A COMPUTER MODEL OF MAN AS AN ORGANIZATIONAL DECISION-MAKER

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ABSTRACT

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By

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A new computer-simulation formal model of Homans' exchange theory, based on the Gullahorns' work but written in FORTRAN and SLIP, is introduced and described. A section of a single run is discussed in detail, and a large-scale multi-run experiment is presented and analyzed using information-theoretic techniques.

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computer. To all of these persons and institutions I extend gratitude and credit, while reserving to myself responsibility for whatever weaknesses remain in spite of them.

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I. INTRODUCTION

The social-psychological theory of George Homans (The Human Group, 1950; Social Behavior, 1961; and "Fundamental Social Processes," 1967) presents an important challenge to workers in the field of formal theory. In his work, most notably the latter two publications, Homans has sketched a very rich and appealing deductive system which points toward explanations of both short-run and long-run regularities in human social behavior. For an overview, ordinary language augmented by a small technical vocabulary serves very well--one can grasp quickly and easily what is meant, and a range of levels of specificity can be used to illustrate a point. However, when it comes to systematically exploring the consequences of any reasonable set of assumptions in a field as complex as human behavior, ordinary language becomes slow and cumbersome. Also, the multiple shades of meaning of words which can be used to advantage in overviews and sketches become a hindrance to the workings of deductive logic unless they

are buttressed with explanatory qualifications. The function of such formalizations as the algebraic model of Herbert Simon (1952) and the formal-logic model of Ronald Maris (1970) is to provide an efficient tool for performing the essentially mechanical tasks involved in deducing the logical consequences of specified assumptions. This leaves the investigator free to do the creative work of first specifying assumptions and postulating and designing the rules by which his postulates will interact, and then analyzing the logical results of these postulates and rules in relation to the social phenomena they are intended to explain. While this is done at the cost of translating the original theory into a less rich and readily grasped language, the advantage is the ready availability of large numbers of deductions whose antecedents we may be certain are completely specified in the original postulates and rules.

Computer simulation is another method of expressing a theory in a form in which deductions can be made with greater ease and rigor than by using ordinary language. As such, it is comparable with the algebraic methods of Simon and the logical methods of Maris. However, it has the advantage that it is practical to specify propositions

and rules of deduction at a very fine level of detail and generate many thousands of intermediate ("micro-level") conclusions. This, of course, is due to the fact that a theoretical model that is expressed in a formal language such as IPL-V or FORTRAN may be acted on directly by a high-speed computer to produce as output the logical consequences of the theory and supporting circumstances ("givens" in the language of Homans) given it as input.

Significant work in the use of computer language as a tool for drawing deductions from Homans' theory has been done by John and Jeanne Gullahorn in their general model of small-group behavior, HOMUNCULUS (1964, 1965), and in more circumscribed areas such as the resolution of role conflict (1971).

This work has been done in a language called IPL-V (Information Processing Language, version V), an early list-processing language. List processing offers numerous advantages over more linear languages such as FORTRAN, most notably the greater ease in adding new categories and information structures both during the development of a model and during the process of producing the deductions to be output from it ("running the program"), since not

all of the kinds of information necessary to complete the deductions need be explicitly specified at the beginning, but only rules for generating new data types as needed. The chief drawbacks of IPL-V as compared with FORTRAN are precisely its advantages as compared with machine language. First IPL-V is more concise and handles housekeeping details more automatically than machine language, but is less concise and "automated" than FORTRAN. Second, for this and other reasons, IPL-V is easier for a human to write and to comprehend than machine language, but less so than FORTRAN. The ease or difficulty with which a person can understand a formal language puts a practical limit on the degree of complexity that can be expressed in the language since even if a computer can process it exactly as presented, the designer can no longer understand his own theory sufficiently to guide the machine and interpret its results. For this and other practical reasons, the Gullahorns have discontinued further work in IPL-V.

Fortunately, a compromise between IPL-V's list processing capability and FORTRAN's greater conciseness and understandability exists. This compromise is the SLIP (Symmetric List Processor, Weizenbaum, 1963) system, which gives FORTRAN list processing capabilities similar

to those of IPL-V, without sacrificing readability or programming ease.* The remainder of this paper is concerned with program MEETING, a new social-psychological formal model of small-group interaction written in FORTRAN-4 using the SLIP system and implemented on a CDC 3600. Following a brief description of the general workings of the model and its relation to Homans' theory, I will give a detailed description of a part of one "run" of the program to illustrate "micro-level" results, and a summary of the results of a 32-run simulation experiment as an example of "macro-level" deductions to be drawn from the model.

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*This discussion of programming languages is not intended as a technical documentation of programming technique, but as an illustration of the relationship between the medium used (algebra, formal logic, IPL-V, or FORTRAN) and the power of the theoretical model.

II. DESCRIPTION OF THE MODEL

Program MEETING is divided into five major segments. The first, and least important to the theory, is the housekeeping or executive section, which performs the various technical tasks necessary to the running of any large computer program. In addition, this section controls the printing of all intermediate and final results produced. (The section consists of the main program and subroutines SENTNC, SOCGRM, AND SUMREE.)

The second major segment of the model corresponds to what Homans calls the "givens" (1961, Chapter 11), that is, those items of information which the theory does not explain, but rather uses to explain other things. These include the number of persons in the group, the set of transaction categories used (adapted from Bales, 1953), and the initial values of all the variables of interest to the theory. Most of the important initial conditions are determined by parameter cards read in at the beginning of each run. These include the "intrinsic" values of acts;

each person's initial task-oriented opinions; measures of his reluctance to change those opinions, his specific social-emotional opinions (liking), and his general social-emotional opinion (group satisfaction); his predefined rank or authority in the group; and a measure of how seriously he takes his rank in comparison with that of others' ("authoritarianism"). These are discussed more thoroughly in the first section of the annotated sample output. The first act, which begins the group interaction, is also treated as "given." (The subprograms manipulating the "givens" are BEGIN, INTRIN, AND UNLIST, although many of the assumptions that occur throughout the model may also be considered givens of the situation.)

The third, fourth, and fifth sections of the model correspond to the stimulus-organism-response paradigm used in many schools of psychology, including behaviorist, cognitive, and humanistic. The third section consists of one subroutine (STIMUL) which allows the group member with the highest desire to talk to emit his selected act or acts, and calls these acts to the attention of the other group members.

When a group member has emitted an act, the other group members witness it and react to it. This is the

fourth, or "Organism," section of the model. They may change their liking for the person who spoke, in which case they will feel an impulse to show either solidarity or antagonism. If a person's level of satisfaction with the group as a whole changes he will be likely to consider showing either tension or tension release. If his opinion is changed by what he hears, he will tend to want to express his new opinion. Finally, if he is the group leader, he may see in the emitted act an occasion that calls for the exercise of leadership. All of these possible acts arise from a person's internal state. No decision is made at this point whether an act so arising will be actually carried out . . . that is a function of the "Response" section.

In addition to the short-term result of giving rise to an impulse toward a specific action, which takes place only when a threshold corresponding to stability of opinion is passed, a person's witnessing of another's act will have long-term effects. Even if the act did not immediately result in a change in the person's task-oriented or social-emotional opinions, it will contribute positively or negatively to the cumulative total of influences which may eventually produce an effect. Thus,

there are long-term effects on opinion, liking, and satisfaction even if the effect is not immediately apparent. The very fact that a given act occurs makes it less valuable the next time it occurs in the near future, according to Homans' fourth proposition. In the computer model, this effect persists for ten acts.

Another long-term effect of receiving or witnessing an act has to do with whether the act is perceived as a reward or a punishment for a previous act. In the model, the simplifying assumption is made that reinforcement effects on acts other than the one immediately preceding the act in question, or an immediately previous act by the same actor, are negligible. This assumption can, of course, be removed at a later time. If these conditions are met, then the person who emitted the act immediately prior to the current act will be somewhat more likely to emit the same act in the future if he found the current act rewarding, and less likely to emit it if he found the current act punishing. If the person was rewarded for his act, he also will be especially likely to emit the act as a response to a repetition of the same stimulus as the one which preceded his act, or even a stimulus similar to it. This is discussed in detail in the annotated sample output.

A final effect on the "internal conditions" of group members when an act is emitted is that each other member's desire to talk is increased by an amount characteristic of him (his "activity level"), plus an additional amount for each of the specific acts that he now has in mind as a result of changes in his task-oriented or social-emotional opinions. (The "Organism" portion of the model is handled in subroutines P5 EVAL, INOPIN, JADED, EMOTH, UPDATE, TOPIC, and REMEMB.)

The final section of the model to be discussed is Response. This section is divided into five parts, one for each of Homans' first four propositions, plus a final decision subsection. (Proposition five is considered part of the Organism section of the model, although its effects become apparent in the Response section.) The order in which the evaluation of considered responses takes place follows the numbering of the propositions in Social Behavior (Homans, 1961).* However, in this discussion the verbal form of the propositions is taken from "Fundamental Social Processes" (Homans, 1967), as the later

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*The naming of subroutines P1 and P2 also follows the 1961 usage.

statement is more in accord with the present model. Everything in this section is seen from the point of view of one individual, the person with the highest desire to talk.

The first part of the Response section is evaluated with Homans' second (1967) proposition, which is:

> If in the recent past the occurrence of a particular stimulus, or set of stimuli, has been the occasion in which a person's activity has been rewarded, then the more similar the present stimuli are to the past ones, the more likely the person is to perform the activity, or some similar activity, now.

