A COMPUTER SIMULATION MODEL OF COMMUNITY REFERENDUM CONTROVERSIES

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Since the Second World War there has been a great upsurge of interest in the application of mathematical and scientific procedures to many problems of public opinion and communication. While this development has often appeared under new labels such as "operations research" or "systems analysis," it is actually an expression of the experimental tradition in psychology and an extension into the social sciences of quantitative model building stimulated by modern electronic computers. Perhaps nowhere is the development more exciting than in the study of social interaction and attitude formation in a community, midway between the contrived social groups of the laboratory and the great expanse of diverse activity in an entire nation.

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THIS PAPER sets forth the details of a computer simulation model of community referenda.[1] The model was constructed with the specific case of fluoridation controversies in mind. Nevertheless, the formulation is sufficiently general so that it may be applied to research on other referendum issues, as well as to nonpolitical situations of individual decision making within a larger social context. The model will be set forth in general terms, with occasional references to the fluoridation issue for the sake of concreteness. We have several purposes in mind: to describe the specific features of this particular simulation model, bringing several levels of theory and both experimental and field phenomena to bear upon the total conception; to illustrate the properties of the model by giving some results of a preliminary trial upon artificial, albeit realistic, data; to discuss some of the broad problems that are likely to be encountered in this type of approach; and finally, thus, to elucidate the general character of simulation technique, which seems to offer eventual promise of uniting theories of individual behavior with theories of group behavior.

[1] Our work was made possible by a contract to the Simulmatics Corporation from the Social Studies Branch of the Dental Health Division of the United States Public Health Service. We have profited greatly from the advice of many individuals, including Dr. Stephen Kegeles, former Chief of the Social Studies Branch, Dr. Myron Lefcowitz, present Chief, Dr. Benjamin Paul, Dr. William Gamson, and Mr. Arnold Simmel. Other members of the Simulmatics Corporation contributing their special insights on community controversies and computer simulation were Professors James S. Coleman, William N. McPhee, and Ithiel de Sola Pool.

Research on fluoridation referenda seems to have reached a preliminary plateau. Many suggestive variables, both psychological and ecological, have been identified, but the explanatory power of each separate variable is weak and the ordinary linear regression models of traditional statistics do not sufficiently increase the explanatory power of sets of these variables. Furthermore, the static character of statistical models and their reliance on linear assumptions seem to place an upper limit on their potential usefulness. There has consequently appeared a desire for a more systemic approach,[2] one that would be able to handle dynamic interactions among a complex of variables. Many other areas of behavioral science research (*e.g.* juvenile delinquency and the national political process, to name two) are possessed of a similar methodological need. The timely advent of computer simulation offers a technique for formulating systemic models, thus promising to meet this need.

Our method for representing the total political process in a community during a campaign on a local issue is the construction of a miniature dynamic model of the relevant features and processes of a campaign. The model is in the form of a computer program that can be run on a high-speed computer as a symbolic imitation of the campaign. This symbolic imitation may be called a "simulation." A single simulation will take but a few minutes on the IBM 7090, thus permitting a number of simulations under differing assumptions and conditions.

The model is an ambitious conception, which one must expect to be initially somewhat imprecise, owing to present limitations of knowledge in the general fields of psychology, sociology, and political science, as well as in the specific area of fluoridation referenda. It is anticipated that repeated tests of the model with actual campaign data will lead to substantial improvements.

In presenting the model a great many small details must be covered. This paper is organized so that readers who so desire may gain a general understanding without penetrating to the finest level of detail. First, a broad sketch is given, and then the model is reviewed more completely.

BROAD DESCRIPTION OF THE MODEL

On the basis of actual survey data gathered in the community by a probability sample ten or more weeks prior to the scheduled referendum, a large number of actual people (*e.g.* 500) are anonymously represented in the computer. For each person the computer repre-

[2] S. Kegeles, "Some Unanswered Questions and Action Implications of Social Research in Fluoridation." *Journal of Social Issues*, Vol. 17, 1961, pp. 75-81.

sentation contains the following: demographic characteristics; predisposing experiences and attitudes toward the referendum campaign arguments; frequency of exposure to the several news channels; attitudes toward well-known persons and institutions in the community (who might subsequently prove pivotal in the campaign); knowledge, if any, and acceptance of various standard assertions, pro or con, on the referendum issue; frequency of conversation about local politics, and the demographic characteristics of conversational partners, if any; initial interest in the referendum issue, initial position on the issue, and voting history in local elections.

The model specifies processes by which each individual may change in certain respects as the campaign progresses. Changes can be effected in two general ways: (1) by exposure to public "assertions" from "sources," these appearing in communication "channels" (broadly defined); (2) via conversations with others who have some stand on the issue and who may also make assertions.

The standard local communication channels are represented in the computer, and can be loaded each simulated week with appropriate assertions from sources. (For research purposes, the distribution of assertions would be pre-determined and used as an independent variable. For field purposes, the assertions could instead be determined by content analysis of the actual channels.) Each simulated week each individual in the computer population is subject with varying probabilities to exposure to the several channels, and hence to particular assertions.

