of interpersonal learning has been described in detail by Earle & Miller (1969) and is essentially the same as the interpersonal conflict paradigm described by Hammond (1965). The application of the lens model paradigm to the study of task learning and task learning combined with interpersonal learning is described below.

Training

Prior to interpersonal interaction, the contents of subjects' cognitive systems (relative to the interaction task) are determined through individual training procedures. In dyadic task learning it is required that both subjects be trained on the same task; Figure 2a shows the structure of the task learning training tasks. The two subjects, S_1 & S_2, are trained identically on a two-cue probabilistic learning task composed of either a linear cue and a random cue or a nonlinear cue and a random cue. Pairs of subjects who think the same (use the same cue in the same way, either linearly or nonlinearly) are thus produced for the task learning control condition.

In dyadic interpersonal learning it is required that the subjects be trained on different tasks; Figure 2b shows the structure of the interpersonal learning training tasks. The two subjects, S_1 & S_2, are trained entirely differently, i.e., on tasks which share no elements.


TASK LEARNING
Y
X1
X2
S1
TRAINING
Y
X1
X2
S2
TRAINING
Y
X1
X2
S1
S2
INTERACTION
LINEAR
NONLINEAR
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INTERACTION
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X1
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Figure 2a

INTERPERSONAL AND TASK LEARNING

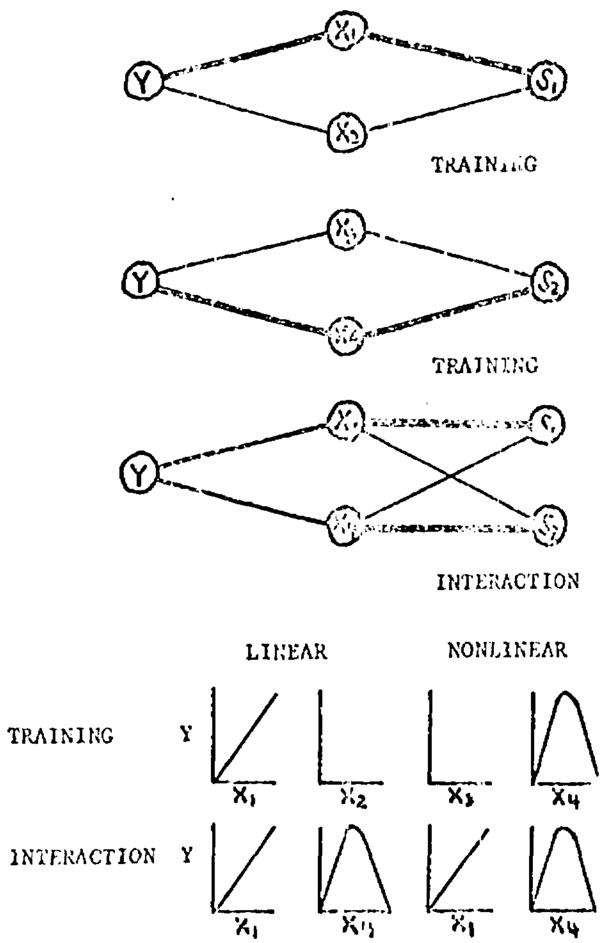

Figure 2b

For example, if S_1 is trained on a task composed of a linear cue and a random cue, S_2 would be trained on a task composed of a different random cue and a nonlinear cue. This procedure insures that the subjects will have something to learn from one another in the interaction stage.

Interpersonal Interaction

After the contents of two subjects' cognitive systems have been appropriately determined through training, the subjects are brought together to work both individually and jointly on an interpersonal interaction task. In both task learning and interpersonal learning the interpersonal interaction task must be composed of elements from both training tasks plus elements unique to the interaction stage. The formation of the interaction task from the training tasks is illustrated in Figures 2a and 2b. Note that the same task used for task learning is used for task learning combined with interpersonal learning -- a direct comparison between the performances of these two groups is thus possible.

In task learning a pair of identically trained subjects confront the interaction task. These two subjects must learn from the task to change their cue weightings and to use the new cue according to the correct rule. When interpersonal learning is combined with task learning, each subject can learn from his partner the importance of the new cue and how it is related to the criterion. This potential exchange of useful information -- thus interpersonal learning -- should improve the performance of the subjects in that condition over that of subjects in the task learning condition. Performance in relation to the interpersonal interaction task (and any change in performance due to interpersonal learning) is measured through the use of multiple regression statistics -- specifically the lens model equation.

The Lens Model Equation

The lens model equation provides the quantitative measurement of the changes in relations between the interacting systems of the lens model paradigm. In the study of interpersonal learning the lens model equation can be used to show who learned what from whom. The original form of the lens model equation (Hursch, Hammond & Hursch, 1964) was this:

$$r_a = \frac{R_e^2 + R_s^2 - \Sigma d^2}{2} + C\sqrt{1 - R_e^2}\sqrt{1 - R_s^2}$$

where

r_a = The correlation between the subject's judgments and the criterion variable

R_e = The multiple correlation between the cues and the criterion variable

R_s = the multiple correlation between the cues and the subject's judgments

Σd = the sum of the products $(r_{e_i} - r_{s_i})(\beta_{e_i} - \beta_{s_i})$ where r_{e_i} = the correlation between cue i and the criterion variable, r_{s_i} = the correlation between cue i and the subject's judgments, β_{e_i} = the beta weight for the correlation between cue i and the criterion variable and β_{s_i} = the beta weight for the correlation between cue i and the subject's judgments.

C = the correlation between the variance unaccounted for by the multiple correlation in the task and the variance unaccounted for by the multiple correlation in the subject's judgment system.

An alternative formulation of the lens model equation has been given by Tucker (1964):

$$r_a = GR_eR_s + C\sqrt{1-R_e^2}\sqrt{1 - R_s^2}$$

where

G = the correlation between the variance accounted for by the multiple correlation in the task and the variance accounted for by the multiple correlation in the subject's judgment system.

Both the Hursch, Hammond & Hursch and the Tucker formulations of the lens model equation are used in the present study. Note that in Tucker's formulation G and C are complementary terms -- G indicates the degree of linear covariation between the two systems, the subject and the task, while C indicates the degree of nonlinear covariation. A subject's overall relation to the task -- his adaptation to the task, r_a -- can thus be decomposed into a linear or simple component (GR_eR_s) and a nonlinear or complex component ($C\sqrt{1 - R_e^2}\sqrt{1 - R_s^2}$). Such a decomposition of adaptation can be very useful analytically -- especially (as in the present case) where the task to which the subject must adapt is itself composed of simple linear and complex nonlinear components. When the information from a subject's linear and nonlinear components of adaptation is combined with the cue dependency information (from the Hursch, Hammond & Hursch equation), it can be determined _what_ a subject has learned. When task learning is experimentally controlled, it can further be determined _from whom_ the subject learned what he did.

Procedure

Forty male University of Oregon students were divided into two groups of 10 pairs of subjects. One group of 10 pairs (TL) participated in the task learning condition while the other group (IPL) participated in the interpersonal learning combined with task learning condition. All subjects were paid $1.50/hr. for 2-3 hours. Approximately one third of the participation time was required by the training stage, while the remainder was occupied by the interpersonal interaction stage.

Training

Subjects appeared in pairs. The two subjects were individually trained on tasks which required them to make judgments about the value of a criterion, Y, on the basis of the values of two cues, X_1 & X_2. A set of 60 5x8 training cards was used by each subject. On each training card were printed two bar graphs ranging in height from one to ten centimeters; these graphs represented the values of cues X_1 & X_2. The criterion value, Y, ranging from one to twenty, was printed on the back of each card.

Four different sets of training materials were used, the tasks differing on two factors -- cue-criterion correlation and cue-criterion function form or rule. The four training tasks were these (Figure 3a):

(1) X_1 linear and strongly correlated with Y, X_2 uncorrelated with Y;

(2) X_1 nonlinear and strongly correlated with Y, X_2 uncorrelated with Y;

(3) X_1 uncorrelated with Y, X_2 linear and strongly correlated with Y;

(4) X_1 uncorrelated with Y, X_2 nonlinear and strongly correlated with Y.

Which of these four training tasks a pair of subjects was trained on was determined by their assignment to one of the TL or IPL groups, to be described below. All subjects were informed of the correct criterion value on each of the 60 training trials; all subjects likewise were trained to reach a criterion at which their judgments correlated at least .75 with the cue which was strongly related with the task criterion, and not more than .25 with the cue which was uncorrelated with the task criterion. In all four training tasks the relation between the two cues and the criterion was less than perfect (R = .92), making it impossible for any subject to be correct on every trial. Training instructions informed all subjects that one of the two cues would be much more important than the other in determining the value of the criterion; subjects were also told that a certain (linear or nonlinear) rule related the cues to the criterion. The subjects' training thus consisted of determining which of the two cues was important and learning to use that cue according to the appropriate rule.

TRAINING TASKS

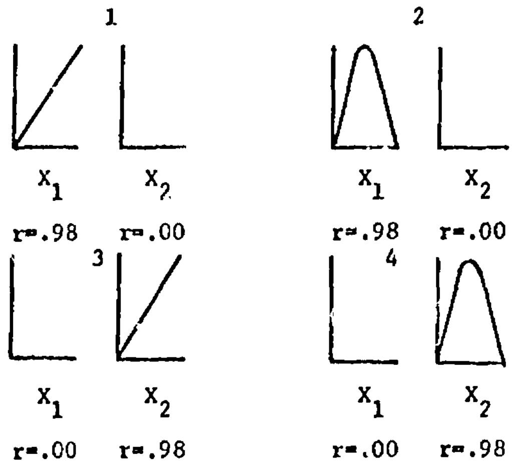

Figure 3a

INTERACTION TASKS

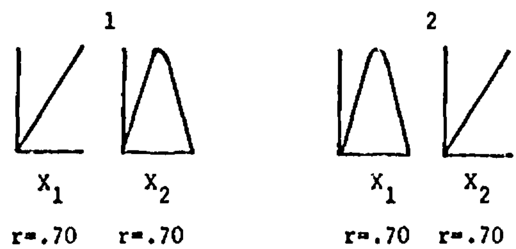

Figure 3b

Interpersonal Interaction

Upon completion of training, a pair of subjects was brought together to work both individually and jointly on an interpersonal interaction task. The joint task was similar to the training tasks, i.e., both subjects were required to make judgments about the value of a criterion, Y, on the basis of the values of two cues, X_1 & X_2. Also as in training, sets of 60 5x8 cards were used to present the cue values as bar graphs, and the correct criterion value, Y, was shown to the subjects at the end of each trial. The interaction procedure differed from the training procedure in that after both subjects had made their private individual judgments, they were required to announce these judgments to one another, to discuss between themselves any aspects of the task they wished and to agree on a joint judgment (J) which represented both their points of view. The correct answer feedback was presented immediately after the joint judgment was recorded.

Two different sets of interpersonal interaction materials were used, the tasks differing on which of the two cues was related to the criterion by a linear rule and which was related by a nonlinear rule. The two interaction tasks were these (Figure 3b): (1) X_1 linear and moderately correlated with Y, X_2 nonlinear and moderatately correlated with Y; (2) X_1 nonlinear and moderately correlated with Y, X_2 linear and moderately correlated with Y. Which of these two interaction tasks a pair of subjects confronted depended on their training and their assignment to a TL or IPL group. In both cases, three random orders of the 60 cards were used in order to minimize task sequence effect.

TL groups. There were two TL groups, a linear group (5-pairs) and a nonlinear group (5-pairs). In the linear TL group both subjects in a pair were trained on training task #1; nonlinear pairs were trained on training task #2. When linear TL pairs were brought together for the joint task, they worked on interaction task #1; nonlinear pairs worked on interaction task #2. Both linear and nonlinear TL subjects, then, worked with partners trained the same as they were, on joint tasks which differed from their training tasks in two ways: (1) The cue they were trained to use had lost validity (.98 → .70); and (2) The cue they were trained to ignore had gained validity (.00 → .70), and was related to the criterion by a new, unknown rule.

IPL groups. There were also two IPL groups, though they did not differ in an important way, as did the two TL groups. In IPL Group A (5-pairs), one subject was trained on training task #3, while the second subject was trained on training task #2; Group A pairs worked on interaction task #2. In IPL Group B (5-pairs), one subject was trained on training task #4, while the second subject was trained on training task #1; Group B pairs worked on interaction task #1. The only difference, then, between IPL Groups A & B was in the positions of the linear and nonlinear cues. Otherwise, all IPL subjects, from Groups A & B, linear and nonlinear, worked with partners trained differently from the way they were trained (different cue, different rule), on joint tasks which differed from their training tasks in the same ways as in the TL groups: (1) The cue they were trained to use had lost validity (.98 → .70); and (2) The cue they were trained to ignore had gained validity (.00 → .70), and was related to the criterion by a new, unknown rule. Subjects in the IPL groups (as opposed to the subjects in TL groups) had the opportunity to learn from their differently trained partners the significance of the newly important cue and how to use the rule relating it to the criterion.

In both interpersonal interaction tasks the two cues were uncorrelated with one another; also, as in the training tasks, the multiple correlation between the two cues and the criterion was less than perfect ($R = .92$), making it impossible for any subject to be correct on every trial. Interaction instructions informed all subjects that they were required to apply their trained judgment policies to a set of problems "based on real situations," i.e., problems different in some way from those on which they were trained. The interpersonal interaction stage thus consisted of the modification by the subjects of their trained policies on the basis of information provided by their partners and/or the tasks.

Measures of Interpersonal Learning

Interpersonal learning is measured by means of a comparison between the adaptation to the interaction task by TL subjects and the adaptation to the interaction task by IPL subjects. Any significant differences in task adaptation between the two groups of subjects can be attributed to interpersonal learning. The task adaptation of both TL and IPL subjects is measured through the use of the lens model equation, described above. Four of the lens model parameters were used in analysing task adaptation in the present study: (1) r_a -- the correlation between the subject's judgments and the criterion variable, a measure of overall task adaptation; (2) GR_eR_s -- the linear component of the subject's task adaptation; (3) $C\sqrt{1 - R_e^2}\sqrt{1 - R_s^2}$ -- the nonlinear component of the subject's task adaptation; (4) r_{s_i} -- the correlation between cue i and the subject's judgments -- a measure of cue utilization or dependency.

