Some direct tests of concept identification models¹

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Models of concept identification which are derived from assumptions about the underlying cognitive process can be tested directly by means of noncontingent reinforcement sequences and constraints on the set of stimuli. Some examples of such direct tests are presented in this paper.

Recent studies (Levine, 1966; Levine, 1963; Richter, 1965) have demonstrated that certain assumptions about the cognitive processes in concept identification can be tested in a decisive manner by procedures that take into account some specific characteristics of the stimulus sequence. The study reported here may be viewed as an extension of that work. Stimuli for this experiment varied on four binary dimensions: shape, size, color, and border. The stimulus sequence for the first three trials was constrained so that each stimulus differed from each of the remaining two stimuli on exactly two dimensions. This arrangement allows the logical elimination of exactly half the remaining hypotheses on each trial, regardless of the classification responses ("VEK" or "NONVEK") and the outcome ("right" or "wrong"). It was therefore possible to establish noncontingent reinforcement sequences for the first three trials without inconsistency.

Another constraint on the stimulus set was the inclusion of exactly one pair of stimuli that differed from each other on all four dimensions. Such a pair is referred to in the following as a *complementary pair*. Since 16 distinct stimuli can be constructed from four binary dimensions, eight can be selected without including any complementary pairs. Selection of one additional stimulus yields a sequence of nine stimuli in which one complementary pair is included.

Stimulus sequences with these properties were used to test assumptions of the Trabasso-Bower (1966) model. The assumption that S begins in a guessing state and does not process hypotheses until he makes an error was tested by telling S "right" after each of the first three responses and making the hypothesis that was consistent with those responses the solution to the problem. The Trabasso-Bower assumption implies that S is still in a guessing state on Trial 4 and remains there until an error occurs. Thus, the probability of errorless performance on the six contingent trials is predicted to be quite low.

The Trabasso-Bower model also assumes that S utilizes the stimulus-response-reinforcement information on error trials to eliminate one-half of the available hypotheses. According to the model, S samples from that set of hypotheses that are consistent with the reinforcement on an error trial. Thus, if S is shown one member, C_1 , of the complementary pair of stimuli and told "wrong," and on the next trials is shown the other member, C_2 , S should, with Probability 1, make the same response to C_2 as to C_1 . For example, suppose that S is shown a large red circle with a border and responds "VEK." When he is told "wrong" by E, he will select one of the four hypotheses: (1) a "VEK" is small, (2) a "VEK" is blue, (3) a "VEK" is square, (4) a "VEK" is unbordered. If the second member of the complementary pair is presented on the next trial, i.e., a small blue square with no border, any one of the four hypotheses will lead S to respond "VEK" to C_2 . The event—S makes the same response to C_2 as to C_1 —will be termed a *match* (M). It must be conceded that P(M) could be somewhat less than 1 since S may occasionally forget what he is doing, but P(M) should be very close to 1 in any case. Furthermore, this same prediction holds for sequences in

which C_1 and C_2 are separated by K trials (complementation with Lag K), as long as S is told "right" on these trials. This is due to the Trabasso-Bower assumption that the hypothesis is retained until S makes an error.

Levine (1966) proposed a much different model in which Ss are assumed to process available information with almost no loss. The Levine study showed that the numbers of "right" and "wrong" outcomes strongly affected the probability of correct solution after three reinforced trials. The effects of outcomes are investigated further in the present study.

METHOD

The Ss were 14 undergraduates from an introductory course in psychology; they were run individually. A within-S design was used, each S performing 18 tasks of nine trials each. The experiment required a maximum of 30 min. The apparatus was a cabinet with an open back and a rear-projection screen in the front, described by Kenoyer (1967). The stimulus was displayed on the screen by means of a Carousel projector. The projector advanced immediately after each response, which consisted of pressing one of two panels. The panels on the left and right were labeled "VEK" and "NONVEK," respectively. The E told S "right" (R) or "wrong" (W) after each response. For all but two of the stimulus sequences, the first three trials were reinforced noncontingently using the following reinforcement patterns: RRR, RRW, RWR, WRR, and WWR. Two sequences included both of the complementary stimuli in the first three of the sequences, and so reinforcement on the C_2 trial was contingent. For some sequences, reinforcement of all subsequent trials was contingent on S's response being consistent with the hypothesis uniquely determined by the stimulus-response outcome information on the first three trials. The other sequences, in which the C_1 to C_2 lag was several trials, were reinforced noncontingently throughout, E saying "wrong" after S's response to C_1 and "right" after all other responses.

RESULTS

The conditions in which the initial outcome sequence was RRR are particularly relevant to the Trabasso-Bower (1966) model. Fourteen Ss were each given three RRR tasks; 41 out of these 42 tasks led to errorless solution. Frequencies of errorless solution are also shown for the remaining initial sequences. Chi-square tests were performed to assess the reliability of the differences. Solution probability for the RRR condition is greater than for WRR, the next condition in order ($\chi^2 = 13.715$, $df = 1$); WRR and RWR conditions pooled yield a higher probability than RRW ($\chi^2 = 7.554$, $df = 1$); and the probability for the WWR condition is not reliably different from either the pooled WRR and RWR conditions or the RRW condition.

The Trabasso-Bower model's prediction for complementary pairs applies to those conditions in which S was told "wrong" when C_1 was presented and "right" thereafter until C_2 was presented. Table 2 indicates that the relative frequency of matches was quite variable over conditions, and was not, in general, near 1.

Table 1
Errorless Solutions in Each Condition

Initial Sequence	Number of Errorless Solutions	Number of Tasks	Proportion of Errorless Solutions
RRR	41	42	.976
WRR	28	42	.667
WWR	22	41	.537
RRW	16	42	.381
RWR	9	14	.643

Table 2
Matches in Each Complementation Pattern

Complementation Pattern	Number of Matches	Number of Tasks	Proportion of Matches
C_1C_2	12	14	.857
RC_1RC_2	12	14	.857
RRC_1RRRRC_2	17	28	.607
C_1RC_2	7	14	.500
C_1RRRRC_2	0	14	.000

DISCUSSION

The high proportion of errorless performances in the RRR condition strongly supports the assumption that Ss formulate Hs before making errors. The proportion of Ss giving matches on complementary trials was clearly much less than one, indicating that Ss either fail to use accurately the stimulus-response-outcome information on error trials or fail to retain the hypothesis that is selected when subsequently told "right." The latter alternative does not seem reasonable in light of the near-perfect performance in the RRR condition.

The differences among problems with different initial reinforcement sequences indicate the importance of this variable in determining performance and suggest a need for further experimentation in which the initial reinforcement sequence is manipulated.

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NOTE

1. This study was done under the auspices of the Human Learning Research Institute, Michigan State University.