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In a test of three computer models to simulate group decisions, data were used from 31 American and Austrian groups on a total of 307 trials. The task for each group was to predict a series of answers of an unknown subject on a value-orientation questionnaire, after being given a sample of his typical responses. The first model, used the mean of the individual opinions as a simulation of the group judgment, simulated exactly over half of the trials. The simulation was improved in model two, which also used the mean, when individual opinions were weighted according to their total participation in the discussion and "learning" was added. This was especially true when the cutting points were changed so that the mean would represent more extreme opinions. The best simulation occurred with model three, which used the median of the individual opinions as a simulation of the group decision. Using this model, over 75% of the trials were accurately simulated. (Author)

Computer Simulation of Small Group Decisions:

Model Three *

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A comprehensive scheme for the simulation of interpersonal behavior in small groups has been outlined by Bales, Couch, and Stone in their description of the "Interaction Simulator" (Bales, Couch, & Stone, 1961). The process of simulation would begin after a set of subjects are given a battery of personality and performance tests. Before they come together for a group discussion, the ideal computer simulation would indicate which subject will choose each of the seats around the table, to whom each will speak and in what order, and how the problem-solving will proceed as the group reaches one or more decisions. This simulation would then be compared with the outcome of the actual group discussion. So far relatively little of this scheme has been programmed for the computer although Bales, Couch, Stone and others have been able to generate theories and methods which bring the task much closer to realization than when it was first proposed (See Bales, 1968; Couch, 1960; Stone et al, 1966).

The present simulation model~~s~~ is ~~are~~ concerned with only one aspect of the more general problem, namely the process by which group members pool individual opinions to form a group judgment. This ~~These~~ model~~s~~, ~~which pose different methods of averaging individual judgments,~~ is ~~are~~ based on earlier models which used some of the same data to test the simulations (Hare, 1961; Hare and Richardson, 1966). In addition to the data from groups composed of American college students used to test the previous simulations, new data have been obtained from groups of Austrian college students solving a set of similar problems.

The process to be simulated

The process to be simulated is the formation of a group opinion about a subject, once individual members have formed opinions about the same subject. Since several pre-computer studies of group decisions have indicated that the "pooling" of individual opinions may represent accurately the results of group discussion, it is expected that this process will involve some form of averaging such as taking the mean, median, or mode.[1]

The group to be simulated is a five-man laboratory discussion group of college undergraduates. They are seated at a table with three members along one side, one at each end, and the fourth side open towards the experimentor who records the interaction rate for each member and monitors the task. The task is described in some detail in a previous article (Hare, 1961). In brief it consists of giving each of the group members a question from a questionnaire concerned with value-orientations, together with the answer given by an "unknown subject."[2] The group members are told to pool their information about the unknown subject and then predict his answers to a set of ten or more questions. After each prediction the unknown subject's actual answer is revealed and is discussed by the group before the members make their next prediction. Before each trial the group members record their individual predictions.

Three models of group decisions

The first model for group decisions assumed that group members took an average of their individual opinions and that this average was best represented by the mean (Hare, 1961). The computer program began with the five individual predictions as inputs. The group decision was simulated by taking the mean of the five predictions. The predictions for the American groups were made on a seven point scale where -3 represented "strongly disagree," + 3 represented "strongly agree," and 0 represented no opinion. Since group members were required to give some opinion, the computer program provided for an alternative in the case where the mean of the five opinions was actually zero.

The members of the Austrian groups used a five point scale in giving their opinions, ranging from "Entschieden Ja" through "Unentschieden" to "Entschieden Nein." In this case the "undecided" category was allowed so that it was not necessary to avoid the mid-point on the scale.

The second model used the mean of the individual opinions as the best estimate of the group decision, but this time members' opinions were given different weights according to their position in the communication network, their interaction weights, or their success with the task. Simulated group members also "learned" more about the unknown subject as the trials progressed by considering the extent to which he had been opinionated in his answers. The routine which simulated the effects of task success and learning were primarily the work of Richardson.

The third model, which was developed in Vienna, assumes that the majority opinion or the median is the best predictor of group decisions. In the case of a five man group, a majority of three also contains the median. The decision to use both of these possibilities grew out of a discussion between Hare and Scheiblechner as they attempted to find the reasons why the previous simulations failed to predict more of the group decisions. Hare proposed using the majority opinions and Scheiblechner the median. The program written by Hare is actually the one used in the third model. It begins by finding a majority of three when there is one for each trial. However when there is no majority the median is used. In a few cases, in the

American groups, where the lack of a recorded opinions for some individuals would place the median in the "no opinion" category, a majority of two is used. Using this model in a five man group it is never necessary to use any of the "learning" features of model two, nor do the "weights" assigned the subjects make any difference.

