Confidence in decision as an index of perceived accuracy of information processing[1]

ROBERT D. HOGE, Carleton University, Ottawa, 1, Canada

The effects of variations in accuracy of information processing on confidence in decision were explored within a complex decision task. Ss were exposed to a series of decision problems under different time-pressure conditions and were required to make a choice and a confidence rating in the case of each problem. Problems varied in terms of response uncertainty and relative amount of information. The confidence measure was significantly affected by the response uncertainty and amount of information variables, but did not show a systematic relation to variations in accuracy of processing. The confidence measure did prove to be a stable index of response uncertainty even in those cases where the subjective probability distribution departed from the objective distribution.

Subjective uncertainty can be defined as the S's perceived uncertainty with respect to the choice situation; it is the subjective correlate of problem uncertainty. One index of subjective uncertainty is confidence in decision, and this index has been shown to be sensitive to a number of contributors to problem uncertainty. For example, Sieber & Lanzetta (1964) found that confidence in decision decreased with increases in response uncertainty,[2] where the latter variable was manipulated in terms of the number of alternatives. Hoge & Lanzetta (1968) varied response uncertainty in terms of the probability distribution across the set of alternatives and found a systematic decrease in confidence with increases in response uncertainty. Relative amount of information on which the probability distribution is based constitutes a second factor affecting subjective uncertainty. Several investigators have demonstrated a relation between relative amount of information and confidence in decision (Hammer & Ringel, 1965; Hoge & Lanzetta, 1968; Irwin, Smith, & Mayfield, 1956): Confidence in decision increases with increases in the relative amount of information. A third factor that might be expected to affect subjective uncertainty is accuracy of information processing. The probability of choosing the correct alternative within an uncertain situation is affected not only by the objective probabilities associated with the alternatives and by the amount of information upon which the distribution is based but also by the accuracy with which the information was dealt with.

Numerous investigators (e.g., Hayes, 1962; Peterson, Schneider, & Miller, 1965) have demonstrated the existence of limits on the information-processing capacity of the individual. Some efforts have also been made to assess degree of sensitivity to decision quality. For example, Adams & Adams (1961) report two experiments in which the S was required to make an estimate of his accuracy of choice in terms of expected percentages of correct choices. A relatively close relation between perceived accuracy and performance was obtained. Similar results have been obtained by Levy, Evans, & Humes (1967), Stichman (1967), and Ulehla, Little, & Weyl (1967). Most of these experiments have dealt with perceived accuracy of choice within relatively simple tasks and have not considered the question of perceived accuracy of choice within the context of other determinants of problem uncertainty. The goal of the present experiment was to explore the relation between variations in accuracy of information processing and confidence in decision within a multidimensional task.

SUBJECTS

Twenty male Carleton undergraduates served as Ss within the experiment.

DECISION TASK

The decision task employed in the experiment and the operational definitions of response uncertainty and relative amount of information follow closely the procedures of the Hoge & Lanzetta (1968) study. The S was presented with a set of airplanes and was required to select the best plane to perform a military mission. The S evaluated the planes in terms of a specified set of characteristics: delay, speed, distance, and armament. Seven possible values were associated with each characteristic. The values were ordered from best to worst, and a numerical weight was associated with each characteristic. The highest value was assigned a weight of 7 and the lowest value a weight of 1. These weights were to be used by the S in his comparison of the planes, and they were also employed, as will be shown, in the assignment of objective strengths to the planes. The characteristic-value matrix is shown in Table 1. All problems within the experiment involved six alternative airplanes. Decisions were made on the basis of limited information; that is, information was provided along one, two, or three of the dimensions for each alternative. The S never dealt with a completed matrix. Uncertainty was created by informing the S that a single best plane existed within each problem matrix, though its identity generally could not be known with certainty without all of the information available. Table 2 shows a sample problem matrix.

INDEPENDENT VARIABLES AND DESIGN

The response-uncertainty manipulation required variations in the probability distribution across the set of alternatives and was achieved through use of the numerical weights associated with the alternatives. The strength of an individual alternative was determined by averaging the weights associated with its characteristic values; the distribution of strengths across the alternatives was defined in terms of the distribution of these average weights. It was assumed that the S's probability of choice of an alternative would be determined by the distribution of absolute strengths.