A set of rules is applied to determine which of these assertions are accepted. The chief determinants are: attitude toward the communication "source," previous acquaintance with the assertion, congeniality of the assertion in terms of special predispositions, and position on the referendum issue.

As a result of this exposure process, the following individual variables may change: assertions accepted, attitude toward particular communication sources, probability of exposure to the various channels, interest in the issue, and position on the issue.

Following exposure to the assertions in the channels for a simulated week, the individuals in the computer population are allowed to hold "conversations" with each other. Conversational *potentiality* is approximated on the basis of social network information, *i.e.* meshing demographic characteristics and a shared habitual locus, if any, of conversation about community affairs. Conversational *rate*, expressed as a greater or lesser probability that potential conversations will actually be held, is determined on the basis of the level of interest in the fluoridation issue. In each simulated conversation, the conversational

partners make assertions about the issue. Reactions to these assertions are determined on several bases, including: the ideological compatibility of the partners, particularly on community matters underlying the referendum issue; previous acquaintance with, and congeniality of, each assertion; and position on the issue.

The total campaign is simulated by a succession of ten or more computer cycles. Each cycle represents a week of elapsed time, and in each week each individual is potentially exposed to communication channels and to conversational partners. At the end of the final week, the vote on the referendum may be simulated from the interest levels, positions, and voting turnout histories of the individuals. However, the simulation of voting turnout is perhaps the most difficult feature of the whole enterprise, and can be by-passed. Instead, one might simply examine the final state of all assertions, interest levels, and positions. This can be validated against a later survey rather than the actual vote. A simulated campaign can be run contemporaneously with an actual campaign, in advance of an actual campaign, or as a post-mortem.

Although the specifications for our simulation may give the off-hand impression that fluoridation campaigns are very "busy," this is certainly not our intent. The typical campaign does not produce a rash of public propaganda every week; neither is the rate of conversations likely to be very high.

The simulation is designed so that each person's exposure to arguments and conversational rate depends upon his level of interest in the issue, which in turn depends upon previous exposure to arguments and information, and the outcomes of prior conversations. The system is such that it is possible for "nothing much to happen" or, on the other hand, for interest gradually to build up until certain segments of the population become quite active and involved (though other segments may remain relatively dormant).

BROAD PRINCIPLES GUIDING DESIGN OF THE MODEL

Two broad principles lie at the core of the design of the model. First, it is clearly desirable for the model to possess some degree of *overdetermination,* by which is meant that a multiplicity of variables in the model can tend to act in the same direction—there may be multiple routes to the same general outcome. A second general principle is needed to guard against trivial overdetermination, however. This would happen if the several variables in the model were so tightly linked together by functional interconnections that there were no circumstances at all under which they could operate independently.

The second principle might be called "loose coupling," referring to the general nature of the interconnections between variables.

These two principles are brought most directly to bear on the choice of dependent variable for the model. Instead of employing simply one dependent variable, position on the issue, we use the two additional variables, interest in the issue and the acceptance of various assertions about fluoridation. (This latter is a vector, in effect representing as many variables as there are assertions.) Interest in the issue is crucial because it monitors the conversational rate, the probability of exposure to propaganda in public channels, and the probability of eventually voting on the issue.

The assertion acceptances are important for several reasons: they provide a mechanism by which a "conversation" can result in more than just the regression of each individual's position toward that of the other (it should be possible for new assertions to be accepted without necessarily a change in position on the issue); the individuals in the model can evaluate the credibility of public sources and conversational partners, and thereby be more or less prone to influence by them and further exposure to them; there is indirect pressure on individuals to alter their positions on the issue in case of inconsistency between position and assertion acceptances; and, finally, it is of essential interest to the theorist to trace the spread of particular assertions during a campaign, and the model should certainly not omit this feature.

The position, interest, and assertion-acceptance variables are coupled together in the model in ways that will tend to produce correlations among them. However, it is known that attitude positions are not always consistent with cognitive content[8] (particularly for individuals with low interest), and it is common-sensical to suppose that interest in the issue is not always consistent with the other two variables. Therefore, the model permits occasional inconsistencies among the three variables. The model is such that there will be a general tendency for interest to increase during the campaign and for positions to tend toward extremity on one side or the other. However, neither of these tendencies need be pronounced if the campaign is quiet, and neither will be uniformly applicable to all persons. Some persons will show the reverse tendencies. The details are given in the next section.

In order that these details not seem arbitrary when they are presented, it is necessary to state our general assumptions about influence processes.

An individual is confronted with various assertions on fluoridation from a source in a communication channel or from a conversational

[8] M. J. Rosenberg, "A Structural Theory of Attitude Dynamics," *Public Opinion Quarterly*, Vol. 24, 1960, pp. 319-340.

partner. The model should operate so as to satisfy the following four desiderata:

1. Influence will be successful (*i.e.* new assertions will be accepted) under a fairly wide range of conditions, particularly when the influencee has a mild position on the issue but is sufficiently interested to expose himself to campaign stimuli.