In addition to the lens model parameters of individual task adaptation, two measures of joint task adaptation are reported: (1) r_{J_i} -- the correlation between cue i and the joint judgments made by a pair of subjects -- a measure of joint cue dependency; (2) $|J - Y|$ -- the absolute error in joint judgment on each trial -- a response measure of joint task adaptation.

RESULTS

The results for measures of individual task adaptation are presented first, followed by the results for measures of joint task adaptation. In both cases the results focus on two main points: (1) The differences in task adaptation between task learning and interpersonal learning, including the effects of cognitive complexity on both types of learning; (2) The determination of what information is learned by one person from another, in relation to a particular interpersonal interaction task.

Individual Task Adaptation

Results on three related groups of measures of individual task adaptation were analyzed.

Subject-task Adaptation (r_a)

The correlation between a subject's judgments and the criterion variable, r_a, is a measure of overall task adaptation. r_a was computed for 6-blocks of 10-trials for each subject, and transformed to Fisher Z-scores for subsequent analyses. A 2x2x6 ANOVA with repeated measures on the third factor was used to analyze the effects of Interaction Groups (TL x IPL), Cognitive Complexity (Linear x Nonlinear) and Blocks, respectively. As is shown graphically in Figure 4, subjects in the IPL group adapted significantly better to the interpersonal interaction task than subjects in the TL group ($F_{1,36} = 4.3889$; $p < .05$; $\omega^2 = 7.81\%$). Further, Nonlinear subjects, across the

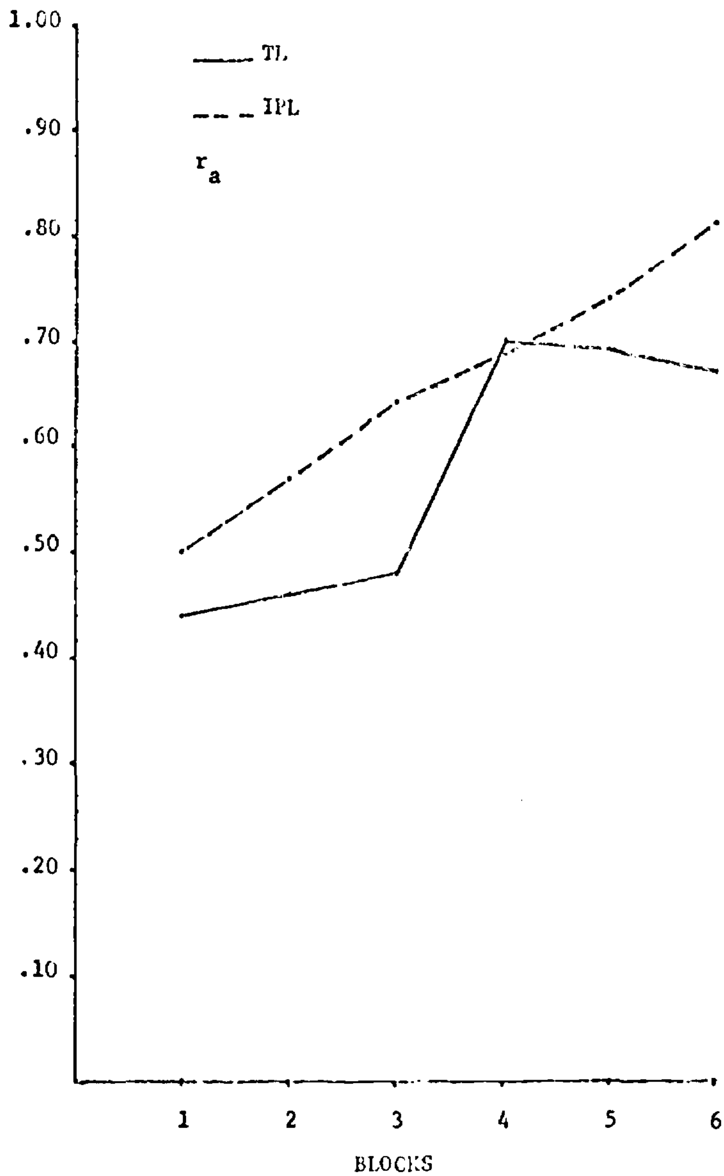

Figure 4

two Interaction groups, adapted significantly better than Linear subjects ($F_{1,36}$ = 7.4829; $p < .01$; $\hat{\omega}^2$ = 13.95%). Cognitive Complexity, however, interacted significantly with Interaction Groups ($F_{1,36}$ = 15.6436; $p < .001$; $\hat{\omega}^2$ = 26.80%). Planned comparisons between individual groups indicated that the interaction was due to the difference in adaptation between Linear and Nonlinear subjects in the TL group ($F_{1,36}$ = 22.3826; $p < .001$; $\hat{\omega}^2$ = 51.67%) (Figure 5), and the lack of such a difference in the IPL group ($F_{1,36}$ = 0.7438; $p > .25$; $\hat{\omega}^2$ = 0.00%) (Figure 6). The Linear subjects in the TL group differed from the averaged Linear and Nonlinear subjects in the IPL group ($F_{1,36}$ = 25.9667; $p < .001$; $\hat{\omega}^2$ = 45.42%), while the Nonlinear subjects in the TL group did not differ from the averaged subjects in the IPL group ($F_{1,36}$ = 1.0422; $p > .10$; $\hat{\omega}^2$ = 0.14%).

A significant Blocks effect ($F_{5,180}$ = 10.3152; $p < .001$) was further analyzed by means of linear trend analyses. There was an overall significant linear trend toward the criterion for all subjects ($F_{1,38}$ = 45.4283; $p < .001$; $\hat{\omega}^2$ = 52.62%); TL and IPL groups did not differ in linear trend ($F_{1,38}$ = 0.3020; $p > .25$; $\hat{\omega}^2$ = 0.00%). TL subjects produced a linear trend ($F_{1,18}$ = 15.0304; $p < .005$; $\hat{\omega}^2$ = 41.23%), with no difference in trend between Linear and Nonlinear subjects ($F_{1,18}$ = 0.4733; $p > .25$; $\hat{\omega}^2$ = 0.00%). The subjects in the IPL group did likewise ($F_{1,18}$ = 38.3657; $p < .001$; $\hat{\omega}^2$ = 65.44%), with a slight difference between Linear and Nonlinear subjects ($F_{1,18}$ = 3.1584; $p < .10$; $\hat{\omega}^2$ = 9.74%). Linear subjects across Interaction groups showed a linear trend ($F_{1,18}$ = 29.1410; $p < .001$; $\hat{\omega}^2$ = 58.46%), with no difference between TL and IPL groups ($F_{1,18}$ = 0.4545; $p < .25$; $\hat{\omega}^2$ =

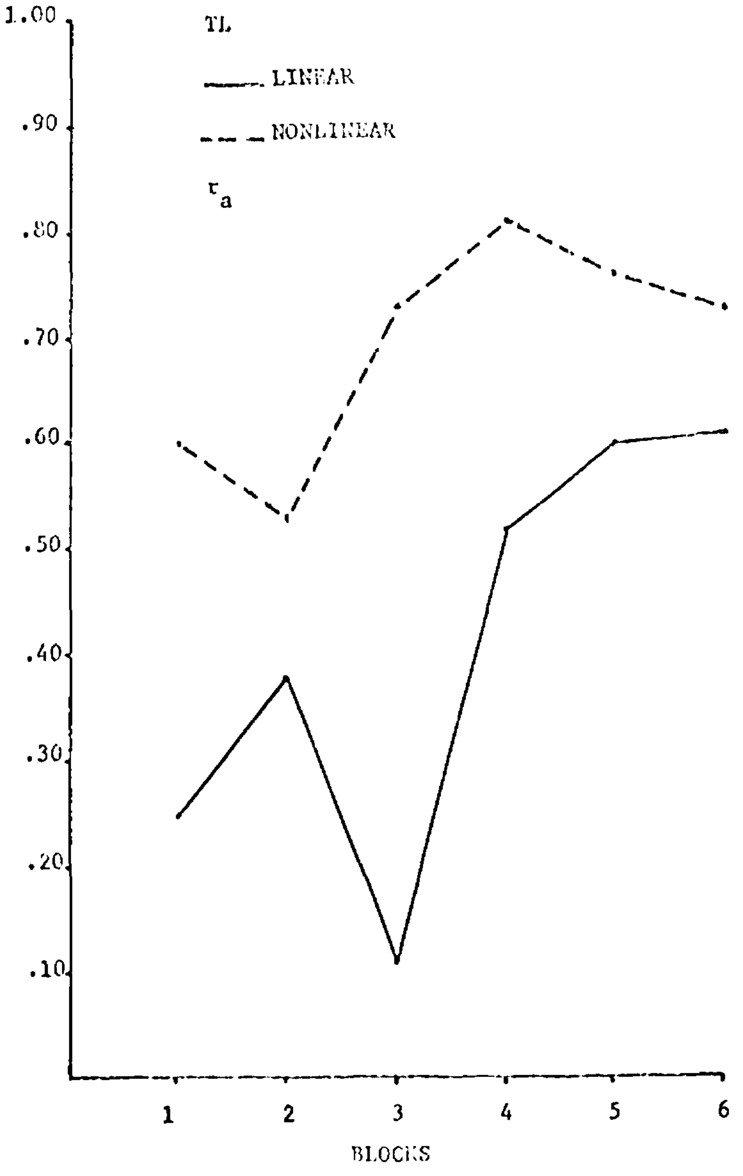
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Figure 5

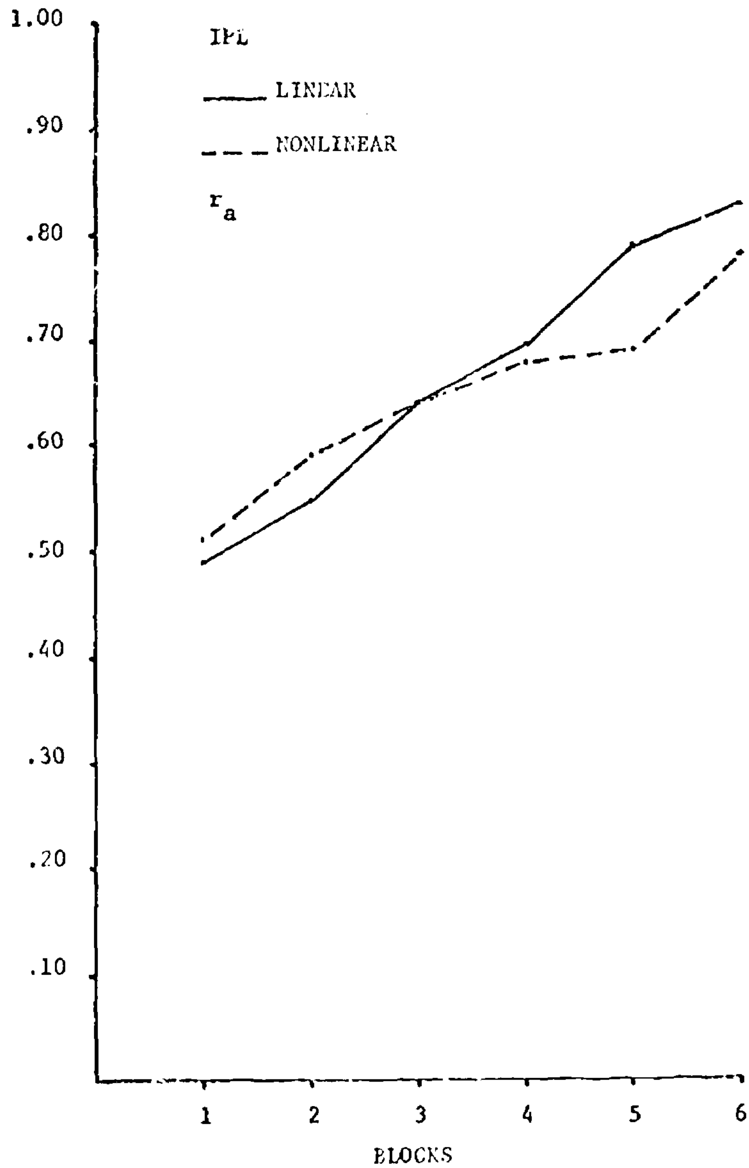

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Figure 6

0.00%). The same was true for Nonlinear subjects ($F_{1,18}$ = 16.6159; $p < .001$; ω^2 = 43.84%), ($F_{1,18}$ = 0.6748; $p > .25$; ω^2 = 0.005%). Finally, Linear subjects did not differ in linear trend from Nonlinear subjects across Interaction groups ($F_{1,38}$ = 2.6786; $p > .10$; ω^2 = 4.03%).

The main results which emerge from these analyses of overall adaptation are these: (1) All groups adapted significantly to the interpersonal interaction task; (2) The IPL group adapted significantly to better to the task than the TL group; (3) The superiority of the IPL group was due to the superiority of the Linear subjects in the IPL group over the Linear subje[illegible] in the TL group. In sum: Cognitively simple Linear subjects bene[illegible] from IPL interaction, while cognitively complex Nonlinear subjects did not. Further understanding of the interaction between Cognitive Complexity and Interaction group can be gained through the analysis of the components of adaptation.

<u>Components of Subject-task Adaptation (GR_eR_s, $C\sqrt{1 - R_e^2}\sqrt{1 - R_s^2}$</u>

In Tucker's (1964) formulation of the lens model equation, subject-task adaptation, r_a, is decomposed into linear and nonlinear components. Analyses of each of these are described in turn.