In the response model under discussion, the person with the highest desire to talk will attempt to choose a response from a set of three "considered acts" in short term memory, in such a way as to obtain an acceptable level of reward or at least to avoid punishment. Principles derived from Homans' second proposition are used in the first part of the response section to select which three acts will be considered, and in what order. The order is important, because, once an act has been deemed "good enough," no further acts will be considered. This is a "satisficing" rather than an "optimizing" model (Gullahorn & Gullahorn, 1971).

The first step in determining these considered acts involves the internal stimuli provided to a person by

recent changes in his own feelings or opinions, or by the leadership role. These stimuli give rise to tendencies to emit specific acts, as discussed in the Organism section. It is assumed that, under similar circumstances of internal stimulation, the person has been consistently rewarded in the past for emitting these acts, if only by "getting it off his chest." This is essentially what Homans is saying about anger in proposition five,* but here it is generalized to a number of other acts.

If the person had three such desired acts in mind already, the first part of the Response section is complete. Otherwise, the remaining spaces in short-term memory must be filled. If the particular stimulus-act that has just occurred is one that the person has responded to in the past in this group (that is, at an earlier point in the computer run), and his responses to the act have been rewarded more often than punished, then the person will remember which past acts of his were rewarded as responses to this stimulus, and add these acts to his short-term

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*"When a person's activity does not receive the reward he expected, or receives punishment he did not expect, he will be angry, and in anger, the results of aggressive behavior are rewarding" (Homans, 1967).

memory for further consideration until either short-term memory is full (three considered acts) or he has no more previously rewarded responses to the present stimulus to consider.

Again, if short-term memory is full the first stage of response selection is over. Otherwise, the person continues looking for acts to consider. All acts are considered to belong to one of five general categories: Positive Social, Negative Social, Task Questions, Task Answers, and Inaction. If the person's responses in this group (computer run) to the general category represented by the stimulus-act have been rewarded more often than punished, then acts which have been rewarded following any act in the category are brought into short-term memory, up to a maximum of three.

Finally, if short-term memory is still not full, the person engages in what might be termed "exploratory behavior"--he brings his total of considered acts up to three from a list of appropriate responses from his experience outside the present group, that is, from a reference group.

Thus in the first part of the Response section, a person calls to mind three acts from which he will attempt

to choose a response, in a sequence of stimulus-generalization starting with his internal state, followed by the specific external stimulus, a generalized form of the external stimulus, and as a last resort, a similar stimulus in a generalized reference group.

Once this is done the person begins evaluating his three considered acts, in the second through fifth parts of the Response section. The second part corresponds to Homans' First (1967) proposition:

> The more often a person's activity is rewarded, the more likely he is to perform that activity.

This is handled in the computer model by looking up a number in the person's long-term memory which represents how often he has been rewarded for each considered act. (This number is maintained in the Organism section by adding one each time the person is rewarded immediately after emitting this act and subtracting one each time he is punished, to a limit of ± 5.) The number will be used in the last part of the Response section together with other values to determine which (if any) of the three acts will be selected.

Homans' Third proposition,

> The more valuable the reward of an activity is to a person, the more likely he is to perform the activity,

is dealt with in the third part of the Response section of the computer model. The person begins by predicting what response he is likely to receive for each of his three considered acts. The predicted response will be the act following the last time that he has emitted the considered act, or, if he never has emitted the act before, it will be the most appropriate response according to his reference group. The value to the person of receiving this response to his considered act is then associated with the considered act for later use in deciding on the person's actual response. This value is determined in the same way that the value of an act actually witnessed is determined in the Organism section, except that the element due to a change in the other person's opinion is absent, since the person will assume the other's opinion to be unchanged, and satiation is treated separately.

The effects of satiation in the Response section are handled by the fourth part, which corresponds to Homans' fourth proposition:

> The more often in the recent past a person has received a particular reward, the less valuable any further unit of that reward becomes to him.

The "recent past" is here defined as the last ten acts. In the model of a decision-making group as currently programmed, the additional assumption is made that emotional responses decrease in value more rapidly than "constructive" task-oriented actions. This "given" can be altered for future models of other types of group. Satiation is discussed in more detail in the Technical Appendix.

In the last part of the Response section, the act which the person will actually emit is selected. The person examines his three considered acts in order, taking into account his desire (if any) to emit the act as an expression of internal state, how frequently it has been rewarded, and the value and satiation of the response he expects to receive for the act if he emits it. These values are used to determine a "profit" value for the act. As soon as an act is found whose profit is at least as great as the value which the person considers "good enough," that act is selected. If no considered act meets this satisficing criterion, the acts are then examined in order until one is found with a non-negative profit. If all

acts have negative profits, none is emitted, and the selected act is "doing nothing."

Once an act has been selected, the person's desire to emit any suppressed actions that he has considered but not chosen is reduced. At this point the Response section is complete and the chosen act will be the act emitted in the Stimulus section of the next iteration of the model.*

(The Response section of the program consists of subroutines P1, P2, P3, INTRIN, P4, JADED, and CHOOSE.)

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*In the model of a decision-making group currently programmed, an additional step occurs if the selected act is the "unsafe" one of showing antagonism to a person with higher rank. In this case, the act is changed to one of showing tension, and a desire to show tension again is also stored, since the negative affect is not completely expressed by showing tension just once.

III. ANNOTATED SAMPLE OUTPUT

A. Parameters (Table 1)

The first part of the output produced by a run of the simulation program is a copy of the 43 input parameters used in that run. This can be seen in Table 1. In the computer output, the numbers appear on four lines, in the same format as the four input cards that were used to specify them.

The first line contains the relative "intrinsic" values of each of the thirteen interaction categories used. This is its value as a reward as used in proposition three. The simplifying assumption is made that these initial values are the same for all three members of this group, although the effective value of an act when a person receives or expects to receive it will vary with the circumstances and his experiences in the group, especially due to the effects of proposition four (satiation) and proposition five (expectation or justice). The thirteen numbers

TABLE 1

INITIAL PARAMETER SETTINGS

A. Intrinsic Reward Values of Acts

Interaction Category	1	2	3	4	5	6	7	8	9	10	11	12	13
Value*	4	4	5	4	2	3	3	3	3	0	0	0	0

(*In the runs under consideration, these values were identical for all three members.)

B. Initial Attributes of Group Members

	Rank	Activ. Level	Satis. Crit.	Liking Thrsh.	Group Satia. Thrsh.	Chnge. Opin. Thrsh.	Opinion on			Author-itarian
							Topic 1	Topic 2	Topic 3	
Ted	4	1	2	20	30	20	4	2	2	1
Frank	2	2	2	15	25	10	2	4	4	1
George	2	1	2	15	25	10	6	6	4	2

apply respectively to the twelve Bales interaction categories and to "doing nothing."

Part B of Table 1 shows the personal attributes of group members which are specified at the beginning of a run to be used by the model in decision making. The first row refers to attributes of Ted, the second to Frank, and the third to George. Column one is the "rank" of each person--this is an element in how much attention is paid to his opinions by the others, and also determines whether it is "safe" to show antagonism towards him openly.

Column two of the individual parameters contains the "activity level" of each member, which determines how frequently a person will initiate acts, other things being equal. In the sample run, Frank, who has a slightly higher activity level than the others, emitted 62 out of a total of 150 acts.

The third individual parameter, which is the same in this run for all three members, is the satisficing criterion, or the level of anticipated profit that will lead the person to emit a considered act without evaluating further alternatives.

The next two columns are measures of "emotional restraint" in the decision-making group setting. The first

of these is the threshold for the person to change his liking for another individual group member and to consider indicating this by a show of solidarity or antagonism. The parameter in column five is the threshold for the person to change his level of satisfaction with the general trend of the group process. Since the events which influence this satisfaction occur more frequently, this parameter will always be larger than the one for individual liking for a given person. When the threshold is passed, the person will change his evaluation of the group as a whole, and consider indicating this change by showing either tension or tension release.

The value in column six is also a threshold, representing the individual's reluctance to change his opinion. He will change his mind and consider expressing his new opinion only if the net effect of cumulative influences exceeds this threshold. In the sample run, the leader, Ted, because of his higher status and the pressures on him from his superiors outside the group, is assumed to have a higher threshold than do Frank or George.

Columns seven through nine contain the initial opinions held by the members on the three topics the group is to discuss. In the sample output, Ted is placed into a

different relative position on each of the three topics. With regard to the first topic, his initial opinion is intermediate between those of Frank and George. (These opinions, "4" for Ted, "2" for Frank, and "6" for George, can be interpreted as representing some kind of courses of action or evaluations. Thus, Frank might assess a particular product as being quite unimportant to the total sales effort while George is wildly enthusiastic about it and Ted considers it of middling importance.) In contrast, Ted is in an extreme position on topic two, holding an opinion of "2" compared with Frank's "4" and George's "6"; and on the third topic, Ted is a deviate (again with opinion "2"), and the other two are initially in agreement on opinion "6."

The last of the parameters read at the start of a run is printed in column ten. This value represents a person's level of authoritarianism, and is used when a person is evaluating an opinion expressed by someone else, as a weighting factor for the effect of the rank of the other person. Thus, because of Ted's higher rank in the sample run, George, who is more authoritarian than the others, will attach relatively more importance to Ted's opinions than he will to Frank's opinions.