2. However, there are definite resistances to influence, particularly when the influencee has a strong position on the issue and/or a negative attitude toward the communicator.

3. If resistance is very strong, there may be a "boomerang effect" whereby the influencee accepts new assertions opposite to those intended and a new position farther away from that of the communicator.

4. However, there is some way of influencing almost everybody to some degree. (In the real-life case of someone with a very extreme position, this would involve the careful avoidance of areas of resistance, apparent partial agreement with assertions already accepted by the influencee, and the gradual introduction of new assertions previously unfamiliar to him.)

DETAILS OF THE MODEL

Now we describe by means of a sequence of propositions specifically what happens in the simulation during each time cycle. The first half-cycle (A) involves channel exposure, and the second half-cycle (B), conversational exposure.

Each individual in turn is confronted with each channel in turn, and there is a determination of whether the individual is exposed to the assertions made by each source over that channel. Denoting the individual by i, the channel by c, and any particular source by s, the determination is as follows:

A1. The probability that i will be exposed to source s in channel c is a direct function of i's "attraction" toward channel c.

Two broad classes of channels are relevant during a campaign: the general communication channels (radio, TV, newspapers, national magazines), which predominantly carry material irrelevant to the referendum; and particularized "channels" or devices (propagandistic circulars, billboards, town meetings, organized telephoning, etc.), which can be specialized to suit campaign purposes almost exclusively. Exposure to the general channels is mainly a function of habit, whereas exposure to the specialized channels is mainly a function of interest and partisanship. The term "attraction toward channel c" is intended to cover both types of phenomena. The simulation distinguishes between the two by permitting only very slow changes in attraction to

the general channels but very rapid changes in attraction to the special channels under appropriate conditions (see propositions A2, A22, and B27).

A2. Exposure probability to each source in any channel is also a direct function of i's interest in the issue.

A regular newspaper reader will not necessarily notice any given editorial or news item, but if he is interested in the issue, the chances are increased that he will notice it and expose himself to its contents. Exposure probability is applied to each source in the channel separately (rather than to all at once) to allow for the possibility that a report of a speech will be noticed but not the comments of a columnist, etc. Similar considerations apply to all the general channels. The differential salience or "attention value" of different items (*e.g.* cartoons vs. editorials) is handled otherwise than by exposure probability (see A4). Exposure probability operates as a preliminary screen; if items get through that are "inappropriate" (in terms of what the individual would ordinarily expose himself to), they will tend to get screened out subsequently.

The special channels present special problems. Even if an individual is rather interested in the issue, it is unlikely that he will be exposed to, say, a propagandistic circular if he is not on the mailing list. However, if he is on the mailing list, increased interest will result in highly increased exposure probability. Thus exposure probability to special channels as a function of interest should depend multiplicatively upon initial "attraction" to the channel. This is, in fact, the way the mathematics of the system is regulated.

If individual i is exposed to source s in channel c, then all assertions (if any) made by s will be advanced toward i, whose general response will depend upon his "receptivity" to s. The following assumptions are made about receptivity:

A3. Receptivity to s is an inverse function of the extremity of i's attitude position.

It is intuitively reasonable and a matter of some evidence[4] that individuals with more extreme attitude positions are more resistant to influence. Since resistance or nonresistance depends also on other

[4] H. H. Kelley and J. W. Thibaut, "Experimental Studies of Group Problem Solving and Process," in G. Lindzey, editor, *Handbook of Social Psychology*, Cambridge, Mass., Addison-Wesley, 1954; P. H. Tannenbaum, "Initial Attitude toward Source and Concept as Factors in Attitude Change through Communication," *Public Opinion Quarterly*, Vol. 20, 1956, pp. 413-425; M. Sherif and C. I. Hovland, *Social Judgment*, New Haven, Conn., Yale University Press, 1961.

variables, the mediating variable "receptivity" is introduced. The next two propositions specify other influences on receptivity.

A4. Receptivity to s is a direct function of the "attention value" of the assertions made by s.

This proposition represents a device for coping with differential form or placement of items within the communication media (*e.g.* cartoons vs. editorials, as mentioned above, or "prime" vs. "nonprime" time on television). The "attention value" for each source within each channel must be specified as an input to the computer. Two possible values are presently allowed, "high" and "low."

A5. Receptivity to s is a direct function of the "assertion match" between i and s, which is positive when s's assertions agree with those already accepted by i, and negative when they disagree.

The most obvious basis upon which an individual may evaluate the source of a set of assertions consists in the extent to which he agrees or disagrees with those of the assertions already familiar to him. Unfamiliar assertions (which are presumably quite common when the issue is largely remote from the immediate concerns of the general public) should have little or no effect on the individual's receptivity toward the source. The "assertion match" index between i and s is computed by scoring $+1$ for each single assertion agreement, -1 for each single assertion disagreement, and summing.