<u>Linear component (GR_eR_s).</u> The linear component of adaptation within each Interaction group was analyzed by means of a 2x6 ANOVA with repeated measures on the second factor; Cognitive Complexity and Blocks were the two factors. Within the TL and IPL groups (Figures 7 & 8), Linear subjects showed similar significantly greater linear components than Nonlinear subjects ($F_{1,18}$ = 7.5325; $p < .025$; ω^2 = 24.62%); ($F_{1,18}$ = 10.7753; $p > .001$; ω^2 = 32.83%). Linear subjects in both Interaction groups fairly well attained and maintained (except

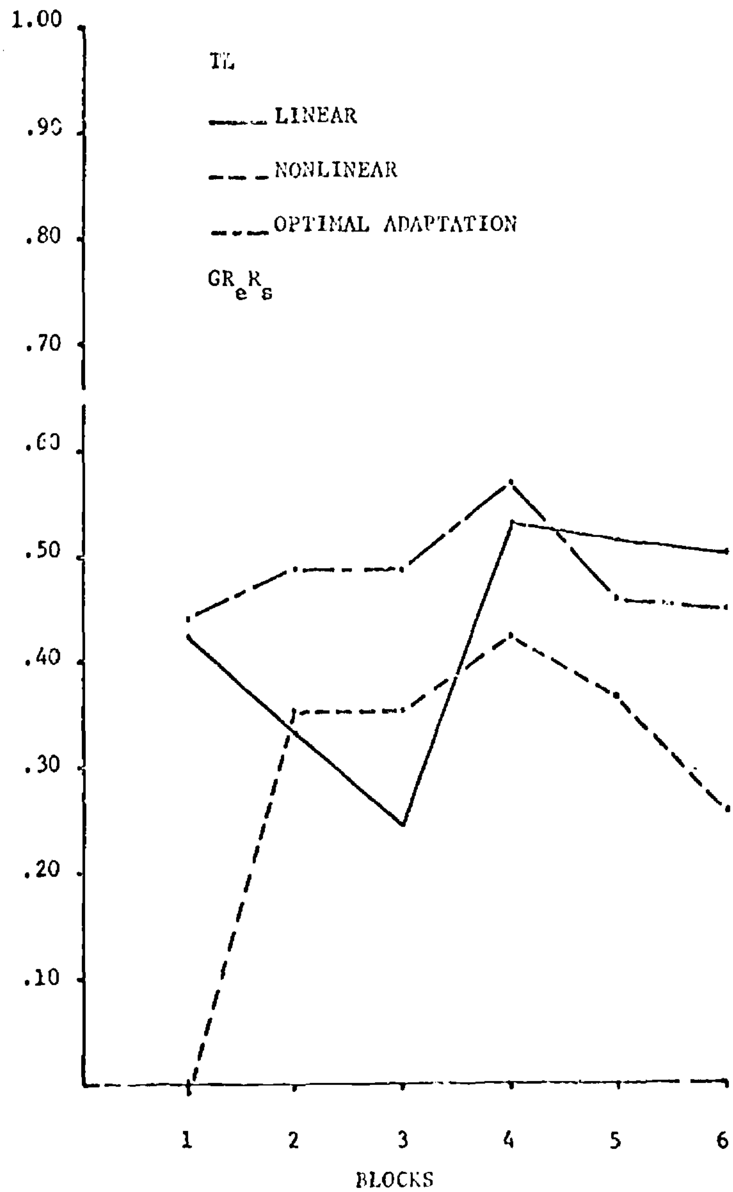
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Figure 7

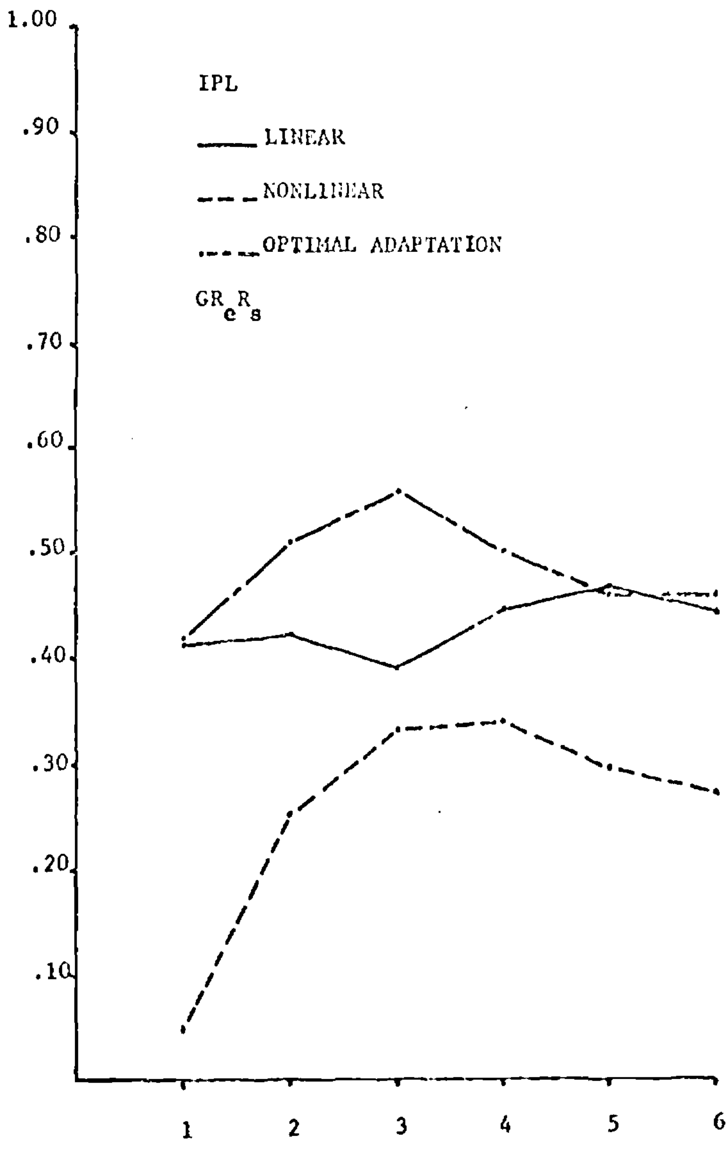
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Figure 8

for dips during the second and third blocks) near-optimal sizes of linear components. Nonlinear subjects, on the other hand, showed progressive increases in linear components (with some tailing-off at the end) in both the TL and IPL groups; significant linear trends in TL ($F = 21.4013$; $p < .005$; $\hat{\omega}^2 = 67.11\%$) and IPL groups ($F = 7.7406$; $p < .025$; $\hat{\omega}^2 = 40.26\%$) indicate that Nonlinear subjects learned to use linear components in both groups.

Nonlinear component ($C\sqrt{1 - R_{\underline{e}}^2}\sqrt{1 - R_{\underline{s}}^2}$). The analysis used with the nonlinear component was similar to that used with the linear component. Within both the TL group (Figure 9) and IPL group (Figure 10) Nonlinear subjects showed significantly greater nonlinear components than Linear subjects: ($F_{1,18} = 87.9195$; $p < .001$; $\hat{\omega}^2 = 95.50\%$) ($F_{1,18} = 5.2896$; $p < .05$; $\hat{\omega}^2 = 17.66\%$). The important result here is the difference between the $\hat{\omega}^2$ for the TL group (95.50%) and that for the IPL group (17.66%); the performance of Linear subjects relative to Nonlinear subjects was much better in the IPL group than in the TL group. The Nonlinear subjects did not maintain optimal sizes of nonlinear components as well as Linear subjects did with linear components; the magnitudes of the nonlinear components were steady, however, with no significant trends. Linear subjects in both the TL group ($F_{1,a} = 6.2220$; $p < .05$; $\hat{\omega}^2 = 34.30\%$) and the IPL group ($F_{1,a} = 12.7939$; $p < .01$; $\hat{\omega}^2 = 54.12\%$) showed significant linear trends, indicating progressive learning of nonlinear components. Note, however, that the positive slope for the Linear subjects in the TL group was a result of early negative nonlinear components; the curve

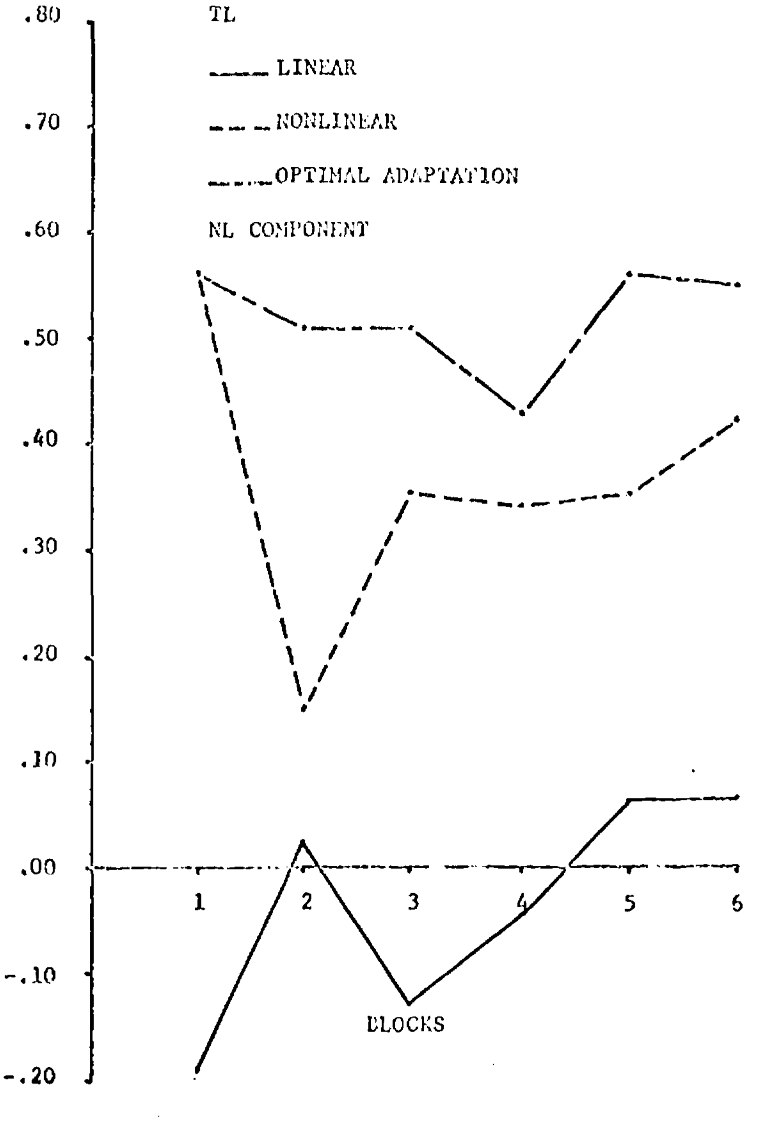
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Figure 9

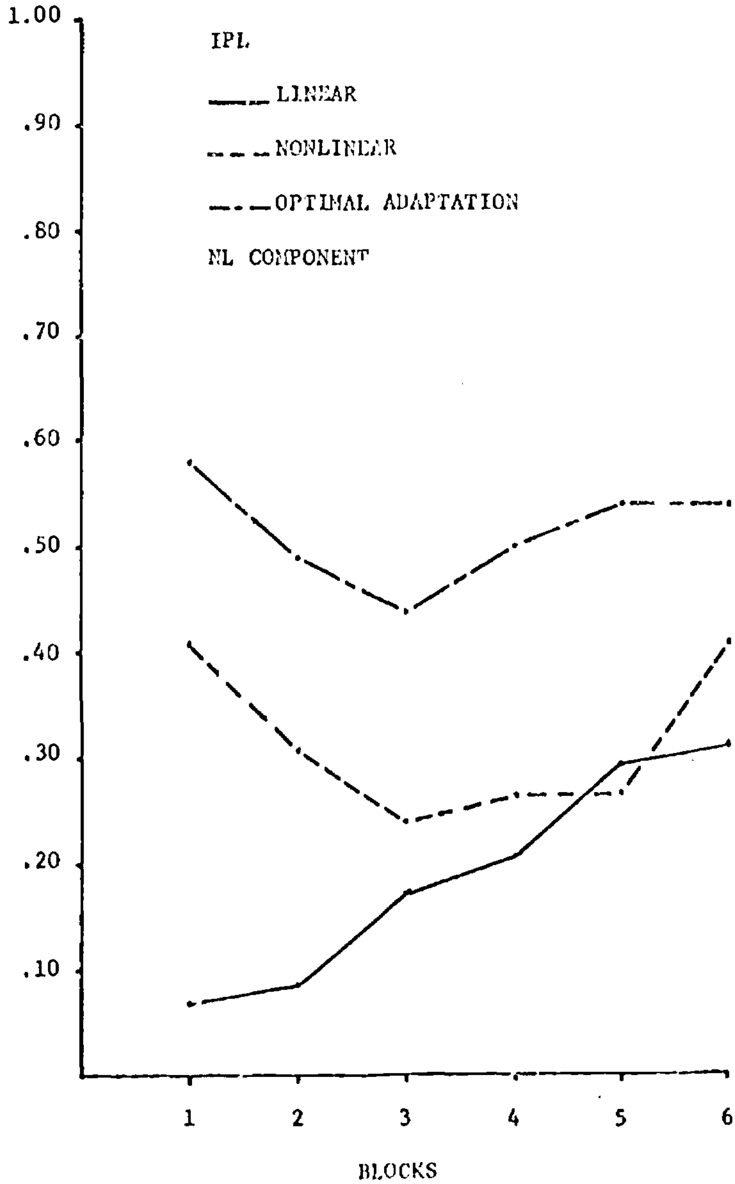
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Figure 10

never rises much above zero. In the IPL group, the magnitude of nonlinear components increased steadily and, in the end, came to match that of the Nonlinear subjects.