Variations in the distribution of strengths across the alternatives were achieved by altering the size of the set of "best" alternatives. For example, a problem might have three alternatives of equal numerical weights, and their average weights might be two units higher than those of the three remaining alternatives (which would have equal average weights). This would constitute a problem with three "best" alternatives and a discrepancy of two units between the average weights of the two sets. Four levels of response uncertainty were created through this

Table 1*
Characteristic-Value Matrix

	Ranked Values						
Characteristics	7	6	5	4	3	2	1
Delay	2	4	6	8	10	12	14
Speed	600	570	540	510	480	450	420
Distance	100	120	140	160	180	200	220
Armament	90	80	70	60	50	40	30

** Delay values are expressed in min; speed values are expressed in mph; distance values are expressed in miles; armament values are expressed in terms of percentage of armament aboard the plane.*

Table 2
Sample Problem Matrix

	Alternative Airplanes					
	1	2	3	4	5	6
Delay	10			8	2	14
Speed	570	450		540		
Distance			160		200	
Armament		50	70			60

procedure: one "best" alternative, discrepancy of four units between "best" and set of worst (RU-1); two "best" alternatives, discrepancy of three (RU-2); four "best" alternatives, discrepancy of two (RU-3); five "best" alternatives, discrepancy of one (RU-4). The sample problem shown in Table 2 is an example of the RU-3 condition.

The second independent variable, relative amount of information, was defined in terms of the number of filled cells per alternative. Three levels of this variable were created: the case in which one cell was filled (I-1), the case in which two cells were filled (I-2), and the case in which three cells were filled (I-3). The third independent variable was time pressure. There were three levels of problem exposure time: no limit (T-1), 15-sec limit (T-2), and 8-sec limit (T-3).

A 4 by 3 by 3 repeated-measures design was employed. The four levels of response uncertainty were combined with the three levels of amount of information to produce 12 problem types. Three examples of each problem were created, and these were distributed between the three time conditions. Ss were run through all 36 problems in a random order, and this order was reversed for half the Ss. The experimental problems were preceded by 21 warm-up problems.

PROCEDURE

The Ss were run individually in sessions lasting approximately 1 h. Instructions were presented by means of a tape recorder and contained an explanation of the problem matrices, the characteristic-value matrix (which was always within view of the S), and the goal of the task. The S was told that each problem contained a single "best" plane, though the identity of this plane generally could not be known with certainty without all of the information. It was stressed that each problem was to be viewed independently of every other problem, and that all of the characteristics were to be regarded as equally important. The use of the confidence scale was explained, and the S was told that his confidence rating should relate to his feeling that he had found the single best plane that existed in each matrix.

Problems were presented by means of a 35-mm slide projector. The E announced the exposure time prior to the appearance of the slide on the screen. At the end of the time limit, the projector was turned off, and the S made his choice in a response booklet. Confidence in decision was rated immediately after choice and was made in terms of a 9-point scale labeled "no confidence" at one end and "complete confidence" at the other end. As soon as the S had recorded his choice and confidence rating, exposure time for the next problem was announced, and the problem appeared on the screen.

RESULTS AND DISCUSSION

Findings with respect to the effects of the response uncertainty and relative amount of information manipulations on confidence in decision were similar to those of the Hoge & Lanzetta (1968) study. Confidence in decision decreased systematically with increases in response uncertainty. An analysis of variance of the confidence data indicated that the results were significant [$F(3,54) = 15.35$, $p < .01$]. Confidence in decision increased with increasing amounts of information [$F(2,36) = 4.27$, $p < .05$]. A significant interaction between response uncertainty and amount of information [$F(6,108) = 2.40$, $p < .05$] also follows the pattern of the results of the previous study. The interaction takes the form of a convergence of the three information conditions at the two extremes of the response-uncertainty dimension and can probably be explained in terms of response uncertainty imposing a limit on confidence scores at these extremes.

The first row of Table 3 indicates a systematic increase in confidence with increasing time pressure. The analysis of variance indicated that the effect was significant [$F(2,36) = 24.80$, $p < .01$]. Data reported in Rows 2 and 3 of Table 3 indicate the time manipulation was effective in producing differential levels of accuracy of information processing. Row 2 reports total number of wrong choices for the three time conditions. A somewhat more sensitive index of accuracy is based on a comparison of objective response-uncertainty values with subjective response-uncertainty values. The objective response-uncertainty value of a problem was calculated in terms of the information-theory formula for average uncertainty and took account of the number of "best" alternatives within the problem. Specific probability values to be used in the formula were arrived at by assuming that, where information is processed with complete accuracy, choices will be distributed equally across the set of "best" alternatives. Thus, problems within the RU-2 condition involve two "best" alternatives, and a probability value of .50 was associated with each alternative. An H value of 1.0 is obtained for those problems. H values for the other response-uncertainty conditions are as follows: RU-1 = 0.0, RU-3 = 2.0, and RU-4 = 2.3. The actual distribution of choices across the set of alternatives within a problem were used within the formula for average uncertainty to calculate subjective response-uncertainty values. In this case, probability values were associated with alternatives on the basis of the proportion of choices associated with the alternative. The index of accuracy reported in Row 3 of Table 3 represents an average across problems within time conditions of differences between objective and subjective response-uncertainty values. The data indicates an increase in size of the difference scores with an increase in time pressure. Comparisons between means were made by t tests, and the differences between the T-1 and T-3 conditions were found to be significant ($p < .05$).