Another basis for the evaluation of a source is the "credibility" of the source. In contrast to "assertion match," which has not yet received sufficient research attention (probably because attitudes have been conceptualized as unidimensional rather than multidimensional), "communicator credibility" has received a fair degree of research attention. Hovland, Janis, and Kelley[5] have made a theoretical distinction between "expertness" and "trustworthiness" as components of "credibility," but it is not clear that these two components have differential effects on communication acceptance. At any rate, the present system makes allowance for variations in communicator characteristics. This variable, labeled "attitude toward source," is intended to include imputed credibility in a summarization of net positive or negative affective orientation toward the source. This variable enters the next proposition along with receptivity.

A6. Individual i will be the more apt to accept assertions made by s the more favorable i's attitude toward s and the higher i's receptivity to s.

[5] C. I. Hovland, I. L. Janis, and H. H. Kelley, *Communication and Persuasion*, New Haven, Conn., Yale University Press, 1953, Chap. 2.

In other words, i will manifest maximal general acceptance of s's assertions when he is interested enough to expose himself to the assertions (A_2), feels favorable toward s (A_6), has a neutral position on the issue (A_3), attends to the assertions (A_4), and finds himself already in agreement with those assertions with which he is familiar (A_5). He will manifest minimal general acceptance under the converse circumstances. A mixture of predisposing circumstances will produce intermediate general acceptance. (In the computer program, weights have been assigned to the predisposing variables determining their relative effectiveness in various combinations. These weights are roughly equal and the several variables combine in approximately additive fashion.)

In addition to general assertion-acceptance level, specific factors pertaining to each individual assertion must be considered.

A_7. If an assertion made by s has already been accepted by i, there cannot be a decrease in acceptance of that assertion under any circumstances.

It seems obvious that if an individual already holds a particular belief (*i.e.* already accepts a particular assertion, such as, "Fluoridated water is good for children's teeth"), this belief cannot be weakened by hearing someone express it. Nevertheless, there is a diabolical case deserving theoretical attention, namely the "boomerang" case in which a disliked, generally disagreeing source expresses this belief. Proposition A_7 asserts that even in this case, the individual will not be driven away from his previous belief. An experimental failure to produce this type of "boomerang" was recently reported by Weiss.[6]

A8. An assertion is more apt to become accepted by i if he has not previously encountered it than if he has previously disagreed with it.

This is straightforward and clear.

A_9. An assertion is especially apt to be accepted by i if it is consistent with his predisposition toward that assertion, and under no circumstances will be accepted if it runs counter to his predisposition.

This proposition assigns a strong role to predispositions toward particular assertions. These variables are conceptualized as personality-based needs that allow individuals to relate themselves expressively and projectively to otherwise remote issues.[7] Certain individuals will

[6] W. Weiss, "Opinion Congruence with a Negative Source on One Issue as a Factor Influencing Agreement on Another Issue," *Journal of Abnormal and Social Psychology*, Vol. 54, 1957, pp. 180-186.

[7] M. B. Smith, J. S. Bruner, and R. W. White, *Opinions and Personality*, New

"want to believe" certain assertions and will find the converse assertions incredible. For example, an individual with an extreme sense of alienation from and hostility toward the perceived sources of community power and influence will be especially disposed to accept the assertion that a fluoridated water proposal is being promoted undemocratically or "railroaded through," and no amount of protestation will disabuse him of this suspicion.[8]

The predisposition must of course "find" the congenial belief, and it is entirely possible for a predisposition to remain "unsatisfied" for lack of exposure to the appropriate assertion. Proposition A9 simply states the consequences of the occurrence of such an appropriate exposure.

In view of the strong effect assigned to predispositions in the model, it is contemplated that the assignment of predispositions be confined in practice to those rare individuals who give very extreme responses on particular attitude scales in the initial survey. For any specified predisposition, the percentage of such extreme individuals would probably not exceed 5 per cent of the total sample.

One further point with respect to the role of predispositions deserves mention. The difficult problem of the relative effectiveness or potency of different assertions is in effect by-passed by the model, rather than met head-on by some arbitrary kind of relative weighting scheme. Assertions are coded in the simulation in nominal fashion (assertion #7, #23, etc.), and the propositions take no explicit account of the actual content of the assertions. Implicitly, however, there are three ways in which the system recognizes the content nature of the campaign, so to speak: first, by which particular assertions are accepted by which individuals at the outset; second, by which particular assertions are made by which sources, how often, with what "attention value," and to whom; and third, by the distribution among individuals of predispositions toward particular assertions.

A10. An assertion is less apt to be accepted by i if it is inconsistent with his position on the issue.

This proposition is in accord with cognitive balance theory[9] and

York, Wiley, 1960; B. Christiansen, *Attitudes toward Foreign Affairs as a Function of Personality*, Oslo, Oslo University Press, 1959; and many others.