A final initialization step which is performed automatically by the program and not printed out is to give each member a moderately positive "liking" of 2 for each other member.

Once the initial state of the group has been specified, the computer begins the process of alternately deducing a "next action" from group state, and a new group state from the previous state and the new activity. This continues until the previously determined number of acts (usually 150) has been deduced.

B. Acts 1-10 (Table 2)

1. TED ASKS FOR OPINION
   ON 1 FROM GEORGE

The initial act shown in Table 2 is arbitrarily assigned by the program in order to get the process of social exchange under way. Thus, the columns corresponding to Ted's reason for acting as he does are meaningless. The only numbers of importance on the right-hand side of the first line are those under the headings of SAT, FRN, and GEO.

TABLE 2

DATA BASE FOR CHOOSING AND EMITTING FIRST TEN ACTS

	SAT	TED	FRN	GEO	ACTOR	ACT	RWD	RSP	VAL	SAT	DES	SOURCE
1 TED ASKS FOR OPINION ON 1 FROM GEORGE	0	0	0	4	0	0 0	0	0 0	0	0	0	0
						0 0	0	0 0	0	0	0	0
						0 0	0	023	0	0	0	0
2 GEORGE GIVES OPINION 6 1	0	3	3	-0	15	→51 7	0	3 3	5	0	10	→A
						3 1	0	51 7	2	0	0	D
						61 7	0	3 3	5	0	0	D
3 FRANK DISAGREES WITH GEORGE	0	0	-0	-5	5	→10 3	0	3 2	5	0	0	→D
						51 7	0	3 2	5	0	0	D
						61 7	0	3 2	5	0	0	D
4 GEORGE DISAGREES WITH FRANK	1	-1	-6	-0	5	→10 2	0	3 3	5	0	0	→D
						51 7	-1	10 3	0	3	0	D
						61 7	0	3 3	5	0	0	D
5 FRANK GIVES OPINION 2 1	1	1	-0	-4	5	10 3	-1	10 2	0	4	0	D
						→51 7	0	3 2	5	0	0	→D
						61 7	0	3 2	5	0	0	D
6 TED DISAGREES WITH FRANK	3	-0	-9	-4	5	→10 2	0	3 1	5	0	0	→D
						51 7	0	3 1	5	0	0	D
						61 7	0	3 1	5	0	0	D
7 GEORGE DISAGREES WITH TED	3	-9	-4	-0	5	→10 1	0	3 3	5	0	0	→D
						51 7	-1	10 3	0	4	0	D
						61 7	0	3 3	5	0	0	D
8 FRANK GIVES ORIENTATION ON 1	0	4	-0	-1	5	10 3	-1	10 2	0	7	0	D
						51 7	-1	10 2	0	7	0	D
						→61 7	0	3 2	5	0	0	→D
9 TED GIVES ORIENTATION ON 1	1	-0	-2	3	5	3 2	0	51 7	2	3	0	D
						→61 7	0	3 1	5	0	0	→D
						51 7	0	3 1	5	0	0	D
10 FRANK DISAGREES WITH TED	5	-12	-0	-7	5	→10 1	0	3 2	5	0	0	→D
						61 7	-1	61 7	3	3	0	D
						51 7	-1	10 2	0	7	0	D

The zero under SAT simply indicates the obvious fact that nothing like the act in question has happened recently. The 4 under GEO shows that George's satisfaction with Ted's act is equal to 4. This is the intrinsic value of act 8 from the first parameter card (equal to 3) minus George's expected reward (here zero because Ted is not replying to an act from George) plus half the current value rounded down (which equals 1). The sum, as indicated, equals 4. Frank's satisfaction, indicated by the heading FRN, is equal to zero because the intrinsic value of act 8 when addressed to a person to whom one has a liking of 2, given the fact that this act has a value of 3 when addressed to oneself, is computed by the formula Value X liking/10, here giving an answer of 3/5 which is rounded down to zero.

The value to Ted of his own act, as well as his motivation for emitting it, are also undefined.

2. GEORGE GIVES OPINION 6 1

This event is the obvious response to the previous one--Ted asks for George's opinion, and George gives it. This is what will happen in general, "other things being

equal," and that condition is a good description of the early stages of this simulation run.

The mechanics of how this act may be deduced from the group situation using the theory embodied in the computer model is summarized in the printout as follows.

The entry →51 7 under the heading ACT means that the act is act 5, giving opinion, it is on topic number 1, and it is addressed to the group (signified by a 7 in the column for the recipient of the act). The arrow indicates that this was the considered act that was actually chosen. The zero under the heading RWD means that this act has neither been rewarded nor punished following the stimulus act (event 1). The entry 3 3 under the heading RSP indicates that George expects someone to agree (act 3) with him (person 3) in response to his act. Under the heading VAL 5 gives the intrinsic value of being agreed with; 0 under SAT indicates that George is not at all satiated with this reward; and 10 under DES gives the relative strength of his desire to emit this particular act apart from considerations of rewards and punishments. This desire, in this case, is due to an internalized norm that direct questions should be answered. Finally, the A under SOURCE means that the reason this act is being considered is that George has

a positive desire to emit it; that is, the discriminative stimulus is internal.

The next two rows of entries under these seven headings correspond to the other two acts that George would have considered emitting had he not decided immediately on the first one. They are interpreted in the same way as for the chosen act, except that no "profit" value is computed because George's motivation to emit his first considered act is great enough that he doesn't bother to evaluate the other two.

The number 15 under the heading ACTOR gives us the strength of George's motivation to emit the act. In this case it is quite high, since both his internalized norm of question-answering and his expectation of reward (being agreed with) favor the act. George's satisfaction with the act as a stimulus is left undefined (indicated by the -0 under the heading GEO) since it is his own act. FRANK's satisfaction, under the heading FRN, is found by the formula: current value - expectation + current value/2. The intrinsic value of an opinion one does not agree with was defined for this run to be a, since it is seen as contributing to the talk at hand. The type of act in question has never occurred before, so satiation is zero (as

indicated under the heading SAT) and the current value is the same as the intrinsic value. Therefore, Frank's satisfaction is 2-0+2/2 = 3. Since TED's previous act was arbitrarily assigned as a "given," his expected reward for the act cannot be determined in the usual way. It is assumed to be zero, so Ted's satisfaction with George's act is 3, the same as Frank's satisfaction.

(The numbers in the printout of GEORGE's act on the left-hand half of the page refer to the fact that the opinion expressed is content code 6 on topic 1. This is George's initial opinion on this topic, taken from the input parameters.)

3. FRANK DISAGREES WITH GEORGE

With the third action, the small-group simulation is in full operation, since MEETING is built on a theory that considers the three-event sequence of stimulus-response-reinforcement. Frank has not encountered the present stimulus before in this group, so his three considered acts (10 3, 51 7, and 61 7--interpreted as above, or see Table 3) are derived from his reference group norms regarding appropriate responses. These "norms" are in

TABLE 3

SUMMARY OF POSSIBLE ACTS

Act	Code	Meaning
1	1	To show solidarity with TED
1	2	To show solidarity with FRANK
1	3	To show solidarity with GEORGE
2	7	To show tension release
3	1	To agree with TED
3	2	To agree with FRANK
3	3	To agree with GEORGE
41	7	To suggest Topic one
42	7	To suggest Topic two
43	7	To suggest Topic three
51	7	To give opinion on Topic one
52	7	To give opinion on Topic two — Seven possible
53	7	To give opinion on Topic three — content codes
61	7	To give orientation on Topic one — for each
62	7	To give orientation on Topic two
63	7	To give orientation on Topic three
71	1	To ask for orientation on Topic one from TED
71	2	To ask for orientation on Topic one from FRANK
71	3	To ask for orientation on Topic one from GEORGE
72	1	To ask for orientation on Topic two from TED
72	2	To ask for orientation on Topic two from FRANK
72	3	To ask for orientation on Topic two from GEORGE
73	1	To ask for orientation on Topic three from TED
73	2	To ask for orientation on Topic three from FRANK
73	3	To ask for orientation on Topic three from GEORGE
81	1	To ask for an opinion on Topic one from TED
81	2	To ask for an opinion on Topic one from FRANK
81	3	To ask for an opinion on Topic one from GEORGE
82	1	To ask for an opinion on Topic two from TED
82	2	To ask for an opinion on Topic two from FRANK
82	3	To ask for an opinion on Topic two from GEORGE
83	1	To ask for an opinion on Topic three from TED
83	2	To ask for an opinion on Topic three from FRANK
83	3	To ask for an opinion on Topic three from GEORGE

TABLE 3 (continued)

Act Code	Meaning
9 1	To ask for a suggestion (topic) from TED
9 2	To ask for a suggestion (topic) from FRANK
9 3	To ask for a suggestion (topic) from GEORGE
10 1	To disagree with TED
10 2	To disagree with FRANK
10 3	To disagree with GEORGE
11 7	To show tension
12 1	To show antagonism toward TED
12 2	To show antagonism toward FRANK
12 3	To show antagonism toward GEORGE
13 7	To do nothing

fact adapted from Bales' early experiments with decision-making groups in the laboratory (Bales, 1953, p. 120), and are shown in Table 4. The three "appropriate responses" used are the three most common responses to the act in these real groups. When agreement is selected but is not actually appropriate to the situation, disagreement is substituted. Thus, when Frank is deciding how to respond to George's expression of opinion, the first thing he considers is commenting on the last act. Since the last event was an opinion which differs from Frank's, "commenting" becomes "disagreeing" with George, act 10 3 under the

TABLE 4

REFERENCE GROUP NORMS (APPROPRIATE RESPONSES)

Stimulus Act No.	Meaning	Appropriate Responses
1	To show solidarity	1, 5, 6
2	To show tension release	2, 5, 6
3	To agree (evaluate)	5, 6, 3
4	To give suggestion	3, 5, 6
5	To give opinion	3, 5, 6
6	To give orientation	3, 6, 5
7	To ask for orientation	6, 5, 3
8	To ask for opinion	5, 3, 6
9	To ask for suggestion	4, 5, 2
10	To disagree	3, 5, 6
11	To show tension	5, 6, 11
12	To show antagonism	12, 2, 5
13	To do nothing	7, 8, 9

Based on Bales, 1953, p. 120.

heading ACT. This has not been rewarded or punished (RWD = 0), and Frank (again consulting his reference group, and interpreting "comment" optimistically as "agree") expects someone to agree with him (act 3 2 under RSP) in his disagreement with George. This has an intrinsic value to Frank of 5, and he is neither satiated with the reward (SAT = 0) nor eager to emit the act as such (DES = 0). Since the resultant value of 5 (printed under ACTOR) is greater than Frank's satisficing criterion (2, from parameter input), he selects this first act to emit, without further consideration of the other two possibilities.