The above analyses of the linear and nonlinear components of adaptation provide two main results: (1) Both Linear and Nonlinear subjects maintained significant components of adaptation of the type on which they were trained; (2) Nonlinear subjects learned to use linear components in both the TL and IPL groups, while Linear subjects learned to use nonlinear components only in the IPL group. The summary result is this: Cognitively simple Linear subjects benefited from IPL interaction because it enabled them to learn to use nonlinear components; cognitively complex Nonlinear subjects did not benefit from IPL interaction because they could learn to use linear components in both the TL and IPL conditions. An examination of subject cue dependencies provides some understanding of what is involved in learning to use linear and nonlinear components of adaptation in the TL and IPL groups.

Subject Cue Dependencies (r_{s_i})

The correlation between a subject's judgments and cue i, r_{s_i}, is a measure of cue utilization or dependency. As with the subject-task adaptation correlation, r_a, r_{s_i} was computed for 6-blocks of 10-trials for each subject, and transformed to Fisher Z-scores for subsequent analyses. Since the interpersonal interaction tasks consisted of two cues, two sets of cue dependency correlations were calculated for each subject -- the correlation with the cue on which the subject was trained and the correlation with the new cue. In order to obtain detailed information concerning the rules used by subjects in relation to the two cues, the two sets of cue dependency correlations were further divided into two subsets -- the correlation with the cue used according to the rule on which the subject was trained and the correlation with the cue used according to the new rule. Four sets of subject cue dependency correlations thus resulted: (1) Trained Cue, Trained Rule (e.g., linear cue, linear rule); (2) Trained Cue, New Rule (e.g., linear cue, nonlinear rule); (3) New Cue, Trained Rule (e.g., nonlinear cue, linear rule); (4) New Cue, New Rule (e.g., nonlinear cue, nonlinear rule). The two sets of Trained Cue correlations are discussed first, followed by the two sets of New Cue correlations.

Trained Cue correlations. A 2x2x2x5 ANOVA with repeated measures on the fourth factor was used to analyze the effects of Interaction groups (TL x IPL), Rules (Trained Rule x New Rule), Cognitive Complexity (Linear x Nonlinear) and Blocks, respectively. As can be seen in Figures 11 and 12, the TL and IPL groups did not differ in level of use of the Trained Cue ($F_{1,72} = 0.2846$; $p > .25$; $\hat{\omega}^2 = 0.00\%$). There was, of course, a tremendous difference between Trained Rule and New Rule use of the Trained Cue ($F_{1,72} = 161.3531$; $p < .001$; $\hat{\omega}^2 = 66.72\%$). Cognitive Complexity had no effect on level of use of the Trained Cue across both Rule groups ($F_{1,72} = 0.7336$; $p > .25$; $\hat{\omega}^2 = 0.00\%$), but an interaction between Rule and Cognitive Complexity ($F_{1,72} = 5.7516$; $p < .025$; $\hat{\omega}^2 = 5.61\%$) resulted from the difference between Linear and Nonlinear subjects in New Rule use ($F_{1,72} = 5.2968$; $p < .025$; $\hat{\omega}^2 = 9.70\%$) and the lack of such a difference in Trained Rule use ($F_{1,72} =$

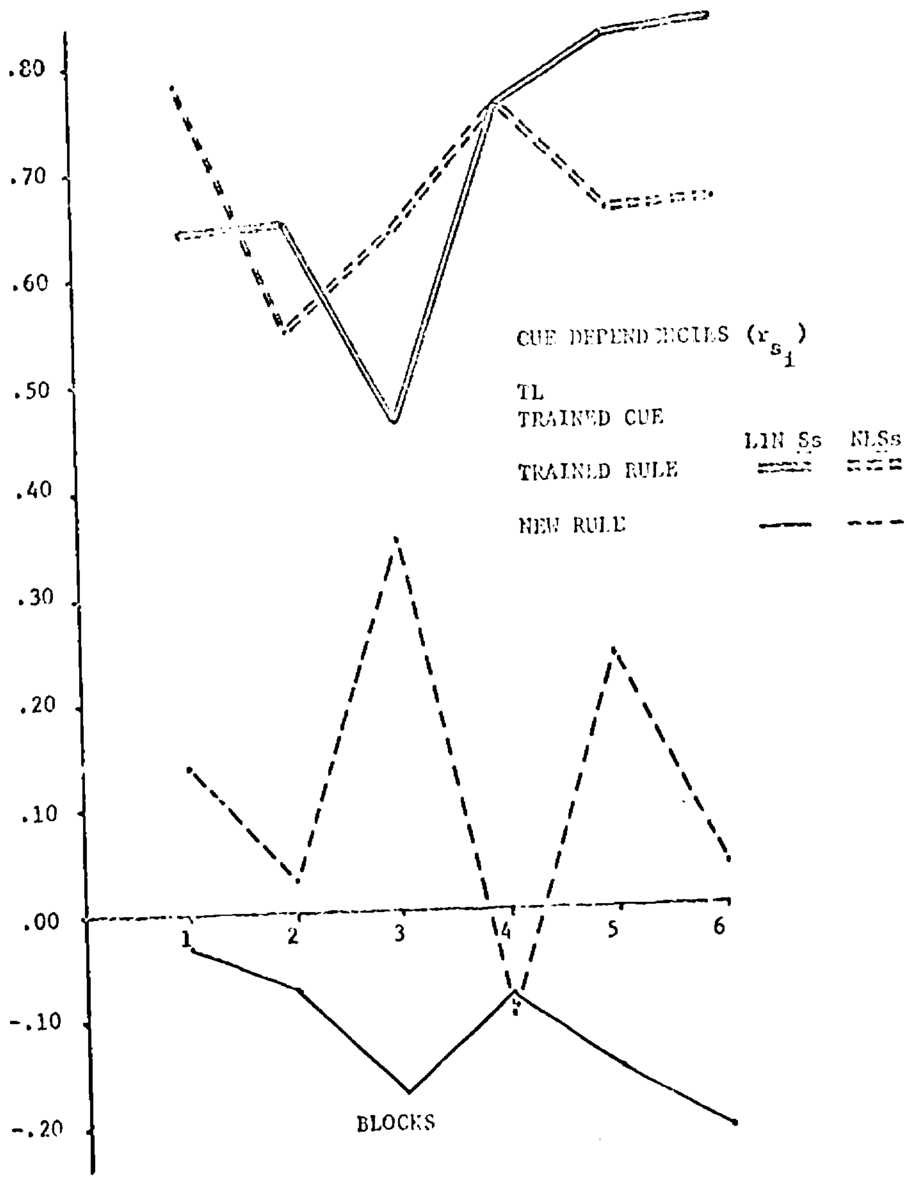

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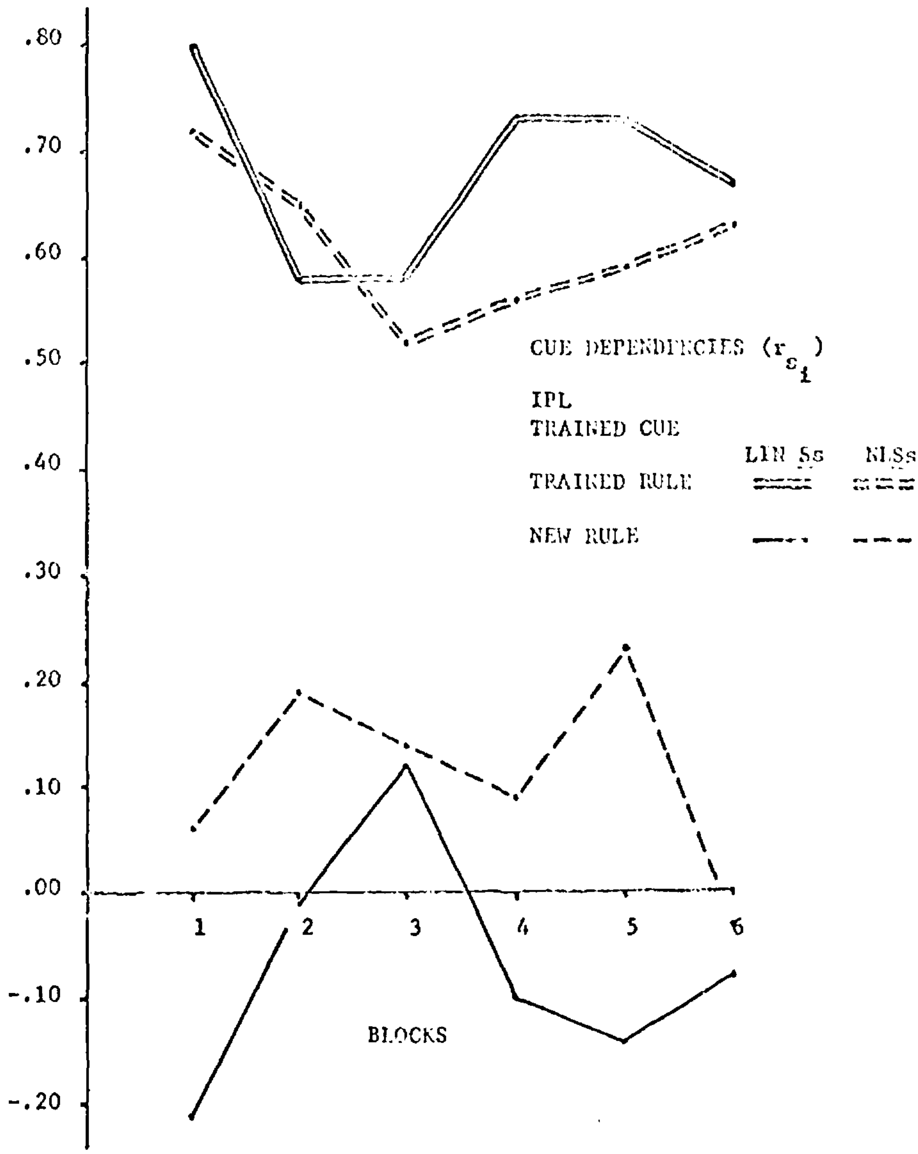
Figure 11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NEW RULE

Figure 12

1.885; $p > .25$; $\hat{\omega}^2 = 0.47\%$). (The apparent linear use of the nonlinear cue by Nonlinear subjects is due to the correlation with the linear part of the nonlinear cue, rather than true linear use of the nonlinear cue.) There was no overall Blocks effect ($F_{5,360} = 1.0085$; $p > .25$), although there was an interaction between Rules and Blocks ($F_{5,360} = 4.4115$; $p < .001$). Linear trend analyses indicated that this interaction is in part due to a slight difference in trends between Trained Rule and New Rule use in the TL group ($F_{1,38} = 3.6269$; $p < .10$; $^2 = 6.16\%$) (Linear use of linear cue by Linear subjects increases over Blocks while nonlinear use of linear cue by Linear subjects decreases). Most of the interaction, however, is due to complex changes in the forms of the curves which are not analyzed here. No other significant linear trends or differences in trends were found among the various groups.

The main results of the analyses of subject Trained Cue dependencies are these: (1) Linear and Nonlinear subjects in both the TL and IPL groups adjusted their trained dependencies on the Trained Cue (approximately .98 → approximately .70), and maintained their task-matching dependencies across blocks of trials; (2) Neither the Linear nor the Nonlinear subjects in the TL or IPL groups used the Trained Cue according to the New Rule to any significant degree. In short, all subjects correctly adjusted their trained policies according to the demands of the interaction task. But the critical policy adjustments occurred in relation to the cue which subjects were not trained to use, but had to learn to use in the interaction task. The subject New-Cue correlations are discussed next.

New Cue correlations. The analysis used with the New-Cue correlations was similar to that used with the Trained-Cue correlations. The ANOVA procedure showed that the TL group (Figure 13) and the IPL group (Figure 14) differed in level of use of the New Cue ($F_{1,72}$ = 4.8251; $p < .05$; $\hat{\omega}^2$ = 4.56%). As with the Trained-Cue correlations, there was a large difference between Trained Rule and New Rule use of the New Cue ($F_{1,72}$ = 27.7243; $p < .001$; $\hat{\omega}^2$ = 25.04%). Cognitive Complexity also affected New Cue use ($F_{1,72}$ = 18.4798; $p < .001$; $\hat{\omega}^2$ = 17.93%). These significant main effects are mitigated, however, by the fact that each of the three 2-way between-subjects interactions was significant; the single 3-way between-subjects interaction was not significant. Planned comparisons between groups were used to interpret the interactions. The interaction between Interaction Groups and Rules ($F_{1,72}$ = 4.1973; $p < .05$; $\hat{\omega}^2$ = 3.84%) (not a strong effect) was due to the difference in magnitude of the effect of Rules within the TL group ($F_{1,72}$ = 5.1731; $p < .05$; $\hat{\omega}^2$ = 9.45%) and within the IPL group ($F_{1,72}$ = 26.7489; $p < .001$; $\hat{\omega}^2$ = 39.16%). The strong interaction between Interaction Groups and Cognitive Complexity ($F_{1,72}$ = 8.8156; $p < .005$; $\hat{\omega}^2$ = 8.90%) was due to the presence of a significant effect of Cognitive Complexity within the TL group ($F_{1,72}$ = 26.4244; $p < .001$; $\hat{\omega}^2$ = 38.86%) and the absence of such an effect in the IPL group ($F_{1,72}$ = 0.8840; $p > .25$; $\hat{\omega}^2$ = 0.00%). Likewise, the interaction between Rules and Cognitive Complexity ($F_{1,72}$ = 5.5711; $p < .025$; $\hat{\omega}^2$ = 5.40%) was brought about by the lack of an effect of Cognitive Complexity within Trained Rule use ($F_{1,72}$ = 1.8788; $p > .10$; $\hat{\omega}^2$ = 2.15%) and the presence of such an effect in New Rule