[8] This particular predispositional factor has been extensively invoked in connection with fluoridation controversies. Cf. J. S. Coleman, *Community Conflict*, Glencoe, Ill., Free Press, 1957; W. A. Gamson, "The Fluoridation Dialogue: Is It an Ideological Conflict?" *Public Opinion Quarterly*, Vol. 25, 1961, pp. 526-537; A. Simmel, "Relative Deprivation as an Hypothesis in Studying Community Acceptance of Fluoridation," paper presented to the Society for Psychological Study of Social Issues, Chicago, Ill., September 1960.

[9] F. Heider, *The Psychology of Interpersonal Relations*, New York, Wiley, 1958,

cognitive dissonance theory.[10] One would not want this proposition to operate too strongly here, however, since that would violate the general principle of "loose coupling" in the design of the system. Furthermore, there are other features of the model (see A14, A17, B22, and B25) which take account of cognitive consistency forces. Concretely, it ought to be reasonably common for individuals to accept assertions contrary to their issue positions. Experience both in the experimental laboratory and in the field suggests considerable latitude for muzziness in the operation of cognitive consistency forces,[11] particularly among uncommitted individuals. Thus the weak phrase, "less apt to be accepted . . . if . . . inconsistent" is used in the proposition, and may be amplified to read "less apt to be accepted if inconsistent, especially under unfavorable conditions of receptivity and attitude (A6), but not especially under favorable conditions of receptivity and attitude."

As a theoretical aside, it should be noted that proposition A10 is deliberately stated in terms of inconsistency between the assertion and issue position, rather than between the assertion and other assertions. Cognitive consistency theories would not necessarily predict resistance (irrespective of issue position) to the co-acceptance of conceptually disparate assertions that happen to favor opposite sides of the issue. For example, the two assertions "Fluoridated water prevents cavities" and "Fluoridated water may have long-range harmful effects" are not intrinsically dissonant with one another, albeit one or the other is necessarily dissonant with the third statement, "I am for (against) fluoridated water."

A11. When i's attitude toward s is negative and his receptivity to s is very low, assertions made by s not previously encountered by i and not consistent with his position will tend to promote acceptance by i of converse assertions.

Here is a "boomerang" of more plausible nature than that discussed under A7. This proposition may perhaps best be understood by phrasing the effect from the point of view of the individual exposed to the assertions of an objectionable source: "I never heard *that* argument before, but if that so-and-so says it's true, then it must certainly be false."

The qualification having to do with position consistency is added to the proposition to handle the possibility that the objectionable

Chap. 7; M. J. Rosenberg and R. P. Abelson, "An Analysis of Cognitive Balancing," in M. J. Rosenberg *et al.*, *Attitude Organization and Change*, New Haven, Conn., Yale University Press, 1960.

[10] L. Festinger, *A Theory of Cognitive Dissonance*, Evanston, Ill., Row, Peterson, 1957.

[11] Rosenberg, *op.cit.*

source may make an unfamiliar assertion consistent with the individual's position. In this case, the individual would only spite himself by disbelieving the assertion, and such effects are disallowed by the model. (The model does not require the individual to *accept* this new assertion, however; it allows him to regard it as still "unfamiliar.")

There are other consequences of exposure to the assertions of sources in channels besides changes in assertion acceptances. There may be a change in interest, according to the following rules:

A12. Interest increases as a direct function of the assertion match between i and s.

This proposition takes a view of "interest" as a response habit toward campaign stimuli that can be increased in strength by the implicit social reinforcement of perceived agreement between the assertions of self and the assertions of source. It is not clear how to view the potential effect on interest of disagreement (*i.e.* a negative assertion match) between self and source. One might postulate either a decrease in interest or—and this was the tentative choice for the simulation model—no change in interest. This choice is very much open to any research evidence that might become available. (This particular point seems not to have been directly studied.)

Interest as response habit is not the only possible view of this variable. Other views are invoked in the next two propositions (see also B26).

A13. Interest increases as a direct function of the number of assertions made by s that are relevant to i's predispositions.

"Relevant" here means either "consistent with" or "inconsistent with." If an assertion is consistent with—"ticks off"—a predisposition, then some personality needs of the individual become engaged with the issue, and this should certainly lead to an increase in interest. On the other hand, if the assertion flies in the face of a predisposition, then one would expect the individual to become aroused and indignant, which would also lead to an increase in interest. Both of these cases represent what one might call "expressive interest."

A14. Instances in which i accepts an assertion inconsistent with his position will result in a decrease of interest.

According to A10, an assertion is less apt to be accepted if it is inconsistent with issue position, but we have emphasized that there is considerable latitude for the occurrence of such inconsistent acceptances. When such inconsistent acceptances do occur, however, they lay the groundwork for further encounters with inconsistency. If the individual thinks about the issue, recalling new assertions he has

recently accepted, he may be confronted with inconsistency between new assertions and his issue position. One possible "resolution" of such inconsistency is to stop thinking,[12] or, in terms of the variables of the model, to lose interest. (For other possible resolutions, see B22 and B25). Parenthetically, we should note that proposition A14 is perhaps false for intellectuals, who might become *more* interested when confronted with inconsistency. However, in terms of a probability sample, almost nobody is an intellectual.