Sources of data

The groups used to test the simulations come from three sources: Harvard, Haverford and Villanova, and Vienna. The twenty five-man groups at Harvard were observed as part of an experiment conducted by Churchill (1961). The five Haverford and Villanova groups were observed by Hare and Richardson, and the six Austrian groups were observed at the Institute for advanced Study in Vienna by Scheiblechner.[4] In the majority of the groups the subjects were male undergraduates.

The data for the American groups consist of the individual predications of the unknown subject's responses to the Bales-Couch Value Profive (1960), the group decisions, and the actual responses on the unknown subjects. Two unknown subjects were used, one an actual "unpredictable" graduate student for the Harvard groups, and the other a fabricated "predictable man" for the Haverford and Villanova groups.

The data for the Austrian groups are similar with the substitution of a values test, in German, developed by Reichardt at the University of Vienna. Here a fabricated unknown subject was used who turned out to be relatively unpredictable.

In both countries the individuals' total interaction rates for the entire session and seating positions were recorded. Each five-man group completed roughly ten trials. The Harvard experiment was conducted in a small group laboratory using an observation mirror and the other groups were observed in classrooms.

The computer programs

The program for model one was written in machine language for the IBM 650. For model two the program was first written in SPS for an IBM 1620 and then translated to FORTRAN. The Model three program~~s~~ and adaptations of earlier programs were done in FORTRAN and run on an IBM 1620 Mark II. None of the programs requires a very elaborate computer.

As described above, the basic method of simulating a group's decision in model one was to take the unweighted mean of the individual opinions. For model two, various weights which reflected interaction rate or seating position were used as the "starting weights," i.e., the weights used for the first trial before any learning process had taken place. For interaction rate we predicted that those who talked the most would have the most influence and for seating position, those in seats 1 and 5 at the ends of the table, and 3 in the center of the side facing the experimenter.

Also in model two routines were added to test the hypotheses concerning the relative influence of successful members and the learning process. The weights for the individuals were increased (or decreased) by a certain percentage, depending upon the individual's success (or failure), both absolutely and relatively, on the preceeding trial. With the addition of new information about the unknown subject's actual response for each trial the probabilities for opinionated or uncertain opinions being given as the group predictions were changed. For model three the majority, or median if there was no majority, was selected without the "learning" routines.

Results

In results for the various simulations with the 179 trials of the Harvard groups are given in Table 1, for the 68 trials of the combined Haverford and Villanova groups in Table 2, and for the total of 247 trials with the American sample in Table 3. The data for the 60 trials in the Austrian sample which used a different value test and a narrower range of permitted responses are given in Table 4.

Insert Tables 1, 2, 3, 4 about here

With the first model, taking the unweighted mean, 105 trials out of 179 are correctly simulated for the Harvard groups (Table 1), 34 out of 68 for the Haverford-Villanova groups (Table 2), and 44 out of 60 for the Vienna groups. Thus more than half of the decisions are accurately simulated by the simplest model.[5]

When the various starting weights are used as part of the second model, there is no improvement using the seating weights and only slight improvement using interaction weights in the Harvard and Vienna groups. However this apparent increase is not statistically significant.[6]

For both American and Austrian groups there is some increase in the accuracy of the simulation when the learning routines are added to the unit weights and the interaction. However the increase over the simplest model of unit weights and no learning is not significant.

The introduction of the wider cutting points for the more extreme answers improves the accuracy of the prediction over model one in all cases although learning only adds to the accuracy for the American groups. The improvement for the wider cuttings points, with and without learning, for the combined American groups is significant at the .05 level.

Finally the use of model three, the median, make a significant improvement for both sets of American groups at at least the .05 level, and for the combined American groups at the .01 level. Although there is an increase of accuracy of the simulation in five of the six Austrian groups, the probability that this could happen by chance is more than .05 for a sample of this size.

For ten of the twelve cases, the shift from a "no learning" to a "learning" model, which is usually associated with an increase in the accuracy of the prediction of the actual answer, also results in a greater number of gross errors (See Tables 1, 2. and 4). The most extreme case of this is found in Table 2 when the wide cutting points are used. With no learning there is only one simulation which differs by three points from the actual group decision, whereas with learning the number of errors of this size rises to five. Thus absolute accuracy is purchased at the price of greater relative error when the simulation is incorrect. This is also true for the American groups when the simulation under model three is compared with model one. What is happening here is that the learning routines, the wider cutting points, or taking the median rather than the mean, all have the effect of making a somewhat more extreme prediction, which if it is right, reduces the discrepancy with the actual groups guess to zero, but if it is wrong, increases the number of large errors.

Summary

In a test of three computer models to simulate group decisions, data were used from 31 American and Austrian groups on a total of 307 trials. The task for each group was to predict a series of answers of an unknown subject on a value-orientation questionnaire after being given a sample of his typical responses.