Once Frank has emitted his act, the other two persons evaluate it. The zero in the first column labeled SAT indicates that this kind of act has not occurred recently. George's satisfaction with this act is thus the current value to him (0 intrinsic value - 0 satiation = 0) minus his expected reward (5 intrinsic value - 0 satiation = 5) plus half the current value to him of the actual act (0/2 = 0), which adds up to minus 5, as printed under the heading GEO. Since Ted's expectation is zero and the act has zero intrinsic value and zero satiation, Ted's

satisfaction with Frank's act is zero. The entry -0 under FRN, as usual, indicates that Frank was the person who emitted the act.

4. GEORGE DISAGREES WITH FRANK

In the first three events, each of the three group members spoke once. The principal reason that George speaks next, rather than Ted who has been silent longest or Frank who has the highest interaction rate, is that George has retained some residual desire to keep talking after answering a direct question in event 2. In general, the selection of the next speaker is a summation of a number of weak effects of time, activity rate, and desire to emit specific acts. The overall effect is to give some preference to those with something definite to say, taking into account time spent without talking and individual activity rate.

Once George has decided to talk, he consults his reference group norms (Table 4) for appropriate responses to this stimulus, which he has not reacted to before in this group meeting. The first act he finds is number 3, to comment on the previous event. In this case, the

previous event is disagreement, which is defined as a social-emotional act. As such, George evaluates the action in terms of its reward value for him. Since he found the act punishing (see entry -5 under GEO for event 3), he evaluates it negatively, and so his considered response is converted from 3, "agrees," to 10 "disagrees."

Since he has not been rewarded or punished for this (RWD = 0) and expects someone to agree with him (RSP = 3 3, for reasons similar to Frank's reasons on event 3), with value 5 and no satiation or desire, his motivation to emit this act is 5, as printed under ACTOR, and this act is chosen to be emitted. (The "D" under source again indicates that the act is from experience outside this group.)

Event four is the second negative social act that has occurred, but the first time anyone has disagreed with Frank. Therefore, the group's satiation to this act is one (see the Technical Appendix). Ted is in the position of spectator to event four, as he was to event three, so his satisfaction with event four is one less, or -1, due to his increased satiation. Frank, the recipient of this act, has a satisfaction of -6, which is one less than George's satisfaction with the previous act, since George was then the recipient and had the same expectations Frank

now has, but less satiation. George's satisfaction with his own act is undefined, shown by -0.

5. FRANK GIVES OPINION 2 1

Event five is the first time in this run that a person decides not to do "The first thing that comes into his mind." Since Frank has never responded to the stimulus of disagreement with him before, he consults his reference group norms for appropriate responses. The first one he remembers (Table 4) is act 3, to agree, which becomes 10, to disagree, because Frank found the stimulus act unrewarding. Moreover, Frank recalls (in subroutine P2) that he has been punished in the past for emitting this act more often (once) than he has been rewarded for it (never; RWD = -1). This is a count against the act, but Frank continues considering it, in the hopes that maybe this time will be different. In subroutine P3, he recalls the most recent response he has received following his emitting act 10 3, and finds that it is act 10 2, to disagree with Frank. This has no intrinsic value to him (VAL = 0) and a relatively high satiation of 4 due to the fact that both this exact act and another one like it have occurred recently

and the act is a social-emotional one, which satiates faster than task-oriented acts in this particular group. Since Frank has no desire to emit this act for its own sake, his motivation for it is RWD - SAT, or minus 5. Thus, this act is rejected as a possible response, and Frank goes on to consider the second possibility.

Next on the list of appropriate responses to a disagreement defined by Frank's reference group (Table 4) is act 5, giving opinion. Since the preceding event was a social-emotional act rather than addressed to a specific task-oriented topic, the current group topic (topic one) is assigned to the considered act. Opinions are always addressed to the group; so Frank's second considered act becomes 51 7. Since Frank has not emitted this act before, he has not been rewarded or punished, so RWD = 0. He consults his reference group for a likely response to his act (again since he has no relevant experience in this group), and assumes it will be 3 2, agreeing with Frank. This has an intrinsic value of 5 and no satiation or desire, so Frank's motivation to emit the act 51 7 is equal to 5. Since this is greater than his criterion for an act that is rewarding enough to emit (=2 from input parameters), Frank decides to state his opinion on topic one.

Since this is the second time that someone has given an opinion on this topic recently, but the actor is different, the amount of the group's satiation is one (first column labeled SAT). As Ted was not the previous speaker, his satisfaction with the act is the intrinsic value of an opinion different from his own minus his satiation (2-1 = 1) plus half this difference, rounded down, which is equal to one, as printed under Ted. Since George had expected an act with a value of 5, his satisfaction is five less than Ted's, or -4.

6. TED DISAGREES WITH FRANK

Ted's motivation for choosing this act is essentially the same as Frank's motivation for event 3 above. The satisfaction, both of the recipient (Frank in event 6, George in event 3) and of the spectator (George in event 6, Ted in event 3) are lower here because this is the third time this type of act has occurred recently, rather than the first.

7. GEORGE DISAGREES WITH TED

George is here disagreeing with Ted for the same reason he disagreed with Frank in event 4. Note that he still expects to be agreed with in this action. This is because he has never disagreed with Ted before, and remains optimistic in spite of his bad experience in disagreeing with Frank. The reactions of the corresponding recipients and spectators are again lower due to satiation.

8. FRANK GIVES ORIENTATION ON 1

Since Frank still has never been rewarded for his responses to a disagreement or to any negative social act, he again consults the reference-group norms on appropriate responses. However, he has already tried the first two of these, commenting (disagreeing) and giving an opinion. He has been punished once more than rewarded for both responses (RWD = -1 in each case) and the most recent response he has received is also the same--disagreement with Frank, with zero intrinsic value and a satiation of seven. Therefore, both his first alternatives have a motivation of -8. Frank then considers his final alternative, giving orientation. The topic of his action is defined as the

current group topic, 1, and all orientation is addressed to the group, so the action code is 61 7. This act has never been rewarded or punished, and Frank's experience outside this group leads him to expect someone to agree with him.

This being the first time anyone has given orientation, the group's satiation to this act is zero. Ted's satisfaction with it is 4, based on the formula in P5 EVAL and the input parameter for the intrinsic value of orientation (category 6). Frank's satisfaction is, as usual, shown as -0 since it is his act, and George's satisafaction is minus one because he expected agreement, with value 5, instead of orientation.

9. TED GIVES ORIENTATION ON 1

Event 9 is the first time that someone has rejected an alternative act with a positive intrinsic value. The first appropriate response to orientation that TED finds in his reference-group memory is act 3, to comment on the preceding act. Since Ted found the preceding act rewarding (current and relative value both nonnegative--see discussion under P5 EVAL), this becomes act 3 2, to agree with

Frank. Ted has not been rewarded or punished for this act. He expects someone to give an opinion following his agreement, on the basis of reference-group experience (Table 4). To evaluate this potential "reward," he assumes that the speaker will be Frank, the person who last spoke. Frank has expressed an opinion different from Ted's, so Ted expects an intrinsic reward of 2, the value of an opinion different from one's own. Ted's satiation to the expected act, however, is equal to 3. Thus, in the absence of a specific desire to emit this act, Ted's motivation to do so is -1, and the alternative is rejected. This demonstrates the dynamic interaction of Homans' third and fourth propositions.

After rejecting the first "appropriate response" to Frank's orientation, Ted considers the second act on the relevant set of responses in his "reference group" memory. This is act 6, to give orientation to the group. The topic is the same as that of the previous event, topic one, so Ted's second considered response is 61 7. Ted's motivation for this action is exactly the same as Frank's motivation for the preceding event, with a value of 5, so, since this exceeds Ted's satisficing criterion of two, Ted

chooses this act to emit. The reward he expects to receive is to have someone agree with him, act 3 1.

The group's satiation to orientation is equal to one. Ted's satisfaction is undefined (-0). Frank's satisfaction is equal to minus two because Frank expected agreement, with a current value to him of 5, and received instead orientation, with a current value of 2 (2-5+2/2 = -2 by formula in P5 EVAL). Since George had no expectation of a specific reward, his satisfaction is (2-0+2/2), or +3.