Summarizing the interest-change propositions, interest maximally increases when the source makes a number of assertions with which the individual agrees (A12) and a number of assertions (possibly different) which arouse the individual's predispositions (A13). Interest remains unchanged when the assertions of the source are neither agreeable nor arousing. Interest decreases when the individual has been "conned" by the source, *i.e.* led to accept assertions inconsistent with his position (A14). A mixture of the above effects will lead to an intermediate change of interest, ordinarily a small increase[13] (see also B26).

There may also be changes in attitude toward the issue, toward the source, and toward the channel. These are assumed to be mediated by "satisfaction" with the exposure.

The satisfaction of i with s follows these rules:

A15. Satisfaction varies as a direct function of the "assertion match" between i and s.

A16. Satisfaction is the greater for each assertion by s consistent with i's predispositions, and the less for each assertion inconsistent with i's predispositions.

A17. Satisfaction is the less for each assertion by s inconsistent with i's position on the issue.

The reasoning underlying these propositions is parallel to that for A12-A14, with one exception. In the case of assertions inconsistent with predispositions, there is a negative contribution to satisfaction (whereas there was a positive contribution to interest).

The satisfaction variable enters into proposition A19 for attitude change. First, we state a qualification.

[12] R. P. Abelson and M. J. Rosenberg, "Symbolic Psycho-logic: A Model of Attitudinal Cognition," *Behavioral Science*, Vol. 3, 1958, pp. 1-13.

[13] Experimental research in interest change, comparable in scope to the research effort devoted to attitude change, would be most helpful in correcting possible deficiencies in propositions A12-A14.

A18. As a result of exposure to s, the attitude position of i will change only if s's attitude position is more extreme (in either direction) than i's.

The reason for the inclusion of this proposition is that without it the following undesirable effect would occur: an extreme individual, exposed to the assertions of a source who agreed with the individual but was more moderate, would move toward a more moderate position. One might imagine special circumstances in which this effect was not unreasonable, but if it were to obtain in general it would tend to produce too much of a long-run trend toward neutrality. Abelson has shown that in formulating mathematical rules for repeated change in attitude positions within a group of interacting persons, it is vital to have some feature which maintains extreme attitude positions, lest the rules inexorably produce ultimate attitude agreement in the entire group of individuals.[14]

Proposition A18 requires that the attitude positions of sources be estimated and entered as input to the computer.

A19. The degree of i's attitude position change following exposure to s is a direct function of i's satisfaction with the exposure.

A20. The direction of such attitude position change is toward s if i's attitude toward s was initially positive, and away from s if i's attitude toward s was initially negative; the degree of such change is a direct function of the difference between the positions of i and s.

Many laboratory studies of attitude change as a function of the discrepancy between the attitudes positions of the communicator and communicatee have resulted in changes toward the communicator.[15]

[14] R. P. Abelson, "Mathematical Models of the Distribution of Attitudes under Controversy," in N. Frederiksen and H. Gulliksen, editors, *Contributions to Mathematical Psychology*, New York, Holt, Rinehart & Winston, 1963, in press.

[15] S. Goldberg, "Three Situational Determinants of Conformity to Social Norms," *Journal of Abnormal and Social Psychology*, Vol. 49, 1954, pp. 325-329; C. I. Hovland and H. Pritzker, "Extent of Opinion Change as a Function of Change Advocated," *Journal of Abnormal and Social Psychology*, Vol. 54, 1957, pp. 257-261; C. I. Hovland, O. J. Harvey, and M. Sherif, "Assimilation and Contrast Effects in Reactions to Communication and Attitude Change," *Journal of Abnormal and Social Psychology*, Vol. 55, 1957, pp. 244-252; S. Fisher and A. Lubin, "Distance as a Determinant of Influence in a Two-person Serial Interaction Situation," *Journal of Abnormal and Social Psychology*, Vol. 56, 1958, pp. 230-238; A. R. Cohen, "Communication Discrepancy and Attitude Change," *Journal of Personality*, Vol. 27, 1959, pp. 386-396; P. G. Zimbardo, "Involvement and Communication Discrepancy as Determinants of Opinion Conformity," *Journal of Abnormal and Social Psychology*, Vol. 60, 1960, pp. 86-94; E. Aronson, Judith Turner, and J. M. Carlsmith, "Communicator Credibility and Discrepancy as Determinants of Attitude Change," *Journal of Abnormal and Social Psychology*, in press.

With a communicator of high credibility, change is roughly proportional to discrepancy. With a communicator of low credibility, change increases with discrepancy up to some optimum, after which it decreases very gradually toward zero.[16] Negative change (change away from the communicator) is very rarely found, although scattered instances of such "boomerang effects" have been reported.[17] Laboratory studies, however, very rarely use communicators toward whom genuinely negative attitudes are prevalent throughout the subject group. Skepticism or mild suspicion may be said to characterize the most severe modal reaction to laboratory communicators of low credibility. It seems a safe guess that the boomerang effect is common in the political campaign situation, where genuinely negative attitudes exist and where attitude cleavage is acceptable, indeed appropriate. In A20, therefore, we postulate attitude change away from the source when attitude toward the source is negative.