Table 3
Confidence, Accuracy, and Subjective Response Uncertainty as a Function of Time Conditions

	Time Conditions		
	T–1	T–2	T–3
Mean Confidence	58.93	49.15	44.13
Total Errors	20	20	42
Mean Difference Scores*	.24	.36	.57
Subjective Response Uncertainty	1.56	1.58	1.70

** The Difference Score is based on the discrepancy between the objective and subjective response uncertainty values of a problem.*

The interpretation of the relation between accuracy and confidence is complicated by the fact that the subjective response-uncertainty values also varied with time pressure. Row 4 of Table 3 reveals that this variation took the form of increased subjective response uncertainty with increasing time pressure, a phenomenon due to the fact that responses became more random with increasing pressure. The question arises as to whether variations in confidence between time conditions are reflections of the variations in accuracy or the variations in subjective

Table 4
Multiple Linear Regression Analysis of Confidence Data

	Partial Correlation Coefficients	Multiple Regression Coefficients	Proportion of R^2 Predicted
Subjective Response Uncertainty	–.74	–13.70	.51
Difference Scores	–.28	–6.32	.04

response uncertainty. A multiple linear regression analysis across problems indicated that subjective response uncertainty was significantly related to the confidence measure ($F = 40.02$, $df = 33$, $p < .01$), but that the difference scores were not making a significant contribution. The analysis is summarized in Table 4.

The major conclusion from the data is that the confidence-in-decision measure is an insensitive index of variations in accuracy of information processing within the present case. It is possible, of course, that Ss are sensitive to variations in accuracy, but there is no evidence of this within the experimental context employed in the present study. Both response uncertainty and amount of information are significant contributors to confidence, and they could be "washing out" any effects of perceived departures from optimal information processing. A second conclusion from the data is that the S is able to track variations in subjective response uncertainty, even in those cases where the variable represents a departure from objective response uncertainty. This conclusion is based on the multiple linear-regression analysis which employed data from all three time conditions.

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NOTES

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2. Both objective and subjective response uncertainty values are calculated in terms of the formula for average uncertainty: $H = \Sigma p_i \log_2 p_i$, where p_i is the probability of the i^{th} response alternative.

Effects of meaningfulness and learning instructions on the isolation effect[1]

DIXIE E. GIBBONS and KENNETH L. LEICHT, Illinois State University, Normal, Ill. 61761

Two assumptions pertinent to isolation-effect studies were examined. Contrary to an assumption that the isolation effect is due to differential rehearsal of conspicuous items, instructions designed to distribute practice time across list items did not reduce the isolation effect. Prediction of equivalent total list recall for isolation and nonisolation conditions followed from an assumption that isolating a list item alters the distribution but not total amount of list rehearsal. Contrary to the latter assumption, total list recall was lower in isolation than in nonisolation conditions, except under instructions to distribute rehearsal time and with low-meaningful units.

The isolation effect refers to the finding that recall of an item when it is set apart is superior to recall of the same item when it is not set apart. A typical demonstration of the effect involves an isolation condition, in which an item midway in a list is printed in red when remaining items are printed in black, and a nonisolation condition, in which the same item appears in the same list but with all items printed in black. One account of isolation-effect findings (Waugh, 1969) is that a greater portion of practice time allotted for the list is spent on the item in isolation than in nonisolation conditions. However, total list recall supposedly will not differ for isolation and nonisolation conditions, since the facilitation of total list recall by differential rehearsal of the isolate is offset by the negative effect on recall of reduced rehearsal of remaining list units. A sizable portion of isolation findings agree with Waugh's analysis (cf. Wallace, 1965). One implication of her account is that the isolation effect will be absent when memorization instructions prevent differential rehearsal of the isolate. The deduction was tested by comparing the isolation effect under conventional (C) memorization instructions that permitted differential rehearsal of the isolate and distributed-practice (D) instructions that required equivalent practice on each list unit. In light of the Rosen, Richardson, & Saltz (1962) finding of a greater isolation effect with low-meaningful (LM) than with high-meaningful (HM) units, meaningfulness was also varied. If Waugh were correct, no differences in total list recall between isolation and nonisolation conditions would occur for either LM or HM units, although isolation-effect magnitude could vary with meaningfulness.

METHOD

Seventy-two undergraduates participated, nine in each of eight conditions formed by combination of meaningfulness (HM or LM), isolation-nonisolation (I or NI), and memorization instructions (C or D). Ss were tested in groups in separate replications, random assignment obtaining for each replication. Five 13-item lists for each level of M were formed by randomly sampling without replacement from a pool of AA Thorndike-Lorge (1944) nouns (HM) and from a pool of 60%-80% association-value CVC trigrams from Archer's (1960) norms (LM). In I conditions, the seventh item in each list was set apart by printing it in red. For both C and D instructions, the face page of S's recall booklet indicated that a number of lists would be presented and that after each presentation unordered recall would be requested. The D instructions, modified from Allen (1968), also told S that he was to repeat each list item until the next item