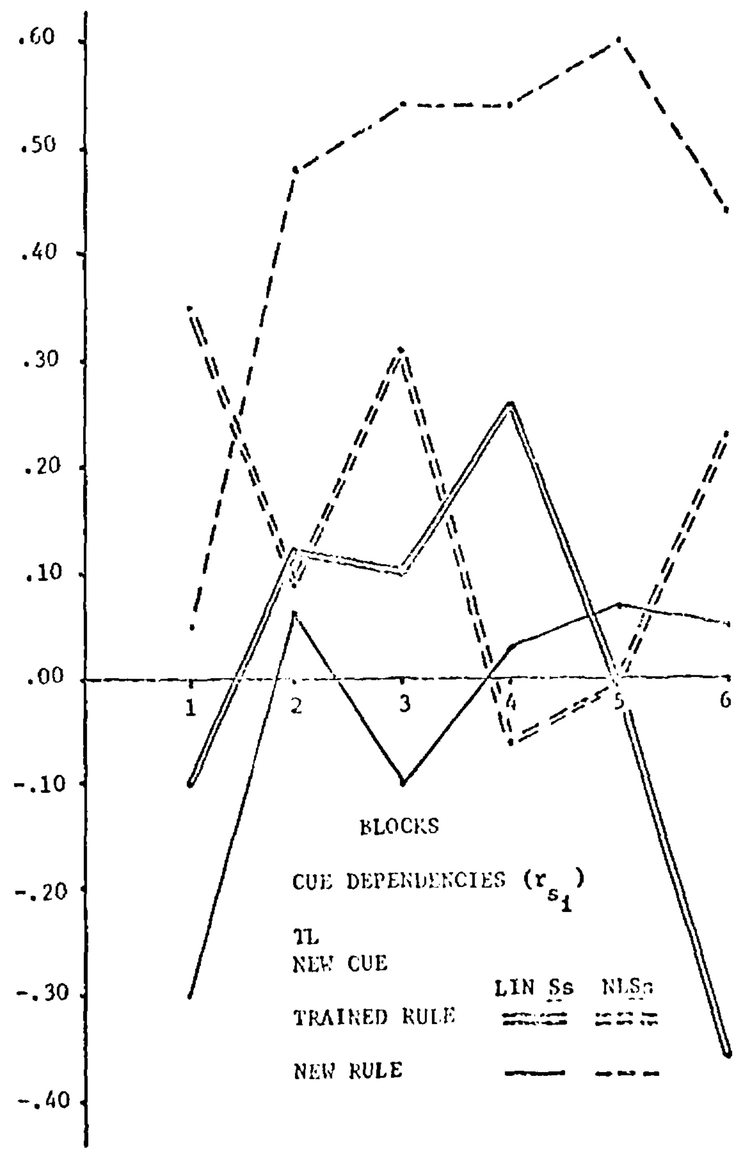
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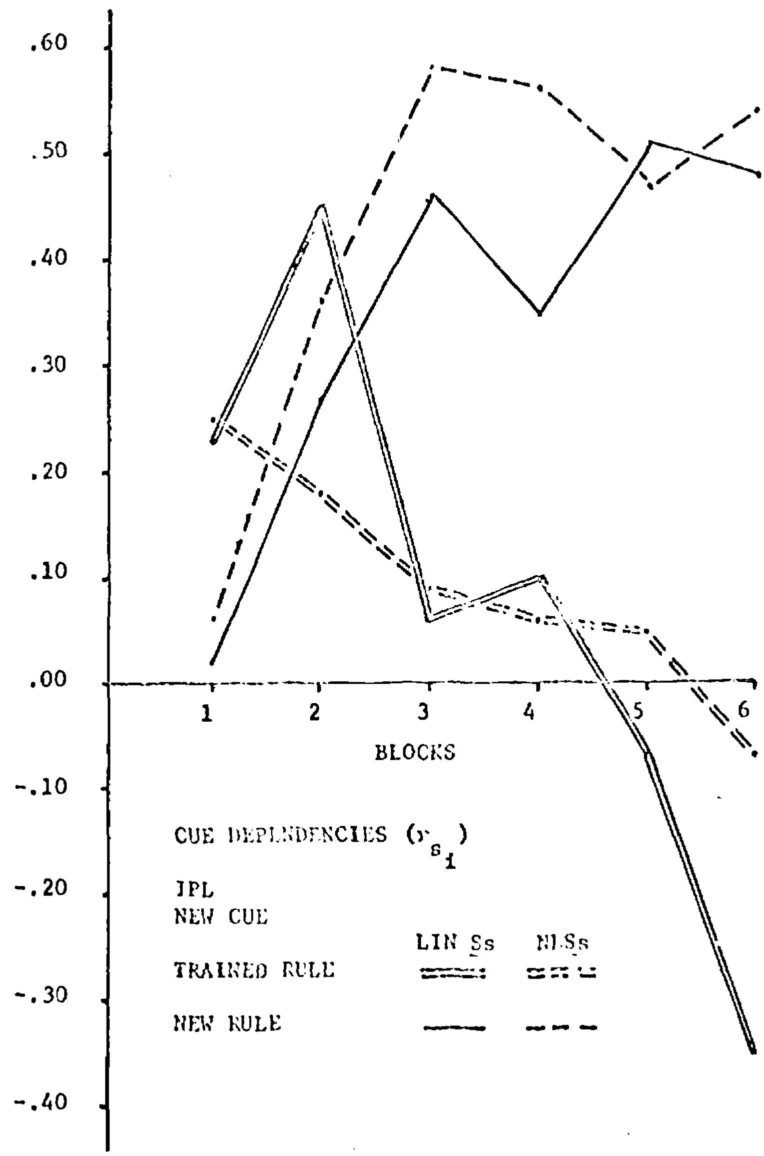
Figure 13



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TRAINED RULE
NEW RULE

Figure 14

use ($F_{1,72}$ = 22.1722; $p < .001$; $\hat{\omega}^2$ = 34.61%). As can be seen in Figures 13 and 14, all of these effects derive from the lack of nonlinear use of the nonlinear cue by the Linear subjects in the TL group.

As was the case with the between-subjects factors, a significant Blocks effect ($F_{5,360}$ = 4.2763; $p < .001$) must be interpreted in terms of the several significant interactions. There was an interaction between Rules and Blocks ($F_{5,360}$ = 4.2785; $p < .001$) caused by increased New Rule use of the New Cue as opposed to decreased Trained Rule use of the New Cue. Linear trend analyses showed that the New Rule and Trained Rule trends are significantly different in both the TL ($F_{1,38}$ = 15.1035; $p < .001$; $\hat{\omega}^2$ = 26.07%) and the IPL ($F_{1,38}$ = 44.9057; $p < .001$; $\hat{\omega}^2$ = 52.33%) groups. A weak 3-way interaction between Interaction groups, Rules and Blocks ($F_{5,30}$ = 2.2628; $p < .05$) occurred as a result of the lack of a strong linear trend for Trained Rule use in the TL group ($F_{1,18}$ = 3.2921; $p < .10$; $\hat{\omega}^2$ = 10.28%). New Rule use in the TL group had a strong positive trend ($F_{1,18}$ = 18.5618; $p < .001$; $\hat{\omega}^2$ = 46.755%), as did New Rule use in the IPL group ($F_{1,18}$ = 19.1544; $p < .001$; $\hat{\omega}^2$ = 47.58%). Trained Rule use in the IPL group showed a strong negative trend ($F_{1,18}$ = 29.4150; $p < .001$; $\hat{\omega}^2$ = 58.69%). The final interaction was 3-way, involving Rules, Cognitive Complexity, and Blocks ($F_{5,360}$ = 3.4099; $p < .005$); this interaction stemmed from the weak difference in trends between Linear and Nonlinear subjects, Trained Rule use, in the IPL group ($F_{1,18}$ = 4.3065; $p < .10$; $\hat{\omega}^2$ = 14.19%). Aside from this minor case, there were no differences in trends between Linear and Nonlinear subjects.

Two main results are derived from the analyses of New Cue correlations: (1) Linear subjects in the IPL group and Nonlinear subjects in both the TL and IPL groups learned to use the New Cue according to the New Rule, adjusting their dependencies to near-matching level after 60-trials (.00 → approximately .50); Linear subjects in the TL group did not learn to use the nonlinear cue according to the nonlinear rule. (2) Subjects in the IPL group showed steadily decreased Trained Rule use of the New Cue, while subjects in the TL group showed more erratic, though decreasing, Trained Rule use of the New Cue. In summary, all subjects _except the Linear subjects of the TL group_ correctly adjusted their trained policies and learned new policies according to the demands of the interaction task.

Summary of Individual Task Adaptation

In the analyses of overall adaptation, r_a, it was shown that, while both the TL and IPL groups adapted to the task, the IPL group adapted significantly better than the TL group. Furthermore, the greater adaptation of the IPL group was shown to be due to the greater adaptation of the Linear subjects in the IPL group relative to the Linear subjects in the TL group. Since both interpersonal learning and task learning contributed to the performance of the subjects in the IPL group, the superiority of the performance of the IPL group over the TL group (in which only task learning occurred) can be attributed to interpersonal learning -- specifically the interpersonal learning of the Linear subjects in the IPL group.

The decomposition of subject-task adaptation into linear and nonlinear components showed that Nonlinear subjects did not benefit from interpersonal learning because they were able to acquire new linear adaptation components through task learning alone, as well as through task learning combined with interpersonal learning. Linear subjects, on the other hand, required interpersonal learning in order to acquire nonlinear adaptation components. The importance of interpersonal learning relative to task learning, then, lay in the ability of simple Linear subjects to learn from complex Nonlinear subjects the use of nonlinear adaptation components.

Examination of cue dependencies provided detailed information on the cognitive functioning of the various groups of subjects -- specifically their utilization of information available in the interpersonal interaction tasks. It was shown that interpersonal learning was not necessary to the adjustment of Trained Rule use of the Trained Cue from training to interaction -- the information in the task was sufficient. Further, and more importantly, it was shown that the critical contribution of interpersonal learning was in learning to use the New Cue. Task learning alone led to more sustained and erratic Trained Rule use of the New Cue than with interpersonal learning combined with task learning. This is understandable since task learning made the job of learning the New Rule difficult; Linear subjects did not learn at all the nature of the new nonlinear rule. Linear and Nonlinear subjects in both the TL and IPL groups appreciated the importance of the New Cue (since they tried to use it according to their Trained Rules); but only Nonlinear subjects were able to learn the New Rule under task learning conditions. The new nonlinear rule remained a mysterious relation to the Linear subjects until it was verbally explained to them by their Nonlinear partners in the IPL condition.

Interpersonal learning has thus been shown to contribute importantly to the individual task adaptation of cognitively simple Linear subjects paired with cognitively complex Nonlinear subjects, in relation to an interpersonal interaction task composed of a linear and a nonlinear cue. Interpersonal learning was necessary to enable Linear subjects to learn the use of the nonlinear cue from Nonlinear subjects.

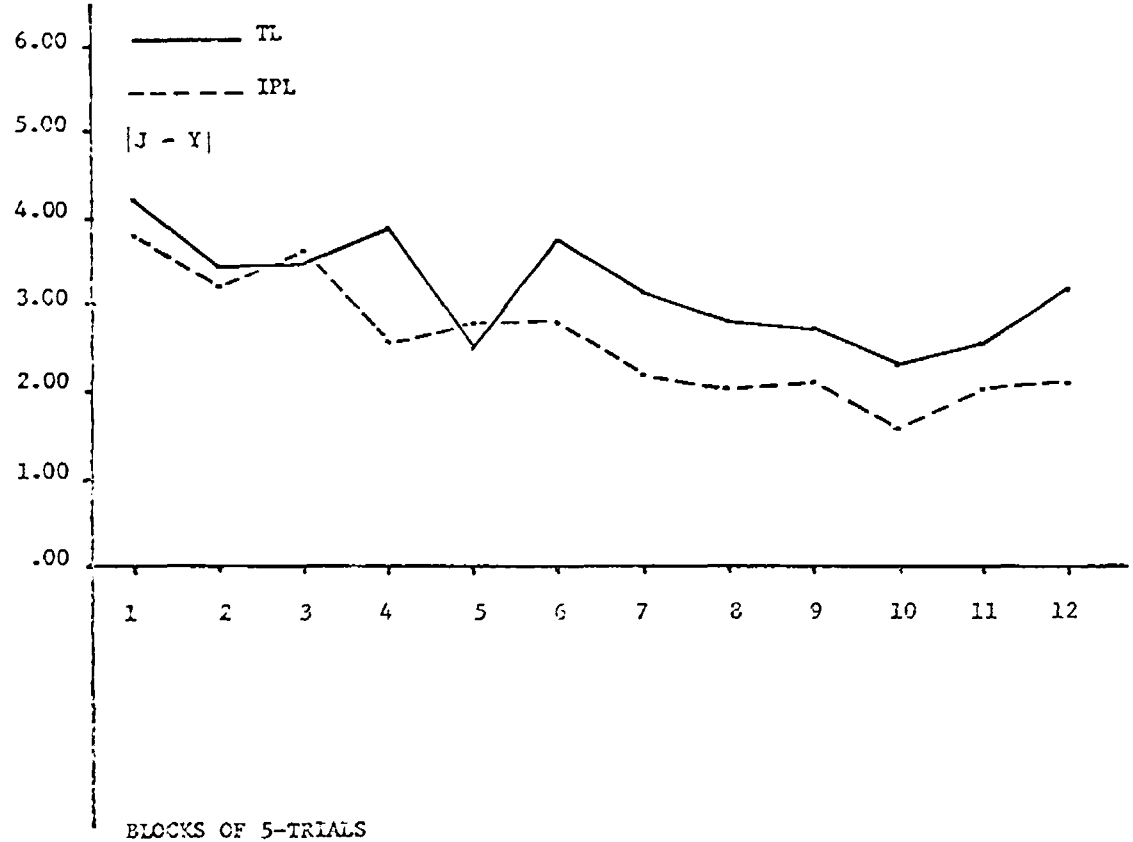
Joint Task Adaptation

After making their individual judgments a pair of subjects announced these judgments to one another, discussed their differences, and agreed on a joint judgment representative of both their points of view. The interactive effects of task learning, interpersonal learning and Cognitive Complexity on individual task adaptation have been described above. The question now is whether the individual adaptation effects carried over to joint adaptation. If joint adaptation was affected in the same way as individual adaptation, it would be expected that pairs of subjects in the IPL group would show greater joint task adaptation than pairs in the TL group; further, within the TL group the Nonlinear pairs should outperform the Linear pairs. Finally, the superior performances of the IPL group and the Nonlinear pairs within the TL group should arise from the nonuse of the nonlinear cue by Linear pairs in the TL group. The results of two measures of joint adaptation are reported -- a response measure and a correlation measure.