The first model which used the mean of the individual opinions as a simulation of the group judgement simulated exactly over half of the trials. The simulation was improved in model two, which also used the mean, when individual opinions were weighted according to their total participation

in the discussion and "learning" was added. This was especially true when the cutting points were changed so that the mean would represent more extreme opinions.

The best simulation occured with model three which used the median of the individual opinions as the best simulation of the group decisions. Using this model over 75 per cent of the trials were accurately simulated.

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Footnotes

1. See Kaplan, Shagstad, and Girshirk, 1950; Stone and Kamiya, 1957; and Hare, 1962, pp. 36--361.
2. For the American groups the times were taken from the Bales-Couch Value Profile (1960). In Austria the items were taken from a questionnaire being developed by Professor Robert Reichart at the Sociological Institute at the University of Vienna.
3. Group members who have more central positions in the communication network by having the more central seats can be expected to have more influence in the discussions (Hare and Bales, 1963). The weights used were 3.50 for seats one and five, 2.75 for seat three, and 1.37 for seats two and four. The derivation of these weights is given in the Hare and Bales article.

   Subjects who talk most also usually have the most influence (Bales, 1953; and Hare, 1962, p. 107.)
4. Other members of the research team who made these observations as a part of a more comprehensive attempt at simulation were Dr. Gerda Bauer, Dr. Herbert Rauch, Dr. Herbert Rieser, Dr. Dieter Bichlbauer, Dr. Klaus Feldmann, Dr. Liselotte Rybczuk, Dr. Elizabeth Taubel, Dr. Peter Siwy, Dr. Dorit Weinberger.
5. In earlier versions of models one and two the published data differed slightly as a result of minor changes in programing as we used new programming languages and machines. Although some of the results of the simulations appeared more orderly in previous tables, they were not significantly different from the present figures.
6. Tests of significance were made by comparing the increase in absolute prediction group by group under each condition using a sign test (Siegal 1956, Table D). If an increase in simulation was observed it was scored as plus, if there was no increase scored as zero, and a

decrease scored as minus. The probability of the number of minuses given the total number of groups in which a change was observed was noted in Table D. As a further test the correlation between the simulated and actual group guesses was computed for each group and the average correlations compared, after using the z transformation. The results were similar.

Table 1

Harvard Groups

Simulation of Group Decisions

[20 Groups, 179 Trials]

Simulation Type		Difference between simulation and actual group decision: 0	1	2	3	Total
Mean: unit weights	No Learning	105	57	15	2	179
	Learning	114	45	18	2	
Mean: seating weights	N. L.	104	52	19	4	
	L.	118	39	17	5	
Mean: interaction weights	N. L.	113	49	15	2	
	L.	119	42	14	4	
Mean: wide cutting points (int. wts.)	N. L.	119	47	10	3	
	L.	125*	35	13	6	
Majority or median [Wts. not used]		133**	35	7	4	

*Significant increase over unit weights - no learning $p < .05$ using Sign Test

** $p < .01$

Table 2

Haverford and Villanova
Groups (Predictable Man)

[5 Groups, 68 Trials]

Simulation Type		Difference between simulation and actual group decision: 0	1	2	3	Total
Mean: unit weights	No Learning	34	28	6		68
	Learning	36	25	6	1	
Mean: seating weights	N. L.	34	25	8	1	
	L.	32	25	9	2	
Mean: interaction weights	N. L.	34	28	6	0	
	L.	35	26	4	3	
Mean: wide cutting points (int. wts.)	N. L.	40	23	4	1	
	L.	40	21	2	5	
Majority or median [weights not used]		48*	13	6	1	

*Significant increase over unit weights-no learning using Sign Test. $p < .05$

Table 3

Total Harvard, Haverford, and Villanova Groups

[25 Groups, 247 Trials]

Simulation Type		Difference between simulation and actual group decision: 0	1	2	3	Total
Mean: unit weights	No Learning	139	85	21	2	247
	Learning	150	70	24	3	
Mean: seating weights	N. L.	138	77	27	4	
	L.	150	64	26	7	
Mean: interaction weights	N. L.	147	77	21	2	
	L.	154	68	18	7	
Mean: wide cutting points (int. wts.)	N. L.	159*	70	14	4	
	L.	165*	56	15	11	
Majority or median [weights not used]		181**	48	12	6	

*Significant increase over unit weights-no learning using Sign Test $p < .05$

** $p < .001$

Table 4

Vienna Groups

Simulation of Group Decisions

[6 Groups X 10 Trials = 60 Trials]

Simulation Type		Difference between simulation and actual group decision 0	1	2	Total
Mean: unit weights	No Learning	44	16		60
	Learning	47	13		
Mean: seating weight	N. L.	44	16		
	L.	42	17	1	
Mean: interaction weights	N. L.	47	13		
	L.	48	11	1	
Mean: wide cutting points interaction weights	N. L.	47	13		
	L.	47	12	1	
Majority or median [weights not used]		56	4		