10. FRANK DISAGREES WITH TED

Frank's reasons for emitting this act are essentially the same as George's reasons for disagreeing with Ted in event 7; that is, reference-group experience suggests commenting on a stimulus act, the stimulus is neither rewarding nor an opinion, so the act becomes disagreement with the stimulus actor (Ted). In both cases, this is an act the respective Ego (Frank in event 10, George in event 7) has never tried before, but expects to be received with agreement, on the basis of the reference-group. It is interesting to note that five of the six possible actor-recipient pairs for the act of disagreement have occurred

in the first ten events of this run. Thus, the beginning of the simulated group meeting is spent in discovering how much disagreement actually exists, and in shattering some unfounded optimism, notably the theory "if I disagree with him, he or someone else will agree with me." The fact that no more overt disagreement is expressed in this particular run until event 143, and that there it is the remaining pairing that has not yet been tried (TED DISAGREES WITH GEORGE) is a crude, but dramatic, illustration of the learning capabilities of the simulated persons.

Since the group's satiation with disagreement has by event 10 reached the value of 5, and the intrinsic value of the act is zero, George's satisfaction with Frank's action is minus seven (-5-0-5/2 = -7-1/2 truncated to -7, by formula in P5 EVAL), while Ted's satisfaction is even lower (-12) because he expected to be agreed with, with a value of five.

C. Ten-Act Printouts (Table 5)

After each ten events Program MEETING prints the current group topic (100 = topic one, 200 = topic two,

TABLE 5

LIKING AND OPINIONS AT THE END OF TEN ACTS

	Liking for Ted	Liking for Frank	Liking for George	Satis. with Group	Opinion on Topic 1	Opinion on Topic 2	Opinion on Topic 3
Ted	99	2	2	0	4	2	2
Frank	2	99	2	0	2	4	6
George	2	1	99	0	6	6	6

From Computer Output.

300 = topic three) and a brief summary of each person's feelings and beliefs. This summary is in the form of a 3 x 7 matrix of numbers at the bottom of each page of acts. The three rows correspond to the three group members, as labeled. The first three columns correspond to liking for Ted, Frank, and George, respectively, with the "99" entries in the main diagonal indicating that an individual's liking for himself is undefined in the context of this simulation. Column four is an individual's cumulative satisfaction with the group ("liking" for the group), and columns 5, 6, and 7 contain his opinions on topics 1, 2, and 3 respectively.

The summary contained in Table 5 shows the initial values of these variables, with one exception, George's liking for Frank, which was initially 2 but has become 1 after the first ten acts. In the computer run George is about to express this change by showing antagonism toward Frank.

These summaries at the bottom of each page of events, when reviewed in sequence, give an idea of the progress of the group meeting, both emotionally and in terms of the task (reaching agreement on the three topics). The final summary after 150 acts (Table 6) shows this group to be a rather successful one. Agreement has indeed been reached on all three topics; George is highly satisfied with the group and both of his co-workers; Ted (the leader) is only a little less so, and Frank has at least developed some liking for Ted, although his liking for George is no more than it was originally and his cumulative satisfaction is only one unit (on a -5 to +5 scale).

TABLE 6

LIKING AND OPINIONS AT THE END OF 150 ACTS

	Liking for Ted	Liking for Frank	Liking for George	Satis. with Group	Opinion on Topic 1	Opinion on Topic 2	Opinion on Topic 3
Ted	99	4	4	3	4	3	3
Frank	4	99	2	1	4	3	3
George	5	4	99	4	4	3	3

From Computer Output.

D. Who-to-Whom Summaries

At the end of any page (group of ten events) in which the group comes to a decision on one of the three topics, the program (in subroutine SUMREE) prints out a summary of how many times each person has emitted each of the thirteen types of acts (12 Bales interaction categories plus act 13, doing nothing) to each other person or to the group. Also printed is the total number of acts which each person has emitted to each other person and to the group (rightmost column of numbers), and the total

number of acts of each type that have been emitted (bottom row).

IV. MACRO-LEVEL SIMULATION EXPERIMENT

As a demonstration of the sort of "macro-level" deductions which can be made from the expression of theory found in MEETING, a simulation experiment was designed and run. First, two personality types, "rigid" and "flexible," were defined using particular sets of values on the input parameters, as discussed in the first section of the Annotated Sample Output. Compared with the "flexible" personality, the "rigid" is slower to show emotion (higher liking-change and satisfaction-change parameters), less ready to change his opinions, and more authoritarian. Using these two personality types, four types of group composition were defined. In each group there are one high-status leader, of either "rigid" or "flexible" personality, and two low-status followers, who are of the same personality type as each other but may be either the same as or different from the leader.

Next, a set of sample tasks was devised. Each simulated group was presented with three tasks. A "task"

is a topic on which the three group members have initially differing opinions and attempt to come to a unanimous consensus. On one topic (X), the leader initially holds a "middle" opinion, one follower is "high," and the other is "low." Topic X is always presented first. On another topic (Y), the leader initially holds a "low" opinion, while one follower holds the "middle" opinion and another holds the "high" initial opinion. On another topic (Z), the leader again holds a "low" opinion while both followers hold the "high" opinion.

The third major variable (after leader personality and follower personality) to be considered is task difficulty. In an "easy" task set, opinions are represented by the integers 3, 4, and 5 for "low," "middle," and "high" opinions respectively, while in a "difficult" task set these opinions are represented by the integers 2, 4, and 6. Since the intervals are doubled, the 3 topics comprising the "difficult" task set may be thought of as being twice as hard as the "easy" one.

If each group situation is paired with each level of task difficulty, we have eight kinds of group situation, which will be denoted by a three-letter symbol describing, in order: the leader personality, the follower personality,

and the task difficulty. Thus, an RFE would have a "rigid" type leader, two "flexible" type followers, and an "easy" task.

In order to provide a basis for assessing the importance of these three variables and determining the stability of their effects, four groups of each of the eight types were created by varying (a) whether topics are presented in the order XYZ or XZY, and (b) whether follower #1 (Frank) or follower #2 (George) holds the "high" opinion on topic Y. These noise variables do not, however, enter directly into the analysis. Instead, each of the eight group composition-task difficulty types will be represented by four examples differing only on the two unanalyzed variables, yielding thirty-two groups in all.

For each group, five overall outcome variables were derived from the large amount of detailed group-process information available. The first variable, mean liking, is the average of the six numbers representing each member's liking for each of the two others at the end of 150 acts. The second variable, mean satisfaction, is the average of the three numbers representing each member's satisfaction after 150 acts. The third outcome measure, called factionalism, is the population standard deviation of the six

liking values used in computing mean liking. It measures whether group members feel about the same about each other, or there exist strong divisions within the group. The fourth outcome variable, task success, is a ranking from 1 (most successful) to 32 (least successful). The twenty groups who reached unanimity on all issues are ranked (1 to 20) on how quickly unanimity was reached, while the remaining twelve are ranked (21 to 32) on how close to agreement they were at the end of 150 acts.

A cutoff point on each of these four outcome variables was defined, assigning each group as "good" or "bad" on each of the variables. The fifth outcome variable for a group is then defined as the number of "good" outcomes on the first four variables for the group. On the first three variables (liking mean, satisfaction mean, and factionalism), the median was used as the cutoff to divide good outcomes from bad outcomes. For task success, the natural cutoff point of achieving unanimity versus remaining in disagreement was used. Finally, an overall "good" group was defined as one with 3 or 4 good outcomes on the first four measures, and a "bad" group as one with 0, 1, or 2. The results are displayed graphically on the following pages (figures 1 through 5). Each of the eight types of groups