Joint Error ($|J - Y|$)

The joint error measure of joint adaptation is a simple response measure consisting of the absolute error of joint judgment on each trial, $|J - Y|$. Scores were averaged over 12 successive 5-trial blocks for each pair of subjects, and analyzed by means of a 2x12 ANOVA; Interaction groups (TL x IPL) and Blocks were the two factors, with repeated measures on the second. As can be seen in Figure 15, the IPL group adapted significantly better to the task than the TL group ($F_{1,18} = 5.0083$; $p < .05$; $\hat{\omega}^2 = 6.70\%$). A significant Blocks effect ($F_{11,198} = 7.3067$; $p < .001$) was further examined by means of linear trend analyses. There was an overall significant linear trend toward the criterion ($F_{1,18} = 32.8630$; $p < .001$; $\hat{\omega}^2 = 61.44\%$), and no difference between the trends for the TL and IPL groups ($F_{1,18} = 1.3054$; $p > .25$; $\hat{\omega}^2 = 1.50\%$). Taken separately, both the TL group ($F_{1,8} = 13.1616$; $p < .01$; $\hat{\omega}^2 = 54.88\%$) and the IPL group ($F_{1,9} = 18.3651$; $p < .005$; $\hat{\omega}^2 = 63.46\%$) showed strong trends toward the criterion.

Another 2x12 ANOVA was used to analyze the effects of Cognitive Complexity (Linear x Nonlinear) and Blocks within the TL group, repeated measures on the second factor. Figure 16 graphically represents the superior performance of the Nonlinear pairs within the TL group ($F_{1,8} = 10.1490$; $p < .025$; $\hat{\omega}^2 = 47.78\%$). The significant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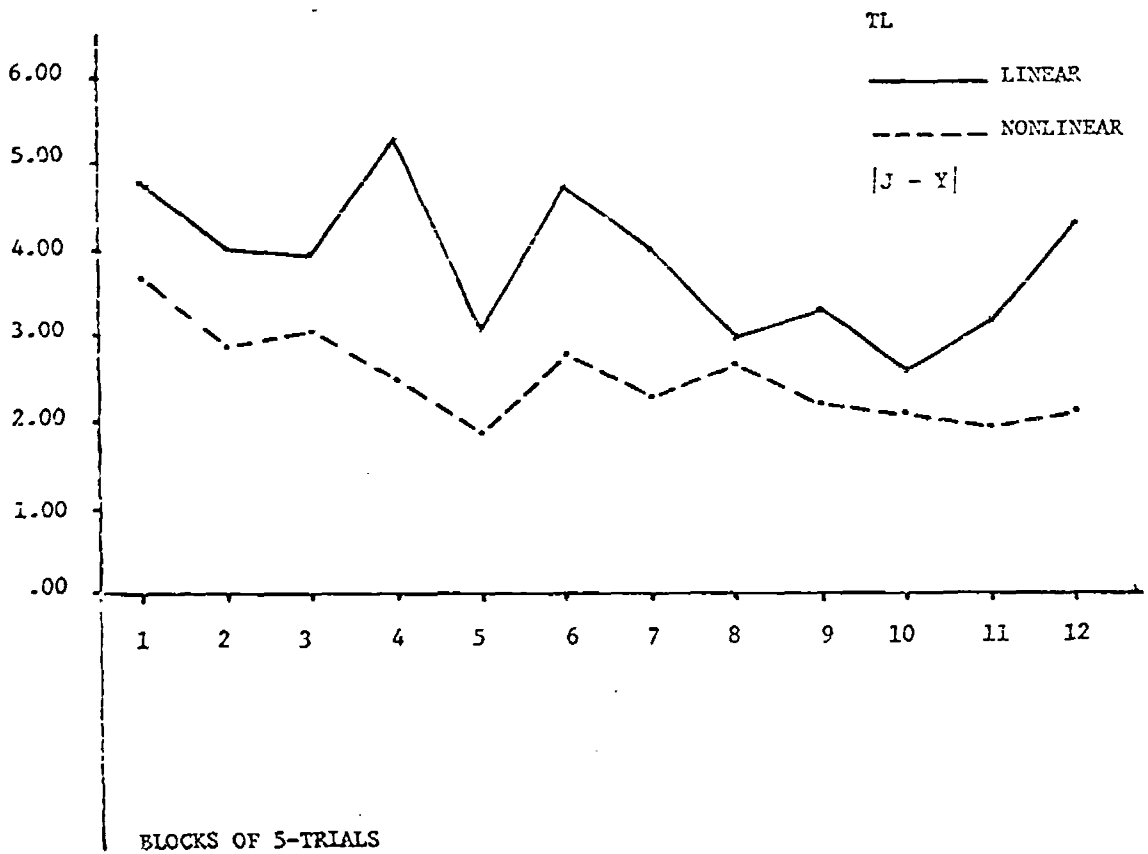
BLOCKS OF 5-TRIALS

Figure 15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BLOCKS OF 5-TRIALS

Figure 16

Blocks effect ($F_{11,198} = 7.3067$; $p < .001$) has been shown above to contain a significant linear trend. There was no difference in trends between Linear and Nonlinear pairs ($F_{1,8} = 0.0174$; $p > .25$; $\omega^2 = 0.00\%$).

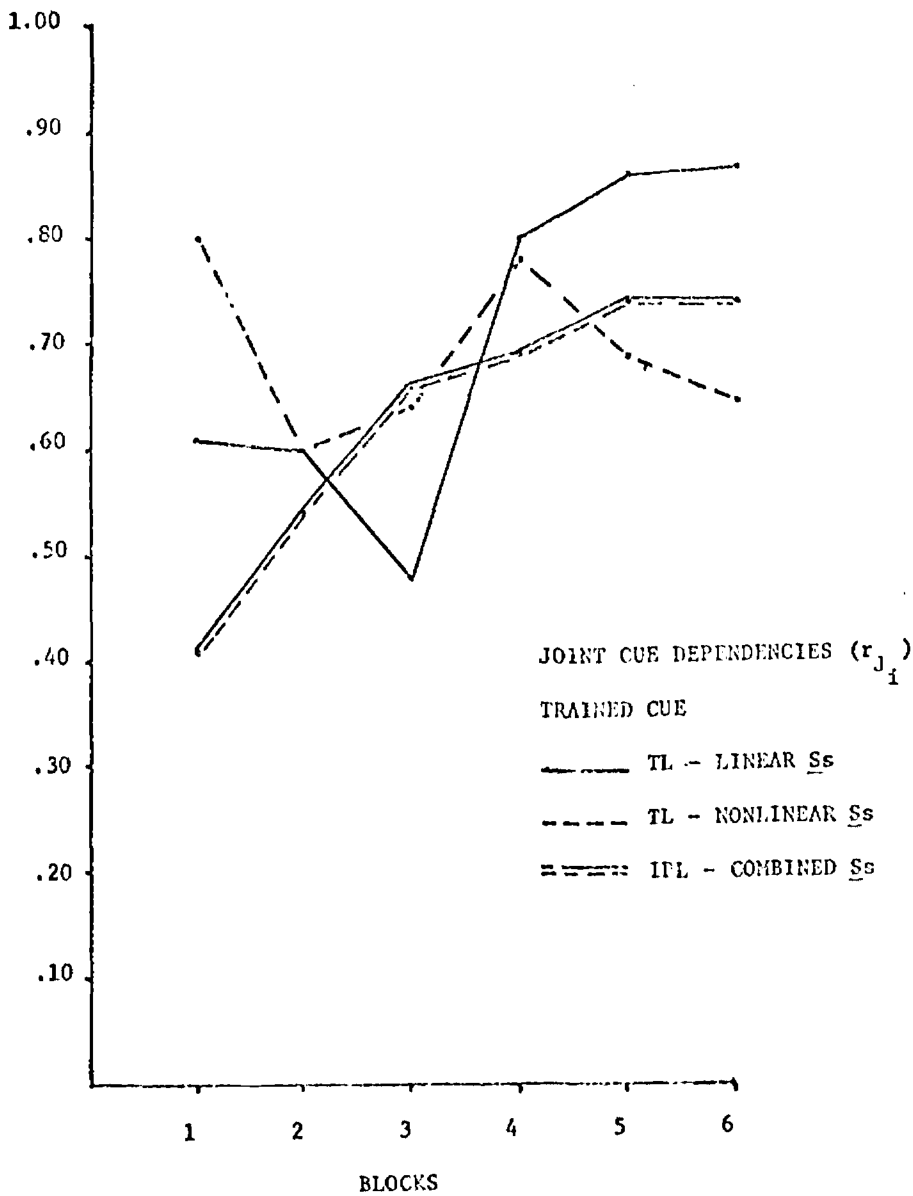
There are two main results of the joint error analyses: (1) While both the TL and IPL groups adapted significantly to the task, the IPL pairs showed significantly greater joint adaptation than the TL pairs. (2) The Nonlinear pairs in the TL group adapted significantly better to the task than the Linear pairs. Further understanding of these performance differences can be gained through analyses of the joint cue dependencies.

Joint Cue Dependencies (r_{J_i})

The correlation between a pair's joint judgments and cue i, r_{J_i}, is a measure of joint cue utilization or dependency. As with the individual subject cue dependencies, correlations were computed for 6-blocks of 10-trials for each pair. Also, two sets of correlations (transformed to Fisher Z-scores) were analyzed -- the correlation with the Trained Cue, and the correlation with the New Cue. Because the IPL group was composed of pairs consisting of one Linear subject and one Nonlinear subject, the Z-scores for these pairs were averaged over the two cues and thus are the same for the Trained Cue and the New Cue. No distinction was made between Trained Rule and New Rule in these analyses. Trained Cue correlations are considered first, followed by New Cue correlations. Cue utilization within the TL group is also examined.

Trained Cue correlations. An unequal N, 2x6 ANOVA with repeated measures on the second factor was used to assess the effects of Interaction groups (TL x IPL) and Blocks on use of the Trained Cue. As can be seen in Figure 17, the TL group used the Strong Cue significantly more than did the IPL group ($F_{1,28} = 5.6423$; $p < .025$; $\omega^2 = 13.40\%$). There was a significant Blocks effect ($F_{5,140} = 3.1958$; $p < .01$), containing a significant linear trend for the IPL group ($F_{1,19} = 10.2614$; $p < .005$; $\omega^2 = 31.65\%$) but not for the TL group ($F_{1,18} = 1.7188$; $p > .10$; $\omega^2 = 6.70\%$). The lack of a trend in the TL group is reflected in the slight difference in trends between Linear and Nonlinear pairs within the group ($F_{1,18} = 3.1841$; $p < .10$; $\omega^2 = 17.92\%$). The TL group in general, then, relied more on the Trained Cue than did the IPL group; they also used it more consistently throughout the 60-trials.

New Cue correlations. The New Cue analysis was similar to the Trained Cue analysis. Figure 18 shows the large difference in New Cue utilization between TL and IPL groups ($F_{1,28} = 12.2386$; $p < .005$; $\omega^2 = 27.25\%$). The significant Blocks effect ($F_{5,140} = 6.6974$; $p < .001$) consisted, in part, of the aforementioned IPL linear trend, and also a linear trend for the TL group ($F_{1,18} = 15.5560$; $p < .001$; $\omega^2 = 59.28\%$). There was a slight difference in trends between the Linear and Nonlinear TL pairs ($F_{1,18} = 3.0704$; $p < .10$; $\omega^2 = 17.15\%$). The IPL group clearly relied much more heavily on the New Cue than the TL group; the TL group, however, significantly increased its use of the New Cue over trials.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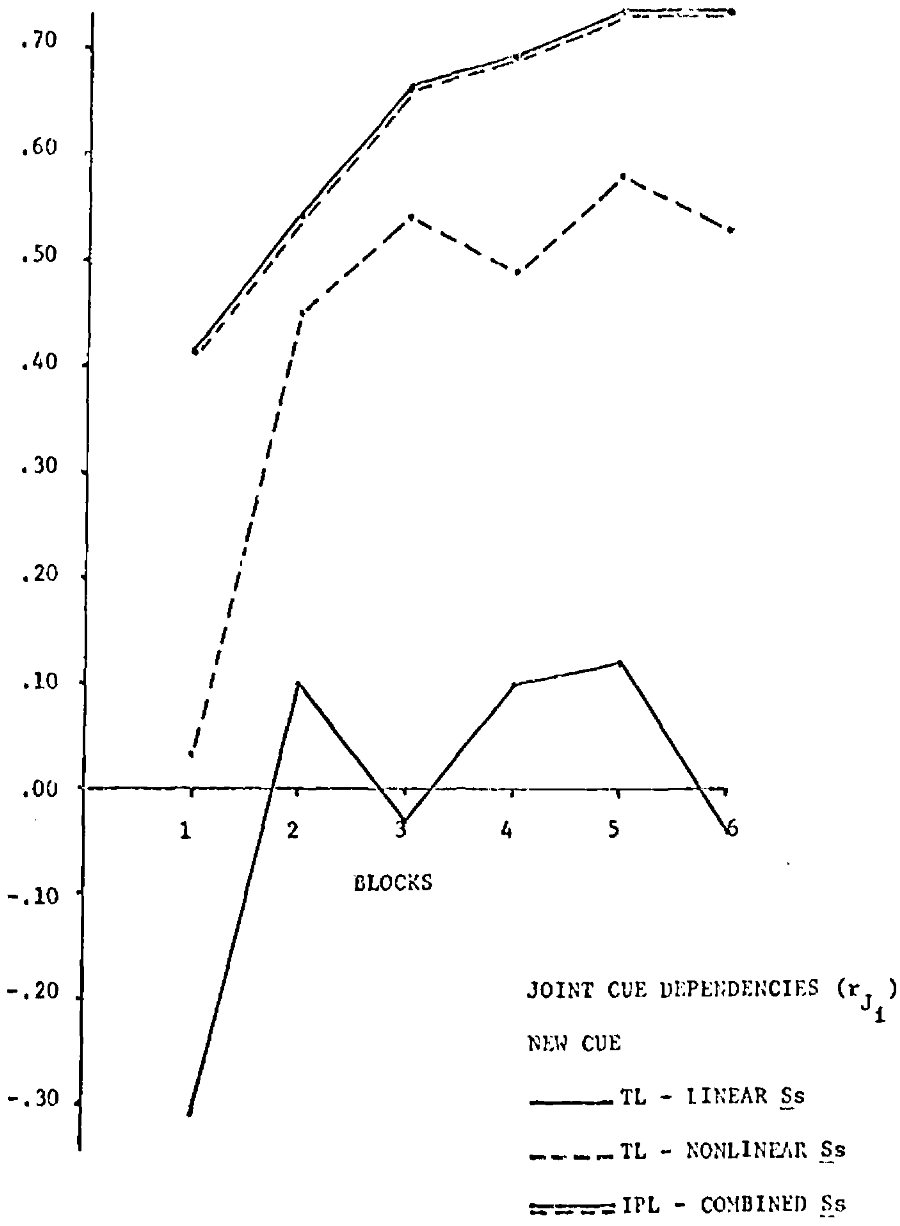
BLOCKS
JOINT CUE DEPENDENCIES (r_{J_i})
TRAINED CUE
TL - LINEAR Ss
TL - NONLINEAR Ss
IPL - COMBINED Ss

