Concept identification as a function of the conceptual rule and length of postinformative feedback interval*

GEDIMINAS NAMIKAS and R. NOEL CAREY
University of Windsor, Windsor, Canada

Each of 144 Ss solved one of two rule-learning problems in a study which combined four rules and three (1-, 8-, and 15-sec) postfeedback intervals in an orthogonal design. Visual stimuli, varying in three (2 relevant + 1 irrelevant) trilevel dimensions, were presented in a random sequence, restricted to an equal number of negative and positive instances. Rule learning was found to increase significantly in difficulty from conjunctive through inclusive disjunctive, exclusive disjunctive, and biconditional rules. The range of postfeedback intervals used in the study did not produce differential performance.

Bourne & Bunderson (1963) observed that performance on attribute identification problems was related to the duration of the postinformative feedback interval (PFI) and the difficulty of the task. Bourne, Guy, Dodd, & Justesen (1965) extended the investigation of the effect to longer intervals and noted that performance was a U-shaped function of the duration of the PFI, with the minimum of the curve shifted to a longer PFI duration for a more difficult problem. In each study, difficulty of the problem was manipulated by varying the number of irrelevant dimensions. The U function was interpreted in terms of the interaction of facilitative effects, due to the greater opportunity for rehearsal of stimulus to response category associations and/or information processing with longer PFI durations, and a decremental effect due to forgetting of stimulus information during the PFI.

The present study extended the investigation of PFI effects to a second type of conceptual task, that of rule learning (Haygood & Bourne, 1965). Problem difficulty for this task has been consistently related to the type of rule which the S has to learn. Characteristically, a hierarchy of task difficulty has been observed for the most frequently investigated rule-learning tasks in which problem difficulty runs from conjunctive to inclusive disjunctive, to conditional, to biconditional, in an increasing order of difficulty (Haygood & Bourne, 1965; Bourne, 1967; Bourne & Guy, 1968a). Under the assumption that information processing operations would be as important in a rule-learning task as in an attribute-identification task, an

interaction between the effect of the duration of PFI and task difficulty, as defined by the rule to be learned, was hypothesized.

METHOD

The Ss were 144 first- and second-year students drawn from introductory psychology courses at the University of Windsor. The apparatus used in the present study was described in detail by Cervin, Smith, & Kabish (1965). Briefly, it consisted of six response panels, separated from each other by wooden partitions, which were arranged in an arc facing a one-way mirror mounted in the wall between the Ss' room and the E's control room. The panels were modified to provide for each S a blue (6.3-V) warning light, which was mounted at the top of the panel and which signaled the beginning of a trial, and a white (6.3-V) light, which was mounted in the middle of the panel and which served as the response signal light. Two response buttons, labeled with "+" and "-" signs and mounted at the bottom of the panel, were used by S to classify the stimuli. A red and a green jewelled light (6.3 V) provided informative feedback after each classification response.

The stimuli were geometric designs varying in three trilevel dimensions. These were color (red, yellow, or blue), form (star, triangle, or circle), and number (one, two, or three identical figures). All possible combinations of these three trilevel dimensions resulted in a set of 27 stimulus patterns ($3^3 = 27$). For a given problem, either color-form or number-form were relevant, while the third dimension, i.e., number and color, respectively, was irrelevant. The stimuli were arranged in a random series with the restriction that each successive block of 12 stimuli would have six positive and six negative instances of the concept. Since for each of the two problems nine possible pairs of two relevant attributes could

be formed, each possible combination of attributes was used equally often within the limits of the design.

The stimulus patterns were projected onto a white transparent viewing screen placed on the one-way mirror, from the E's side of the mirror, using an Ansco 970 slide projector. Both the control room and the experimental room were in semidarkness in order to produce a clear image for the Ss, since the one-way mirror reduced the transmitted light to a considerable extent.

All Ss were told that the stimulus patterns would vary along three dimensions, and the dimensions together with their attributes were described. Since the task was a rule-learning task, the Ss were told also the relevant attributes for their problem and were instructed that their task was to find the conceptual rule which would allow them to categorize correctly each stimulus pattern. The function of the lights and buttons on the response panel was also explained.

For each S, a trial started with the onset of the blue warning light simultaneously with the presentation of a stimulus pattern on the screen. Three seconds later, the white response light went on, indicating to the S that he should press one of the two response buttons. The Ss were instructed to press the response button of their choice as soon as the white light came on and to continue to press the button until one of the two feedback lights came on, indicating whether they had been correct or incorrect. The response interval was 3 sec in duration, after which, simultaneously, the blue and white lights went off, the projector was advanced to a blank slide, and one of the informative lights came on. The light remained on during the duration of the PFI. At the end of the PFI, the feedback light went off, the blue light came on, and the rest of the sequence of events was repeated.