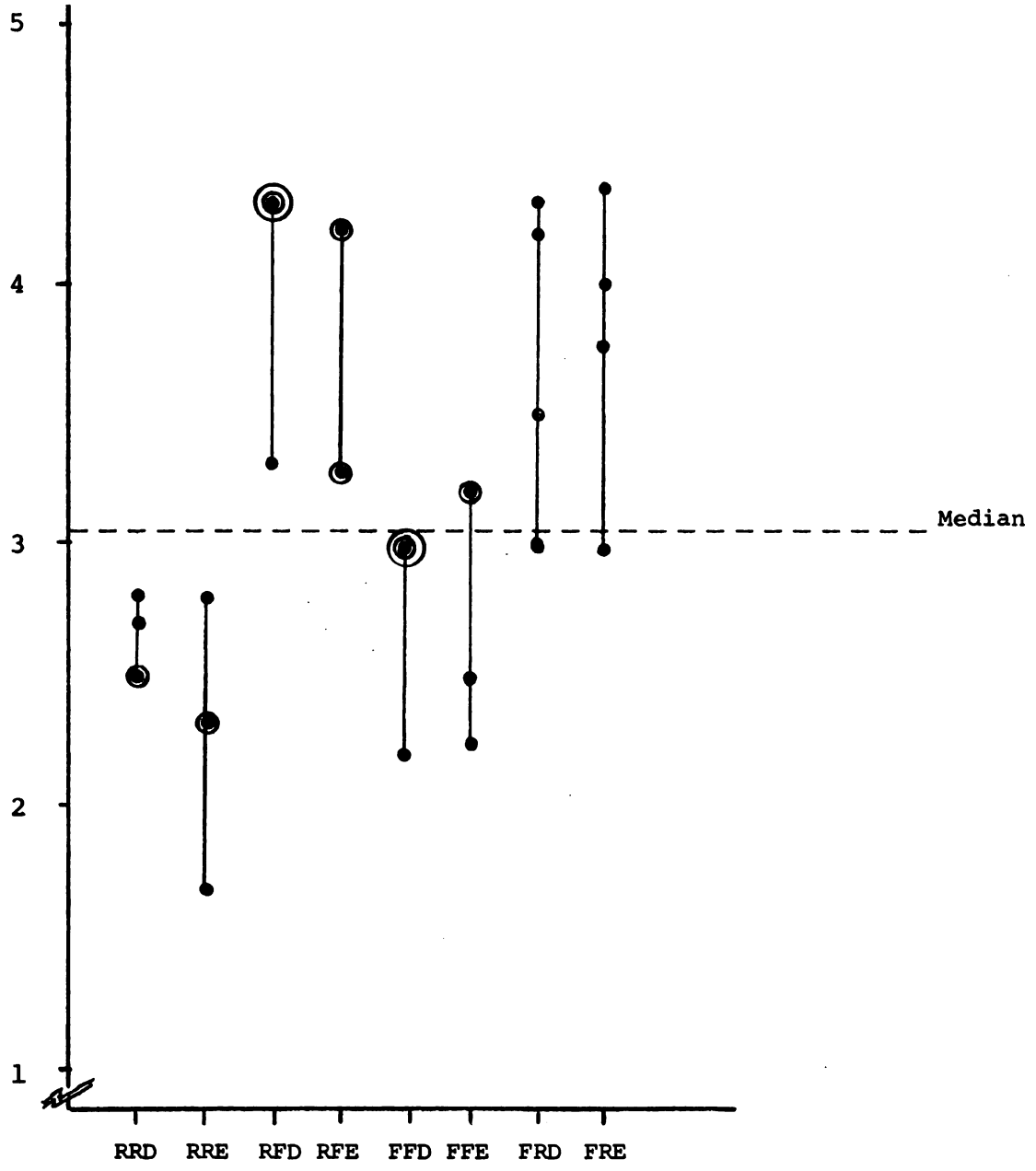

Fig. 1.--Mean Liking.

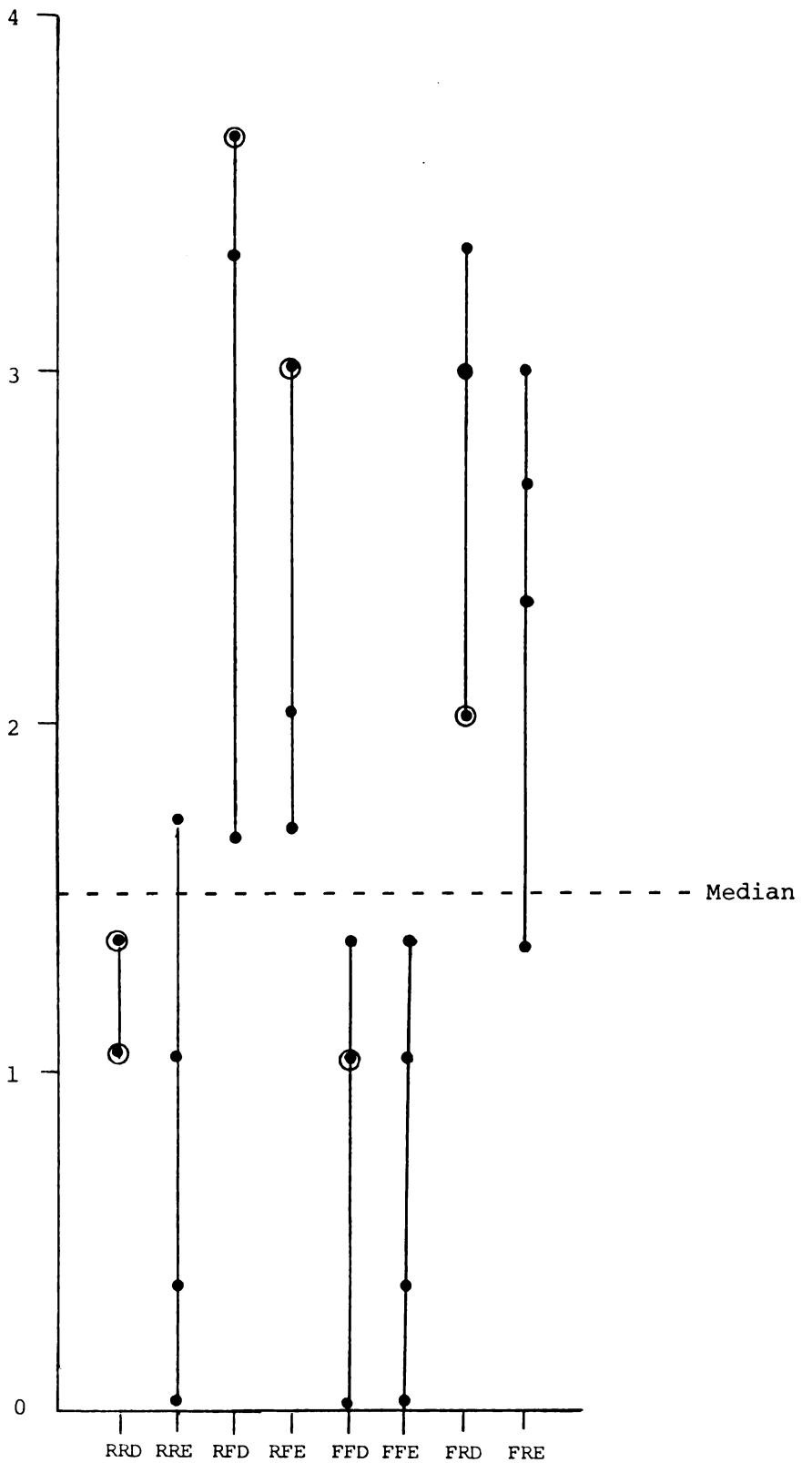

Fig. 2.--Mean Satisfaction

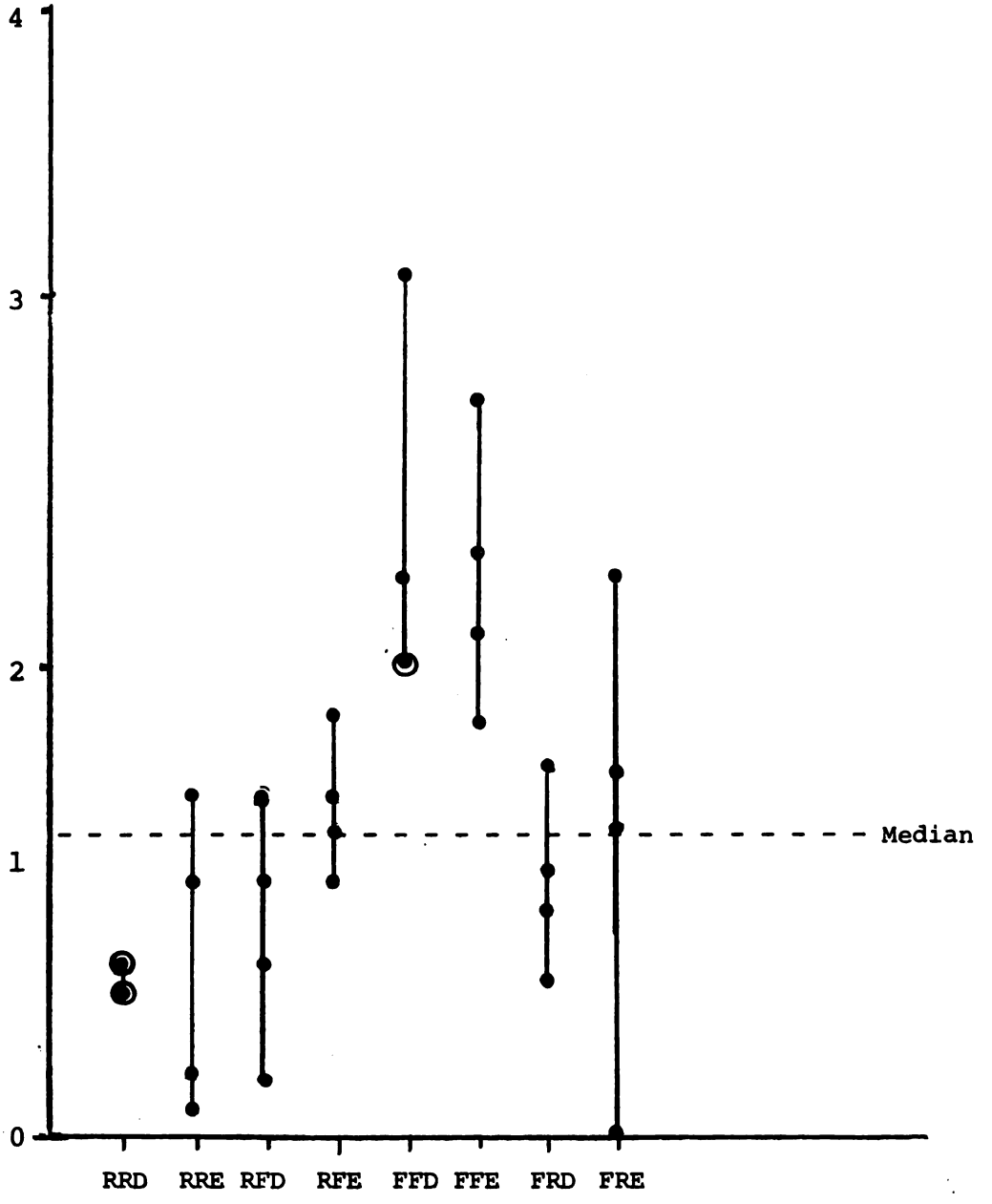

Fig. 3.--Liking Variance (Factionalism).