The proposition that the degree of attitude change is a direct (*i.e.* monotonic increasing) function of the difference between the positions of i and s requires reconciliation with the laboratory finding (in low-credibility conditions) of a curvilinear relation between degree of change and position discrepancy. Completely systematic consideration of this case would necessitate going into mathematical details, but the general line of reconciliation involves taking into account the variables involved in the satisfaction index (A15-A17). As position discrepancy increases, pressure to change increases but satisfaction with what the communicator says decreases. The competition between these two factors can produce a curvilinear relation with maximum change at intermediate discrepancy.

Summarizing the attitude change propositions, attitude position changes maximally toward the position of the source when there is a positive attitude toward him (A20), when his position is very extreme (A18), and when there is great satisfaction with his assertions (A19). Attitude position does not change when the source takes a relatively neutral position or when there is indifferent satisfaction with his assertions. Attitude position changes maximally away from the source when there is a negative attitude toward him, when his position is very extreme, and when there is great dissatisfaction with his assertions. Combinations of these variables produce intermediate effect.[18]

[16] Aronson, Turner, and Carlsmith, *op.cit.*

[17] C. I. Hovland, O. J. Harvey, and M. Sherif, "Assimilation and Contrast Effects in Reactions to Communication and Attitude Change," *Journal of Abnormal and Social Psychology*, Vol. 55, 1957, pp. 244-252.

[18] The mathematical possibilities for interrelationships among the variables in determining attitude position change are quite varied, and a fair amount of juggling may be required to adjust the model to the most satisfactory form.

Attitude toward the source himself may change, according to the next proposition:

A21. Attitude toward s changes as a direct function of satisfaction, the direction of change corresponding to the sign of the satisfaction variable, which may be either positive or negative.

This proposition has the virtue, in addition to its straightforward intuitive appeal, of providing for the case of repeated exposure to an initially respected source who takes an irritating position on the issue (and the converse case, an initially disrespected source who takes a pleasing position). The respected source may put over some assertions (A6) and gradually win the individual over; but if resistance is initially high, the individual will be dissatisfied with the exposure and lose respect for the source. Thenceforth, assertions will be more difficult to put over, produce further dissatisfaction, and the individual will tend to move away from rather than toward the position of the source. (A parallel sequence of events with reverse effect could occur in the converse case.)

Finally, attraction toward the channel may change:

A22. Attraction toward c changes as a direct function of total satisfaction with all sources to which the individual was exposed in the channel.

Either increase or decrease in attraction is possible, since the sign of the total satisfaction variable may be either positive or negative. We have already noted (see the discussion following A1) that attraction to a general channel such as a newspaper is not nearly so volatile as is attraction to a channel specializing in campaign propaganda. Each channel needs a parameter, therefore, which modulates the effect specified in A22.

Following the potential exposure of all the individuals to the material in all channels during a single time cycle, the simulation proceeds to the potential exposure of all individuals to conversations with each other. Each individual in turn is confronted with each of his potential conversational partners in turn. (The network of potential conversational partnerships is fixed at the outset of the simulation on the basis of survey information. This feature is discussed in a later section.) Denoting the individual by i and the potential partner by j, the determination of whether a conversation takes place is as follows:

B1. The probability that i talks to j about the issue is a direct function of i's interest in the issue.

This proposition in a sense defines interest in terms of conversational probability. All effects that raise or lower interest (see A12-A14;

B12-B14; B26) will correspondingly raise or lower conversational probability.

It is not entirely realistic, of course, to suppose that i will have the *same* probability of conversing about the issue during a given week with one conversational partner as with any other conversational partner. Here, as with the channel process, however, exposure operates as a preliminary screen (see the discussion following A2). If the simulation makes i talk with some unlikely people (*i.e.* those who are not very interested in the issue and have no knowledge of the assertions), these conversations will have little or no subsequent effect.

The conversational probability is applied separately to each potential partner by a random-number device. If a conversation is held, all the assertions accepted by j will be advanced toward i. The exposure is a one-way process, for convenience. (But i may get his chance in another portion of the cycle to play the role of "j," whilst j becomes "i.") The general response of i will depend upon his "receptivity" to j. The following assumptions are made about receptivity:

B2. Receptivity to j is an inverse function of the extremity of i's attitude position.

This proposition is parallel to A3.

B3. Receptivity to j is a direct function of the extremity of j's attitude position.

B4. Receptivity to j is a direct function of j's interest in the issue.

These two propositions, taken together, are parallel to the single proposition A4 relating to the "attention value" of the assertions made by a source. In the present context, an interested conversational partner with an extreme position is rather more likely to compel i's attention and make his assertions salient than is a partner lacking either the interest or the conviction.