Figure 17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BLOCKS
JOINT CUE DEPENDENCIES (r_{J_i})
NEW CUE
TL - LINEAR Ss
TL - NONLINEAR Ss
IPL - COMBINED Ss

Figure 18

Within the TL group. Since the TL group was composed of pairs consisting of either two Linear subjects or two Nonlinear subjects, the joint performances of these two types of TL pairs can be compared. A 2x2x6 ANOVA with repeated measures on the third factor was used to examine the effects of Cue (Trained Cue x New Cue), Cognitive Complexity (Linear x Nonlinear) and Blocks on joint cue utilization. Figures 17 and 18 illustrate the much greater use of the Trained Cue over the New Cue ($F_{1,16} = 29.6691$; $p < .001$; $\omega^2 = 58.91\%$). There was a significant interaction between Cue and Cognitive Complexity ($F_{1,16} = 5.4492$; $p < .05$; $\omega^2 = 18.20\%$). Planned comparisons showed that the interaction was due to the lack of a difference between Linear and Nonlinear pairs in Trained Cue usage ($F_{1,16} = 0.2009$; $p > .25$; $\omega^2 = 0.00\%$) and the existence of such a difference in New Cue usage ($F_{1,16} = 7.7390$; $p < .025$; $\omega^2 = 40.26\%$). This difference in use of the New Cue -- much greater by Nonlinear pairs than by Linear pairs -- is the key effect of Cognitive Complexity on joint adaptation. A significant Blocks effect ($F_{5,80} = 3.0683$; $p < .025$) contained a significant linear trend ($F_{1,18} = 5.7074$; $p < .05$; $\omega^2 = 19.05\%$); although there was an interaction between Cues and Blocks ($F_{5,80} = 2.4750$; $p < .05$), there was no difference in trend between Trained Cue use and New Cue use ($F_{1,18} = 0.0392$; $p > .25$; $\omega^2 = 0.00\%$). (Slight differences between the trends of Linear and Nonlinear subjects have been noted above.) Within the TL group, then, the Trained Cue was utilized to a much greater extent than the New Cue. Most of this difference in cue utilization can be attributed to the nonuse of the new nonlinear cue by the Linear pairs.

Summary of Joint Task Adaptation

The joint error and joint cue dependency analyses produced the following main results: (1) The joint adaptation for the IPL pairs was significantly better than that for the TL pairs; (2) Nonlinear pairs in the TL group adapted significantly better than Linear pairs in the TL group; (3) The TL group utilized the Trained Cue somewhat more than the IPL group, while the IPL group utilized the New Cue to a much greater extent than the TL group; the latter difference was due to a great extent to the nonuse of the new nonlinear cue by the Linear pairs in the TL group. These are the effects expected from the individual task adaptation results described above. Thus the interaction between task learning, interpersonal learning and Cognitive Complexity affects both individual and joint task adaptation and constitutes the major finding of this study: Interpersonal learning aided task adaptation relative to task learning when cognitively simple (linear) subjects could learn from cognitive complex (nonlinear) subjects how to use a complex (nonlinear) component of the task.

DISCUSSION

The results are discussed first of all in relation to other empirical studies of interpersonal learning, and secondly in relation to the general methodological problems of the study of interpersonal learning.

Empirical Studies of Interpersonal Learning

The major finding of the present study -- that cognitively simple Linear subjects learned from cognitively complex Nonlinear subjects how to use complex (nonlinear) task components -- confirms the earlier findings of Miller & Hammond (1969) which showed similar effects of Cognitive Complexity on subject task adaptation. Differences in procedure between the two studies provide added weight to the comparable results. In the Miller & Hammond study, conditions analogous to the present TL condition consisted of single subjects, trained to use one of two cues, interacting with tasks consisting of two equally valid cues. One of the two cues in these tasks was the cue the subjects were trained to use and the other was the cue they were trained to ignore (or use only slightly). Thus TL subjects in the Miller & Hammond study had some prior trained knowledge of the New Cue and the New Rule -- they had been instructed in the form of the New Rule in training and had experimented in its use. TL subjects in the present study, on the other hand, worked as pairs of identically trained subjects, none of the members of which had any prior knowledge whatsoever of the New Cue or the New Rule. Similar differences exist between the IPL subjects of the two studies, except, of course, in both cases subjects worked as pairs. Further differences between studies include length of interpersonal interaction (20-trials for Miller & Hammond, 60-trials for the present study) and meaning given to cues (political meaning for Miller & Hammond, simple numerical scales for the present study).

Despite all of the above differences in procedure, then, (and, no doubt, many more) the effects of cognitive complexity were robust enough to determine the outcome of subject task adaptation in both studies. Furthermore, the present study extends these findings from individual task adaptation to joint task adaptation.

The earlier results of Earle & Miller (1969) concerning the effects of Cognitive Complexity on interpersonal learning are clarified by the present findings. The Earle & Miller study, unlike the Miller & Hammond study, contained no control for task learning -- differential interpersonal learning among treatment groups thus could not be assessed. While many of the procedural differences noted between Miller & Hammond and the present study hold for the Earle & Miller study (not including cue meaning), the strong comparability of results between the first two studies argues that inferences drawn from the present TL control condition can be applied to the Earle & Miller results. The effects of Cognitive Complexity on the present TL group were such that Linear subjects were unable to learn to use the new nonlinear rule, while Nonlinear subjects did learn to use the new linear rule; as a result, Nonlinear subjects adapted significantly better to the interpersonal interaction task than Linear subjects. In the Earle & Miller study, Nonlinear subjects, when paired with Linear subjects in an IPL condition, also adapted significantly better than their Linear partners. But in the present study, no difference was found between the adaptation of Linear and Nonlinear subjects in the IPL group. The differences between these two results can be reconciled by noting that it was shown in the present study that use of the nonlinear cue by Linear subjects in the IPL group rose rapidly during the first half of the 60 interaction trials and fluctuated with a gradual rise for the remaining 30-trials. Thus the 20-trials allowed by Earle & Miller may not have been sufficient for complete learning of the new nonlinear rule. Since it has been shown that Nonlinear subjects required no information from Linear subjects in order to learn to use the linear cue -- and they learned more rapidly than Linear subjects learned the nonlinear rule -- the adaptation of the Nonlinear subjects in the Earle & Miller IPL groups cannot be said to have been enhanced by interpersonal learning. The adaptation shown by the Linear subjects, on the other hand, while less than that of their Nonlinear partners, can nevertheless be attributed to interpersonal learning. The results of the present study indicate that, within the span of 40 additional trials, the performances of the Linear and Nonlinear subjects in the Earle & Miller study would have become equal, as the result of interpersonal learning by the Linear subjects.

The finding in the present study that it is the new nonlinear rule that is learned by Linear subjects from Nonlinear subjects in the IPL group provides a basis for understanding the interaction of Cognitive Complexity and interpersonal learning. When a pair of subjects completed individual training and came together to work on the interpersonal interaction task, each was confronted by two differences between the interaction task and his training task: (1) The cue on which he was trained no longer was the sole determiner of the level of the criterion variable -- it had lost a good deal of its validity. (2) The cue he was trained to ignore was no longer insignificant -- it had come to be a partial determiner of the criterion, and was related to the criterion in some unknown way. In order to successfully adapt to the task, then, each subject had to decrease his reliance on his Trained Cue and increase his use of the New Cue, using it according to the New Rule.

In the analyses of the Trained Cue correlations, it was shown that subjects in both the TL and IPL groups correctly adjusted their Trained Rule use of the Trained Cue, decreasing their dependencies to match the interaction task. Now the question is the recognition of the importance of the New Cue. Such recognition can take the form of either Trained or New Rule use of the New Cue. Both the TL and IPL groups initially showed they thought the New Cue was important by using it according to their Trained Rules. Trained Rule use of the New Cue declined quite rapidly in the IPL group, while being maintained at a moderate level or declining slowly in the TL group. Whether they used it according to Trained or New Rule, all subjects recognized the validity of the New Cue (Subjective cue-weightings, gathered every 10 trials from each subject and averaged over trials and subjects showed approximately equal cue weightings -- 54.7 for Trained Cue, 45.3 for New Cue -- with no difference between TL and IPL groups).

Since subjects in both the TL and IPL groups decreased their use of the Trained Cue and increased (or tried to increase) their use of the New Cue, the differences between the two groups must be due to the manner in which the New Cue was used. The analyses of the New Cue correlations showed significant New Rule use of the New Cue by Linear subjects in the IPL group and Nonlinear subjects in the TL and IPL groups. The Linear subjects in the TL group, however, did not learn to use the new nonlinear cue according to the nonlinear rule. The key effect was this: Nonlinear subjects learned, through task feedback alone, the linear rule relating the New Cue to the criterion. Linear subjects could not learn, through task feedback alone, the nonlinear rule relating the New Cue to the criterion.

But Linear subjects, with the aid of Nonlinear subjects (presumably through verbal descriptions), did learn to use the New Cue according to the nonlinear rule. This conclusion -- that verbal descriptions are very important (if not necessary) in the learning of nonlinear rules -- is consistent with several earlier studies. Both Hammond & Summers (1965) and Summers & Hammond (1966) found task instructions to be a critical factor in learning nonlinear rules -- the more explicit the instructions, the greater the use of the nonlinear rule. When no instructions concerning the use of the nonlinear rule were given, the mean cue-utilization coefficient for the nonlinear cue in a two-cue task was approximately .10 (Z), after 100 trials (Hammond & Summers, 1965)! In Summers' (1967) study of rule learning versus cue learning, it was found that in a 3-cue task containing one valid linear cue (the other 2 cues had no validity), there were no differences in task adaptation among cue learning, rule learning and complete learning groups. However, there were significant differences among cue learning, rule learning, and complete learning groups in a 3-cue task containing one valid nonlinear cue: Subjects who had to learn either both the relevant cue and the nonlinear rule (complete learning) or just the nonlinear rule (rule learning) adapted significantly less well than subjects who had only to learn the relevant cue (cue learning). Finally, in a more recent study (Summers, Taliaferro, & Fletcher, 1969), verbal descriptions significantly enhanced the ability of subjects to learn nonlinear aspects of target judgment policies. Subjects not provided with verbal descriptions of the nonlinear components of judgment policies were not able to utilize these components.

In discussing his findings concerning the difficulty of learning to use nonlinear rules, Summers (1967) reasoned that the difficulty lay in the "potentially unlimited number of possible cue-criterion rules." Similarly, Summers, Taliaferro, and Fletcher (1960) pointed out that ". . . if an individual believed that either a high or low level of foreign aid retarded growth, while a 'moderate' level promoted it, this use of the foreign aid dimension would not be reflected in a linear regression model (another information condition). On the other hand, such a use of the foreign aid dimension could readily be transmitted in a verbal description of one's policy." In view of the findings cited here, as well as the Miller & Hammond results discussed earlier, it seems clear that the key to the learning of nonlinear rules lies in some description -- verbal or otherwise -- of the form of the relation between cue and criterion. Without such a description a subject has only three alternatives when faced with a new nonlinear cue: (1) He can assume that it is linear and use it that way (as did the Linear subjects in the present study). (2) After discovering that the relation is not positively linear, he can reverse his rule and try a negative linear relation. (3) Having no luck with the first two alternatives he may try some sort of nonlinear relation; more likely he will assume the cue is not related to the criterion in any way and become very irritated with such an arbitrary, pointless task (not an uncommon response among Linear subjects in the TL group).

In summary, the present findings on the interaction of Cognitive Complexity and interpersonal learning are very simple: It has been shown that cognitively simple subjects can learn from cognitively complex subjects complex information which they could not learn from the correct answer feedback of the task. Some of the methodological implications of these findings are discussed below.