Rankings: Most successful = 1, Least successful = 32

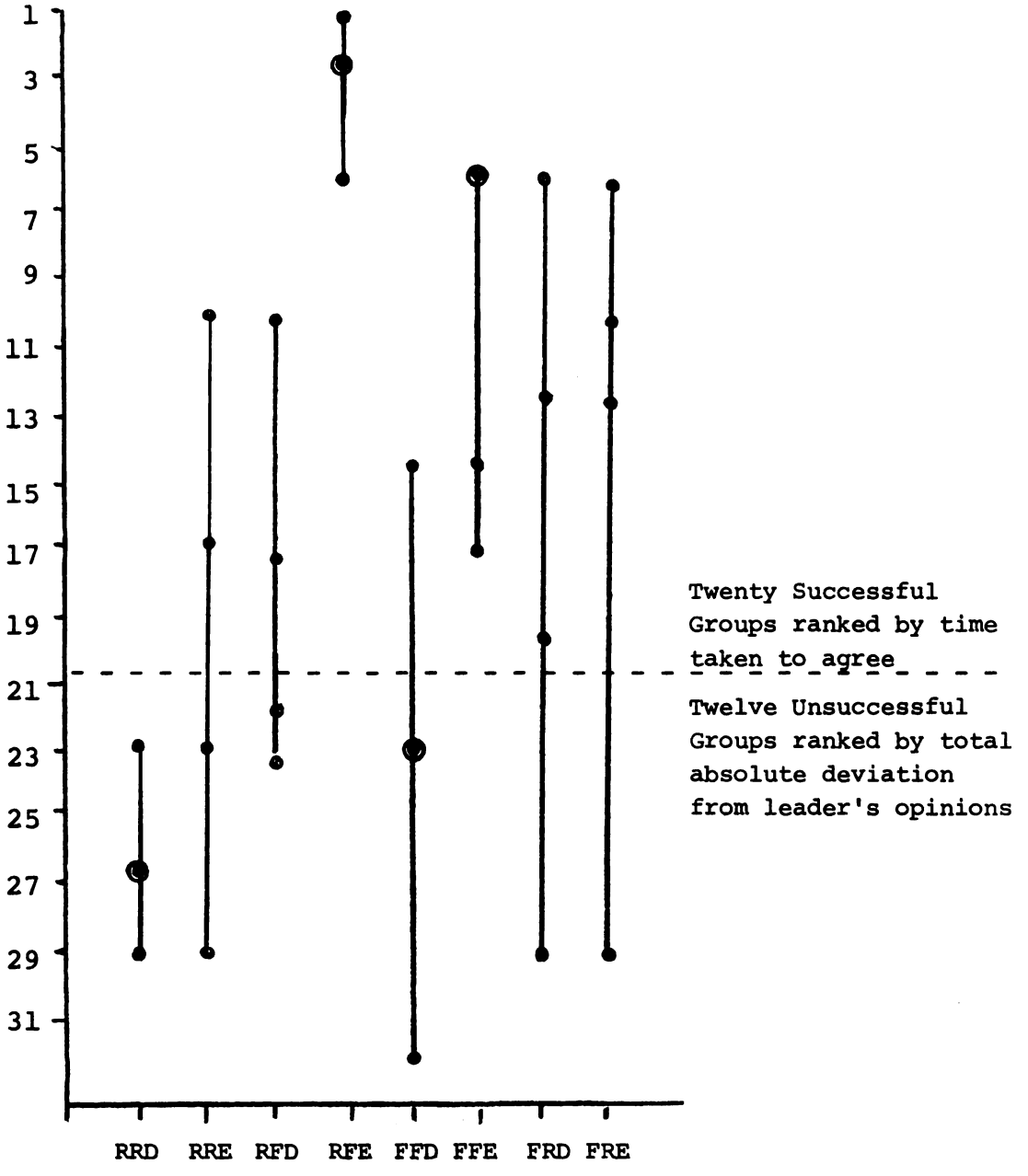

Fig. 4.--Task Success.

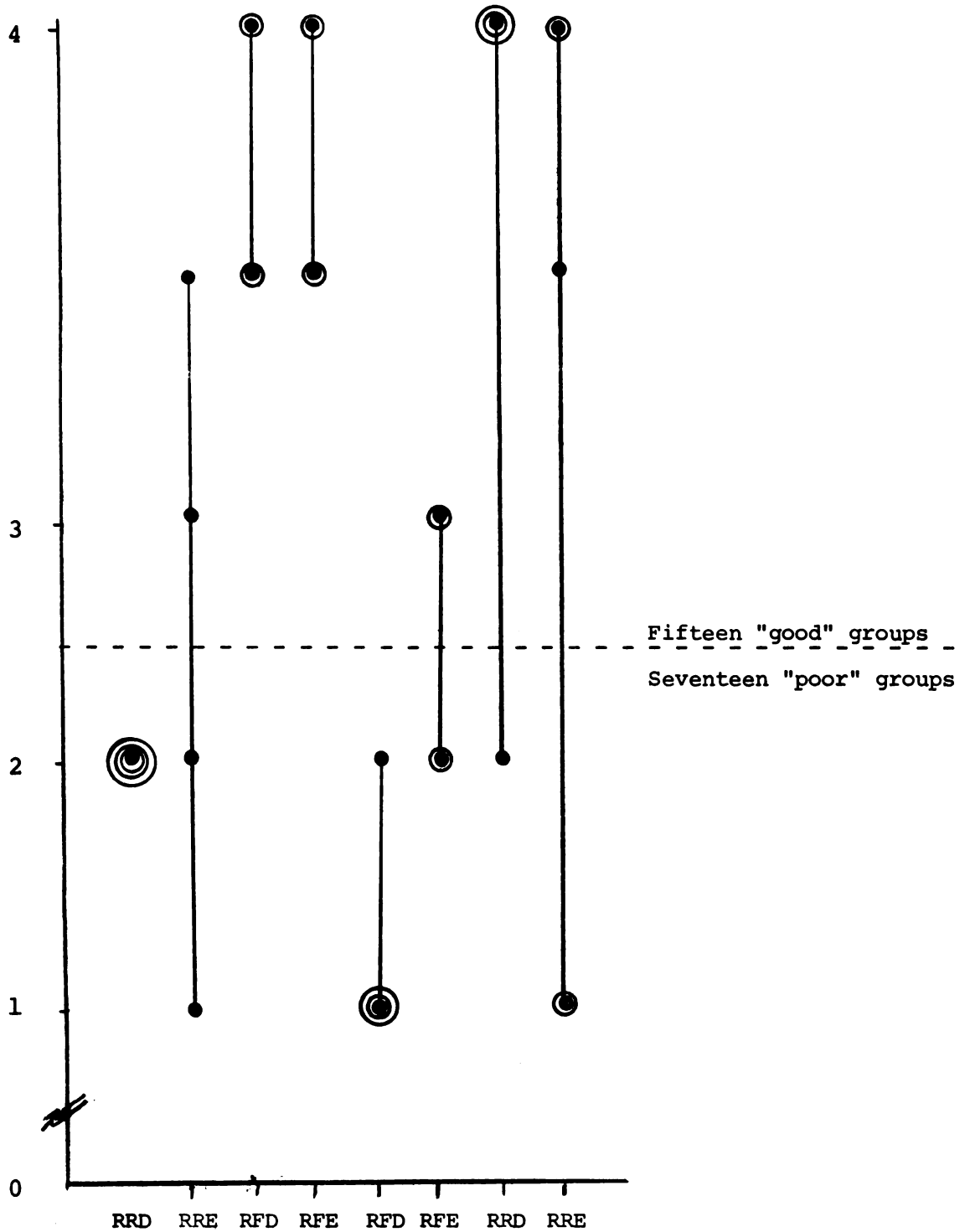

Fig. 5.--Number of "Good" results.

is assigned a point on the X-axis, and an appropriate point on the Y-axis is plotted for each of the four groups of that type. A vertical line connects the points representing the four groups of a given type. A circle around a point indicates that two groups had the same score.

TABLE 7

KEY TO CODES USED TO DESCRIBE GROUPS IN FIGURES 1-5

Code	Leader Personality	Follower Personality	Task Difficulty
RRD	Rigid	Rigid	Difficult
RRE	Rigid	Rigid	Easy
RFD	Rigid	Flexible	Difficult
RFE	Rigid	Flexible	Easy
FFD	Flexible	Flexible	Difficult
FFE	Flexible	Flexible	Easy
FRD	Flexible	Rigid	Difficult
FRE	Flexible	Rigid	Easy

The degree to which the outcome measures are sensitive to the three input variables (leader personality, follower personality, and task difficulty) may be measured using information theory.* The amount of information required to predict whether any group will have a "good" outcome on a given measure varies from 1 bit for mean liking (figure 1) or mean satisfaction to .954 for task success (figure 4). (One "bit," the standard unit of information, is equivalent to the amount of information gained in learning how an honest coin landed.) Knowledge about the group members or the difficulty of the task can reduce the amount of additional information needed to predict the outcome, and thus raise confidence in one's prediction. The uncertainty is never reduced to zero because two of the five input variables which determine the outcome are excluded from the analysis. The importance of these variables is measured by the amount of information about the outcome which remains unknown when group composition and task difficulty are known.