Six Ss were run at a time. When one or more of the Ss failed to appear, replacement Ss were run later. In the case of single replacement Ss, an attempt was made to run two Ss at a time, after which one was discarded at random if only a single replacement was needed, in order to make the conditions somewhat analogous to the group situation in which the other Ss had been run. All Ss were run for 96 trials. The S's responses were recorded automatically by means of an Esterline Angus event recorder and also manually by the E.

The design of the experiment was a 4 by 3 by 2 orthogonal design. The Ss were given one of four types of conceptual rules to learn (conjunctive,

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inclusive disjunctive, exclusive disjunctive, or biconditional). In addition, three durations of PFI (1, 8, and 15 sec) and one of two problems (color-form relevant or number-form relevant) were used. Six Ss were run in each of the 24 groups thus formed for a total of 144 Ss.

RESULTS AND DISCUSSION

An examination of the data indicated that 59 of the 144 Ss (i.e., 41%) failed to reach a criterion of 16 correct consecutive responses within the allotted 96 trials. A chi-square analysis on the frequency of failure indicated that the rule variable was a significant determinant of failure ($\chi^2 = 30.153$, $df = 3$, $p < .01$). The significant chi square was due primarily to the larger than expected number of failures in the biconditional group and the smaller than expected number of failures in the conjunctive group.

An analysis of variance on the trials-to-criterion¹ data indicated that the different rules produced problems of unequal difficulty ($F = 34.77$, $df = 3/120$, $p < .01$). A Newman-Keuls test (Winer, 1962) indicated that the biconditional rule was significantly more difficult to learn than any of the other rules (1% level of confidence). The exclusive disjunctive rule was significantly more difficult to learn than either the inclusive disjunctive or conjunctive rules (1% level of confidence). Finally, the inclusive disjunctive rule was more difficult to learn than the conjunctive rule (5% level of confidence). The respective mean trials to criterion were: conjunctive = 19.4; inclusive disjunctive = 34.7; exclusive disjunctive = 62.2; biconditional = 88.4. No other effects were found to be significant.

A second response measure, total errors, also showed that the different rules produced a differential number of errors to criterion ($F = 31.44$, $df = 3/120$, $p < .01$). A Newman-Keuls test confirmed that the order of difficulty was biconditional, exclusive disjunctive, inclusive disjunctive, conjunctive. All rules differed significantly from each other at the 1% level of confidence (mean errors: biconditional = 44.7; exclusive disjunctive = 25.4; inclusive disjunctive = 16.3; conjunctive = 8.7). A significant blocks of trials main effect ($F = 21.78$, $df = 7/840$, $p < .01$) indicate; that errors decreased as practice progressed. A significant Rules by Blocks of Trials interaction effect ($F = 1.996$, $df = 21/840$, $p < .01$) was largely due to the fact that for all rules, except the biconditional, the greatest decrease in the number of errors was from the first to the second block of 12 trials.

Since the majority of the Ss faced with the biconditional rule were not able to learn the rule, the decrease in errors for this group was relatively small during the initial blocks of trials, contributing to the interaction effect. No other significant effects were obtained.

These results are in agreement with the previous finding (Haygood & Bourne, 1965; Bourne, 1967; Bourne & Guy, 1968a) that the difficulty of an initial problem is related to the rule and that the hierarchy of difficulty, when a reception paradigm is used, runs, in descending order of difficulty: biconditional, inclusive disjunctive, conjunctive.

The finding that the exclusive disjunctive task was significantly less difficult than the biconditional task contradicts observations by Haygood & Bourne (1965) and Haygood & Kiehlbauch (Bourne, 1967, p. 24) that rule-learning tasks which involve complementary rules produce no reliable differences in performance on the complementary tasks. It is, however, consistent with the finding by Neisser & Weene (1962) that exclusive disjunctive problems are easier than biconditional problems and a similar observation by Hunt, Marin, & Stone (1966), who reported a series of studies in which a consistent trend was observed in terms of better performance on exclusive disjunctive problems than on biconditional problems.

The apparent contradiction in the findings may be related to differential task requirements. Neisser & Weene (1962) and Hunt, Marin, & Stone (1966) employed what Haygood & Bourne (1965) have called complete learning tasks in which the S has to learn the rule being used and also identify the relevant attributes. Bourne and his associates have usually taken great pains to minimize the possibility that a rule-learning task would also include attribute-identification aspects through the use of instructions, and sometimes the use of a card which named the relevant attributes and remained available to the S during the rule-learning task (e.g., Bourne & Guy, 1968b). In the present study, the relevant attributes were named for the S at the beginning of the rule-learning task, but the S had to rely on his memory during the task, since external aids, such as a card listing the relevant attributes, were not available. Consequently, it is possible that the Ss who were given the more difficult problems, i.e., the exclusive disjunctive and biconditional rule-learning tasks, might have forgotten the attributes which had been indicated by E as being relevant. The performance on these tasks then

would have been more characteristic of the results obtained by Neisser & Weene (1962) and Hunt et al (1966) in complete learning tasks.