The Methodology of the Study of Interpersonal Learning

In the introduction to this study it was argued that the logic of the study of interpersonal learning required a method which could (1) Assess the effects of an independent variable on task learning; and (2) Assess the effects of the same independent variable on task learning combined with interpersonal learning. With task adaptation as the dependent variable, differences between the two groups could be attributed to the effects of interpersonal learning. In the methods section it was shown that the lens model paradigm for the study of interpersonal learning fulfills the requirements stated above. Finally, the results of the interpersonal learning study reported here demonstrate the usefulness of the lens model paradigm in the study of interpersonal learning. Not only can the lens model method show the occurrence of interpersonal learning, the parameters of the lens model indicate precisely who learned what from whom. It is important to note that within the lens model paradigm the learning and use of _any_ form or degree of cue-criterion relation can be studied. Thus, the present study represents only a tentative step towards the understanding of the effects of Cognitive Complexity (both quantitative -- number of cues, and qualitative -- rule nonlinearity) on interpersonal learning which could be achieved through the use of the lens model paradigm (see Björkman, 1969, for general discussion of the importance of the lens model paradigm).

Despite the demonstrated utility of the lens model paradigm in the study of interpersonal learning, at least one important methodological problem remains open: Brehmer (1969) has correctly pointed out that if two subjects in an IPL condition decide to adapt to the task, the cognitive conflict (differences in cue utilization) between them will be reduced. If, on the other hand, they decide to adapt to each other (i.e., to reduce conflict), they will also adapt to the task. Adaptation to the task and reduction of cognitive conflict are thus confounded. But what is involved in the reduction of cognitive conflict? Precisely the same process as is involved in task adaptation -- i.e., the learning from the other person the rule he utilizes in processing information from the cue on which he was trained.

Without such interpersonal learning the reduction of cognitive conflict would not be possible (assuming a complex rule is involved -- i.e., one that cannot be learned from task feedback alone).

So, the situation concerning the confounding of task adaptation and the reduction of cognitive conflict is not as critical as it first would appear. Still, some experimental or analytical disentanglement of the two factors may prove beneficial to the understanding of both. Brehmer (1969), for instance, suggests the analytical partialing out of conflict from task effects. The details of this procedure (if at all feasible) have not as yet been worked out.

FOOTNOTES

[1]Portions of this work were presented at the meetings of the Western Psychological Association, Los Angeles, April, 1970.

[2]The author gratefully acknowledges the contributions of Kenneth R. Hammond and his associates at the Institute of Behavioral Science, University of Colorado, Boulder. Paul Slovic and Robyn Dawes of the Oregon Research Institute provided invaluable support and assistance.

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207 West Summer Street
New York, New York 10011

3 Commanding Officer
Naval Personnel & Training Research Lab.
San Diego, California 92152

1 Office of Naval Research Area Office
1076 Mission Street
San Francisco, California 94103

6 Director
Naval Research Laboratory
Washington, D. C. 20390
Attn: Technical Information Division

20 Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, Virginia 22314

1 Superintendent
Naval Postgraduate School
Monterey, California 93940
Attn: Code 2124

1 Head, Psychology Branch
Neuropsychiatric Service
U.S. Naval Hospital
Oakland, California 94627

1 Head
Human Factors Engineering Branch (5342)
Naval Missile Center
Box 15
Point Mugu, California 93041

1 Commanding Officer
Service School Command
U.S. Naval Training Center
San Diego, California 92133

1 Officer in Charge
Naval Medical Neuropsychiatric
Research Unit
San Diego, California 92152

1 U.S. Naval Submarine Medical Center
Post Office Box 600
Naval Submarine Base
Groton, Connecticut 06340
Attn: Dr. B. B. Weybrew

1 Commanding Officer
Naval Air Technical Training Center
Jacksonville, Florida 32213

1 Dr. James J. Regan
Naval Training Device Center
Orlando, Florida 32813

1 Chief, Aviation Psychology Division
Naval Aerospace Medical Institute
Naval Aerospace Medical Center
Pensacola, Florida 32512

1 Chief, Naval Air Reserve Training
Naval Air Station
Box 1
Glenview, Illinois 60026

1 Technical Library
U. S. Naval Weapons Laboratory
Dahlgren, Virginia 22448

1 Research and Evaluation Department
U.S. Naval Examining Center
Building 2711 - Green Bay Area
Great Lakes, Illinois 60088

1 Chairman
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Naval Sciences Department
U.S. Naval Academy
Annapolis, Maryland 21402

1 Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps (Code AX)
Washington, D. C. 20380

1 Technical Services Division
National Library of Medicine
8600 Rockville Pike
Bethesda, Maryland 20014

1 Behavioral Sciences Department
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Commanding Officer
Naval Medical Field Research Laboratory
Camp Lejeune, North Carolina 28542

1 Director
Aerospace Crew Equipment Department
Naval Air Development Center, Johnsville
Warminster, Pennsylvania 18974

1 Chief, Naval Air Technical Training
Naval Air Station
Memphis, Tennessee 38115

1 Mr. Joseph B. Blankenheim
NAVELEX 0474
Munitions Building, Rm. 3721
Washington, D. C. 20360

1 Commander
Operational Test & Evaluation Force
U. S. Naval Base
Norfolk, Virginia 23511

1 Office of Civilian Manpower Management
Department of the Navy
Washington, D. C. 20350
Attn: Code 023

1 Chief of Naval Operations, Op-07TL
Department of the Navy
Washington, D. C. 20350

1 Chief of Naval Material (MAT 031M)
Room 1323, Main Navy Building
Washington, D. C. 20360

1 Naval Ship Systems Command, Code 03H
Department of the Navy
Main Navy Building
Washington, D. C. 20360

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Bureau of Medicine and Surgery
Code 513
Washington, D. C. 20390

1 Chief
Bureau of Medicine and Surgery
Research Division (Code 713)
Department of the Navy
Washington, D. C. 20390

9 Technical Library
Bureau of Naval Personnel (Pers-11b)
Department of the Navy
Washington, D. C. 20370

3 Director
Personnel Research & Development Lab.
Washington Navy Yard, Building 200
Washington, D. C. 20390

1 Commander, Naval Air Systems Command
Navy Department, AIR-4133
Washington, D. C. 20360

1 Commandant of the Marine Corps
Headquarters, U. S. Marine Corps
Code A01B
Washington, D. C. 20380

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Orlando, Florida 32813

1 Technical Library
Naval Ship Systems Command
Main Navy Building, Rm. 1532
Washington, D. C. 20360

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Technical Library
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1 Library, Code 0212
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National Naval Medical Center
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Naval Ordnance Station
Louisville, Kentucky 40214

1 Library
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San Diego, California 92152

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Naval Undersea Warfare Center
3202 E. Foothill Boulevard
Pasadena, California 91107

1 Scientific Advisory Team (Code 71)
Staff, COMASWFORLANT
Norfolk, Virginia 23511

ARMY

1 Human Resources Research Office
Division #6, Aviation
Post Office Box 428
Fort Rucker, Alabama 36360

1 Human Resources Research Office
Division #3, Recruit Training
Post Office Box 5787
Presidio of Monterey, California 93940
Attn: Library

1 Human Resources Research Office
Division #4, Infantry
Post Office Box 2086
Fort Benning, Georgia 31905

1 Department of the Army
U. S. Army Adjutant General School
Fort Benjamin Harrison, Indiana 46216
Attn: AGCS-EA

1 Director of Research
U. S. Army Armor Human Research Unit
Fort Knox, Kentucky 40121
Attn: Library

1 Research Analysis Corporation
McLean, Virginia 22101
Attn: Library

1 Behavioral Sciences Laboratory
Army Research Institute of
Environmental Medicine
Natick, Massachusetts 01760

1 Human Resources Research Office
Division #5, Air Defense
Post Office Box 6021
Fort Bliss, Texas 79916

1 Center for Research in Social Systems
The American University
5010 Wisconsin Avenue, N. W.
Washington, D. C. 20016
Attn: ISB

1 Human Resources Research Office
Division #1, Systems Operations
300 North Washington Street
Alexandria, Virginia 22314

1 Armed Forces Staff College
Norfolk, Virginia 23511
Attn: Library

1 Commanding General
U. S. Army Medical Research and
Development Command
Washington, D. C. 20315
Attn: MEDDH-SI

1 U. S. Army Behavioral Science
Research Laboratory
Washington, D. C. 20315

1 Walter Reed Army Institute of Research
Walter Reed Army Medical Center
Washington, D. C. 20012

1 Behavioral Sciences Division
Office of Chief of Research and
Development
Department of the Army
Washington, D. C. 20310

AIR FORCE

1 Director
Air University Library
Maxwell Air Force Base
Alabama 36112
Attn: AUL-8110

1 Headquarters, ESD
ESVPT
L. G. Hanscom Field
Bedford, Massachusetts 01731
Attn: Dr. Mayer

1 AFHRL (HRT/Dr. G. A. Eckstrand)
Wright-Patterson Air Force Base
Ohio 45433

1 Commandant
U. S. Air Force School of Aerospace Medicine
Brooks Air Force Base, Texas 78235
Attn: Aeromedical Library (SMSDL)

1 6570th Personnel Research Laboratory
Aerospace Medical Division
Lackland Air Force Base
San Antonio, Texas 78236

1 AFOSR (SRLB)
1400 Wilson Boulevard
Arlington, Virginia 22209

1 Research Psychologist
SCBB, Headquarters
Air Force Systems Command
Andrews Air Force Base
Washington, D. C. 20331

1 Headquarters, U. S. Air Force Base
Chief, Analysis Division (AFPDPL)
Washington, D. C. 20330

MISCELLANEOUS

1 Dr. Alvin E. Goins, Executive Secretary
Personality & Cognition Research Review Committee
Behavioral Sciences Research Branch
National Institute of Mental Health
5454 Wisconsin Avenue, Room 10A11
Chevy Chase, Maryland 20203

1 Dr. Mats Bjorkman
University of Umea
Department of Psychology
Umea 6, Sweden

1 Technical Information Exchange
Center for Computer Sciences and Technology
National Bureau of Standards
Washington, D. C. 20234

1 Director
Defense Atomic Support Agency
Washington, D. C. 20305
Attn: Technical Library

2 Executive Secretariat
Interagency Committee on Manpower Research
Room 515
1738 "M" Street, N. W.
Washington, D. C. 20036
Attn: Mrs. Ruth Relyea

1 Mr. Joseph J. Cowan
Chief, Personnel Research Branch
U. S. Coast Guard Headquarters
PO-1, Station 3-12
1300 "E" Street, N. W.
Washington, D. C. 20226

1 Executive Officer
American Psychological Association
1200 Seventeenth Street, N. W.
Washington, D. C. 20036

1 Dr. Bernard M. Bass
University of Rochester
Management Research Center
Rochester, New York 14604

1 Dr. Lee R. Beach
Department of Psychology
University of Washington
Seattle, Washington 98105

1 Educational Testing Service
Division of Psychological Studies
Rosedale Road
Princeton, New Jersey 08540

1 Dr. Edward R. F. W. Crossman
Department of Industrial Engineering
University of California, Berkeley
Berkeley, California 94720

1 Dr. Robert Dubin
Graduate School of Administration
University of California
Irvine, California 02650

1 Dr. Philip H DuBois
Department of Psychology
Washington University
Lindell & Skinker Boulevards
St. Louis, Missouri 63130

1 Dr. Marvin D. Dunnette
208 Psychology Building
University of Minnesota
College of Liberal Arts
Minneapolis, Minnesota 55455

1 Dr. Harold A. Edgerton
Performance Research, Inc.
919 - 18th Street, N.W./Suite 425
Washington, D. C. 20036

1 Dr. Robert Glaser
Learning Research & Development Center
University of Pittsburgh
Pittsburgh, Pennsylvania 14213

1 Dr. Albert S. Glickman
American Institutes for Research
8555 Sixteenth Street
Silver Spring, Maryland 20910

1 Dr. Bert Green
Department of Psychology
Johns Hopkins University
Baltimore, Maryland 21218

1 Dr. Lloyd G. Humphreys
Department of Psychology
University of Illinois
Urbana, Illinois 61801

1 Dr. Frederic M. Lord
Educational Testing Service
20 Nassau Street
Princeton, New Jersey 08540

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Park
Goleta, California 93107

1 Mr. Edward McCrensky, Chief
Personnel Administration Section
Public Administration Branch
Department of Social & Economic Affairs
United Nations
New York, New York 10017

1 Dr. Stanley M. Nealey
Department of Psychology
Colorado State University
Fort Collins, Colorado 80521

1 Dr. Gabriel D. Ofiesh
Center for Educational Technology
Catholic University
4001 Harewood Road, N.E.
Washington, D. C. 20017

1 Dr. Joseph W. Rigney
Behavioral Technology Laboratories
University of Southern California
University Park
Los Angeles, California 90007

1 Dr. George E. Rowland
Rowland & Company, Inc.
P. O. Box 61
Haddonfield, New Jersey 08033

1 Dr. J. P. Guilford
University of Southern California
3551 University Avenue
Los Angeles, California 90007

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

1 Dr. Paul Slovic
Oregon Research Institute
P. O. Box 3196
Eugene, Oregon 97403

1 Dr. Ledyard R. Tucker
Department of Psychology
University of Illinois
Urbana, Illinois 61801

1 Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

1 Dr. Lee J. Cronbach
School of Education
Stanford University
Stanford, California 94305

1 Dr. John C. Flanagan
Applied Institutes for Research
P. O. Box 1113
Palo Alto, California 94302

1 Dr. M. D. Havron
Human Sciences Research, Inc.
Westgate Industrial Park
7710 Old Springhouse Road
McLean, Virginia 22101

1 Dr. Roger A. Kaufman
Department of Education
Institute of Instructional System Technology & Research
Chapman College
Orange, California 92666

1 LT COL F.R. Ratliff
Office of the Assistant Secretary of Defense (M&RU)
Room 3D960, The Pentagon
Washington, D. C. 20350

1 Mr. Luigi Petrullo
2431 North Edgewood Street
Arlington, Virginia 22207