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*Since the theoretical model has no stochastic elements, the usual statistical measures such as analysis of variance are inapplicable and/or trivial without numerous ad-hoc assumptions.

The following table gives the total information needed to predict whether a group will be "good" or "bad" on each outcome variable, and the percent of this information which is provided by each of the three input variables and by two combinations of these variables (leader and follower; and leader, follower, and task difficulty).

The table merely summarizes what can be seen from the graphs. It is apparent that very little information about the outcomes is gained by knowing just the leader's personality, just the followers' personalities, or just the difficulty of the task. In only three cases can a single predictor account for more than 10% of the information needed for a prediction. Knowing either of the personality variables gives one 18% of the missing information on factionalism--inspection of the appropriate graph (figure 3) reveals that "flexible" personality types, whether leader or follower, tend more toward strong likes and dislikes than do "rigid" types, which is what one would expect from the relative readiness to emotional expression and change. Similarly, the only surprise about the 12% of task-success information provided by knowing the difficulty of the task is that the percentage is so low--clearly the groups did not find the difference in task

TABLE 8

PERCENT OF TOTAL OUTCOME INFORMATION PROVIDED BY PREDICTIVE VARIABLES

	Outcome Variables (Dichotomized)				
	Mean Liking	Mean Satisfaction	Factionalism	Task Success	No. "Good" Results
Total Information (Bits)	1.0	1.0	.997	.954	.997
% Information Provided by					
Leader Personality	0%	1%	18%	1%	3%
Follower Personality	5%	0%	18%	9%	0%
Task Difficulty	1%	0%	3%	12%	0%
Group Composition*	63%	73%	39%	22%	68%
Group Composition* and Task Difficulty	85%	73%	47%	58%	73%
% Information not available from predictors	15%	27%	53%	42%	27%

*Group composition = leader personality and followers' personalities.

difficulty to be very important to whether the task was finished, and even less important to their mutual liking and satisfaction.

The remaining lines in the table indicate how much information about the outcome is gained when we know more than one item of information about the group. Group composition means the personalities of both the followers and the leader. This can be seen to be a strong predictor of liking, satisfaction, and overall group success. Inspection of the graphs shows that it is the heterogeneous groups that are the most successful, regardless of which personality type is leader and which is follower.

This interesting result arises primarily from proposition four, satiation, except here it is the longer-term pattern of rewards provided by a person of a given personality type rather than any individual reward which is more valuable the less common it is. The emotional restraint and task commitment of the "rigid" personality, and the sensitivity and willingness to change of the "flexible" personality lead to happier (though not necessarily more productive or smoothly integrated) groups when both are present rather than when the entire group is made up of similar personalities.

The effect of group composition on the other two outcome measures is much weaker. In the case of factionalism, there is virtually no new effect beyond simple addition of the effects of the single personality variables. This effect is at least partially consistent in the direction of flexibles being more factional than rigids; the effect of group composition on task success, on the other hand, appears to be a mere artifact of dividing up the original population*--thus, under the particular set of assumptions represented by the model, group composition is nearly valueless in predicting task success.

The last two rows give the breakdown between the total percentage of information available from knowing all three of the predictor variables and the remaining percentage unaccounted for. (Information unaccounted for includes both the two unanalyzed variables and all interaction effects involving them.) Again it can be seen that liking, satisfaction, and overall group success are well predicted by the three input variables, task success only moderately

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*In the limiting case of 5 completely non-interacting independent predictors, each known predictor would provide 20% of the information. Higher values are due to interaction effects accounted for, lower to interactions not accounted for.

well, and factionalism rather poorly, since more than half the determining factors still give us less than half of the required information.

Although the variation among groups of the same type, which arises from the two "noise" variables, was not analyzed directly, the importance of this variation was assessed by determining how much information would be gained by knowing whether a group was the best, second-best, third-best, or worst of its type without knowing the type. This value, which is an upper bound to the effect of the two noise variables (task presentation order and seating order), was found to be 9% for liking, 2% for satisfaction, 25% for factionalism, 26% for task success, and 9% for number of good results.

V. SUMMARY AND CONCLUSION

In this paper, I have introduced a new formal model based on the social exchange theory of George Homans. Like the earlier models of John and Jeanne Gullahorn, from which it derives, the present model is expressed in a language which facilitates the use of a computer to aid in the mechanical aspects of evaluating the consistency of the model (through error messages) and drawing deductions from it (through simulation output).

I have included two types of mechanical deductions which can be drawn directly by applying the model to particular given situations--micro-level deductions about the interaction between various internal states and external actions of group members, and macro-level deductions concerning the information about overall group outcomes which can be gained by knowing various general items of information about the initial state of the group. In addition, I have sketched briefly how these mechanical deducations can

be related back to the verbal theory from which they are ultimately drawn.

Much potentially fruitful work remains to be done toward increasing the power of formal theory in understanding social exchange processes. In one direction, the consequences of the present model may be further explored by closely examining existing results as in the two previous sections of this paper, and also by generating new mechanical deductions from other givens for more analysis. The latter is made more difficult by the fact that the computer on which the existing program was written (a CDC 3600) is no longer available at Michigan State University. Another direction of progress to be made is toward greater refinement of the model, both in the matter of better correspondence with and verifiability against the real world, and in the ability of the FORTRAN formalization to express the theory to human readers, including the programmers responsible for its existence and growth! Only in this way can a well-understood computer model add any enlightenment to the "blooming, buzzing confusion" known as reality.

REFERENCES

REFERENCES

Bales, Robert F. "The Equilibrium Problem in Small Groups." In Talcott Parsons, et al., Working Papers in the Theory of Action. Glencoe, Illinois: Free Press, 1953, pp. 111-161.

Gullahorn, J. T. and J. E. Gullahorn. "Computer Simulation of Human Interaction in Small Groups." Proceedings, Spring Joint Computer Conference, 1964.

Gullahorn, J. T. and J. E. Gullahorn. "The Computer as a Tool for Theory Development." In Dell Hymes (ed.), The Use of Computers in Anthropology. The Hague: Mouton & Co., 1965.

Gullahorn, J. T. and J. E. Gullahorn. "Computer Simulation of Role Conflict Resolution." In J. M. Dutton and W. H. Starbuck (eds.), Computer Simulation of Human Behavior. New York: Wiley, 1971.

Homans, G. C. The Human Group. New York: Harcourt, Brace, 1950.

Homans, G. C. Social Behavior: Its Elementary Forms. New York: Harcourt, Brace & World, 1961.

Homans, G. C. "Fundamental Social Processes." In Neil Smelser (ed.), Sociology. New York: Wiley, 1967.

Ingles, Franklin M. Information and Coding Theory. Scranton: International Textbook Co., 1971.

Maris, Ronald. "The Logical Adequacy of Homans' Social Theory." American Sociological Review, 1970, 35: 1069-1081.

Simon, Herbert. "A Formal Theory of Interaction in Social Groups." American Sociological Review, 1952, 17: 202-211.

Weizenbaum, J. "Symmetric List Processor." Communications of the Association for Computing Machinery, September, 1963.

APPENDIX

TECHNICAL APPENDIX: SATIATION

In Homans' fourth proposition, he states a general rule that the value of a given reward decreases as the number of times it has occurred in the recent past increases. In program MEETING, this proposition was operationalized in a way which entails several additional assumptions.

Because the program is set up to simulate a decision-making group, task-oriented acts are assumed to satiate more slowly than non-task-oriented ones. Satiation to a task-oriented act is defined as twice the number of times the act has been emitted by the same actor in the last ten acts, plus the number of times it has been emitted by anyone else in the last ten acts. For a non-task-oriented act, satiation is this value plus the number of times that any act belonging to the same class of acts (positive social, negative social, or "doing nothing") has been emitted by anyone during the last ten acts (public memory). This represents the assumption that members of

decision-making groups will tire of repeated emotional reactions more quickly than they will tire of "constructive" suggestions, opinions, information, or questions. Table 9 shows how satiation was compared for each of the ten acts described in the annotated sample output. Satiation to potential acts is compared in the same way when considering a response.

TABLE 9

COMPUTATION OF SATIATION FOR ANNOTATED SAMPLE OUTPUT

Event			2 x	(Some act, some actor)	+	(Some act, other actor)	+	(Similar non-task act)	=	(Satiation)
#	Actor	Act								
1	1	81 3	2 x	0	+	0	+	0	=	0
2	3	51 7	2 x	0	+	0	+	0	=	0
3	2	10 3	2 x	0	+	0	+	0	=	0
4	3	10 2	2 x	0	+	0	+	1	=	1
5	2	51 7	2 x	0	+	1	+	0	=	1
6	1	10 2	2 x	0	+	1	+	2	=	3
7	3	10 1	2 x	0	+	0	+	3	=	3
8	2	61 7	2 x	0	+	0	+	0	=	0
9	1	61 7	2 x	0	+	1	+	0	=	1
10	2	10 1	2 x	0	+	1	+	4	=	5