Finally, the lack of a significant effect of the PFI duration contradicts the results obtained by Bourne & Bunderson (1963) and Bourne et al (1965) in attribute-identification tasks. The present observation is not unique, however, since Roweton & Davis (1968) also found no significant effect due to the PFI duration in an attribute-identification task. The single striking feature common to both the present study and that of Roweton & Davis (1968) is the use of a two-category task, while the two studies by Bourne and his associates, in which significant effects due to PFI were obtained, used a four-category task. The interpretation of the PFI effect [in terms of the greater opportunity that a longer duration PFI would present for the formation of associations between stimulus characteristics and the response categories] offered by Bourne & Bunderson (1963) seems relevant for the dichotomous set of results indicated above. In a four-category task, such associations very likely represent a significant aspect of the concept-attainment task, and it would be expected that variables which would affect the formation of such associations would also produce significant effects on concept-attainment performance. On the other hand, in a two-category task, such associations may represent a negligible aspect of the total concept-attainment performance and, consequently, any variables whose effect is due to their influence on the formation of such associations would also be expected to have a negligible contribution to the performance in a two-category concept-attainment task.

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NOTE

1. If a S had not reached the criterion of 16 consecutive correct responses, he was assigned a score of 96 for the purpose of this analysis.

Age and the distribution of observing responses*

A. J. SANFORD and A. JOHN MAULE
 The University, Dundee DD1 4HN, Angus, Scotland

It is hypothesized on the basis of previous work that older people may be under greater stimulus control in a multisource monitoring situation with a signal frequency imbalance across sources than are younger Ss. The results obtained refute this hypothesis and show that older people are less selective. Explanations in terms of probability learning and arousal level are discussed.

The manner in which observing responses (OR) are distributed across sources by Ss is known to be a function of the signal probability distribution across sources. If a man has to monitor the states of several different machines as part of a control process, then he is often more likely to look at a machine which goes wrong often than at one which goes wrong infrequently. The extent to which this type of stimulus control of the OR occurs as a function of stimulus (fault) rate and rate of observation has been investigated by Hamilton (1969). Hamilton used a simulation of an industrial fault-finding situation with three "machines" whose states had to

be monitored by testing each one through a buttonpress operation (this is the operational OR). He found that Ss' OR distribution across the sources was not influenced by signal probability at each source (.6, .3, .1), when the average time between signals was long and Ss could observe at their own rates. However, when signal rate was increased, or Ss were restricted in the rate at which they could observe, they became more selective and tended towards matching signal probability with their OR distribution. The salient variable in controlling selectivity, argued Hamilton, was the average number of samples made before a signal was detected.

This carries important implications for aging studies. One of the best known facts of psychological research in aging is that older people are slower at nearly all tasks they are given (e.g., Birren & Riegel, 1962). In an OR situation there is every reason to

suppose that the same rule will apply. The question examined here is first whether older people are slower than young in an OR situation, and secondly, whether they are more selective as a result. Since the optimum distribution of OR is related to signal probability regardless of speed of observing and signal rate (Hamilton, 1967, p. 45), a greater tendency to structure in old Ss would imply a more economical distribution of effort as a function of age. The possibility of older people's using knowledge of probabilities to overcome the failing sensory-motor skill system was suggested some time ago by Griev (1962, 1968).

METHOD

Twelve old (mean age 69.7 years) and 12 young (mean age 22.8 years) people were voluntary unpaid Ss.¹ Ss sat in a darkened room facing a vertically mounted 4 x 4 ft blackboard upon which were arranged three pinhead-size lights (sources) in an equilateral triangle of 30-in. sides. Viewing distance was 4 ft. At knee level, immediately before the S, was a control panel with three "sample buttons" mounted on it in an equilateral triangle (8-in. sides), each corresponding to one of the lights. When pressed, the appropriate light would flash (red) briefly if a fault was present on that channel. No flash occurred if no fault was present. Mounted immediately below each sample button was a corrector button. If a fault was located, the appropriate corrector button had to be pressed, otherwise the fault would remain and would be seen again the next time the channel was sampled. Each time a sample button was pressed, the OR was recorded on one of three counters. In this way, the number of ORs to each channel was recorded.

Faults occurred at a mean rate of one/12 sec, randomized between 6.4 and 17.6 sec. Probabilities of faults occurring were: Source 1 = .6; Source 2 = .3; Source 3 = .1. In a period of 36 min, approximately 180 faults were presented.

Ss attended two sessions each of about 40 min duration. Session 1 was designed especially to help Ss to understand the analogy of losing money when faults occurred but were not corrected. Ss had a digital counter before them which started clocking up at a rate of one increment per second when a fault occurred. This counter bore the caption "£ lost." Ss saw that they were losing (hypothetical) money, and pressed the sample buttons to find where the loss occurred. On finding the faulty machine they simply pressed the corrector button. A brief session at this ensured that all Ss understood

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