B5. Receptivity to j is a direct function of the "assertion match" between i and j, which is positive when j's assertions agree with those already accepted by i and negative when they disagree.

This proposition is parallel to A5. The next sixteen propositions are also parallel to corresponding propositions for the channel process, with the insertion of j wherever s appeared before.

B6-B21. See A6-A21.

By this abbreviated device we have carried the model for conversational exposure of i to j through potential changes in the assertion acceptances of i, his interest in the issue, his attitude position, and

finally the attitude toward j. Though the verbal statements of these propositions are all the same as before, the mathematical renditions of the formulas involve slightly different parameters. We have proceeded under the commonly held supposition that face-to-face contact is a somewhat more powerful influence than impersonal exposure to sources in communication channels. The calibration between these two types of influences is impossible to pin down, however, without actual field testing of the model, and our present calibration is of course subject to later adjustment.

This completes the set of assumptions about the single dyadic interaction. After each individual i is exposed to *all* his potential partners, j, however, six more rules are applied. The first three deal with the probability that i will "forget" assertions previously accepted, that is, act in future interactions as though he had never encountered them. The fourth rule deals with review and adjustment of attitude position so as to be more consistent with assertion acceptances, and the fifth with over-all changes in interest. The sixth rule spells out the consequences of attitude position changes for the development of new channel attractions.

B22. The probability is greater that an accepted assertion will be forgotten if it is inconsistent with i's position than if it is consistent.

Some kind of forgetting process is necessary in the model, not only because it is realistic to assume one, but because the average number of assertions known to individuals in the population would otherwise tend to increase geometrically. In the conversational process, it is assumed that j asserts everything he knows at the time (see the discussion preceding B2). This is realistic if it involves a few assertions but would be absurd if it typically involved ten or twenty assertions. One survey study has estimated at 1.7 the average number of assertions (true or false, relevant or irrelevant) that will be spontaneously given on the fluoridation issue two months before the balloting.[19] This seems an appropriate order of magnitude, and only some form of forgetting process will maintain this average number within reasonable bounds as the campaign increases in intensity.

Forgetting is taken to be a probabilistic process subject to certain constraints, such as B22. As a study by Jones and Kohler strongly suggests, people tend to remember plausible arguments on their own side and implausible arguments on the opposing side.[20] These latter argu-

[19] This estimate was made from Table 34 of the mimeographed report of an unpublished study by A. Simmel of "Welltown," N.Y.

[20] E. E. Jones and R. Kohler, "The Effects of Plausibility on the Learning of

ments, though remembered, are not accepted; rather, they apparently serve a "straw man" function in imaginary or real debate with the opponent. The simulation does not capture this subtlety, since there is no provision for assertions remembered but not accepted. However, proposition B22 does capture the major effect that people will tend to forget plausible (*i.e.* acceptable) arguments inconsistent with their positions.

B23. Assertions are not subject to forgetting if they are consistent with predispositions.

Assertions that satisfy expressive needs are presumably so functionally important to the individual that they are exempted from the forgetting process.

B24. If j makes an assertion that comes to be accepted by i, then j will not forget that assertion.

When i accepts a new assertion from j, presumably j is usually aware of this. Either from the standpoint of sheer social reinforcement or by virtue of self-conscious use of successful debating tactics, j will tend to use the same assertion in future conversations. Since, in the simulation, all assertions are "used" in conversation, the only special device available to us to set apart special assertions is to exempt them from the forgetting process. Run-of-the-mill assertions will sooner or later be forgotten by repeated applications of random decay probabilities, but the effective ones will remain available for repeated use.

B25. Attitude position change on the issue following all conversational and channel exposures is a direct function of the number of such exposures, and proceeds in the direction consistent with the majority of assertions accepted.

Previous propositions (B10, B14, B17, B22) have involved the reconciliation of assertion acceptances with a fixed issue position. The present proposition invokes the reverse effect, namely, the adjustment of issue position toward consistency with assertions accepted. The reason for making this adjustment depend upon the number of exposures is that the greater the number of exposures, the more salient the issue and the greater the pressure on the individual toward review of his attitude and cognitions.

Indications from the preliminary run of the simulation model are that B25 is not an ideal formulation and requires modification (see below).

Controversial Statements," *Journal of Abnormal and Social Psychology*, Vol. 57, 1958, pp. 315-320.

B26. Interest in the issue increases as a direct function of the number of conversational and channel exposures; if there are no exposures, interest decreases.

This is the final proposition regarding interest in the issue (see also A12-A14 and B12-B14), taking effect only upon completion of each time cycle. The basic idea is simply that interest is a function of exposure. Lacking campaign stimulation, interest will wane.

Following the conversational cycle, a new "week" is in effect, and the individuals are exposed anew to the channels (which now may carry new assertions). Before this takes place, one special phenomenon linking attitude position changes with new channel attractions is invoked:

B27. To the extent that i has changed his position toward one particular side of the issue, he will be that much more attracted to channels biased in favor of that side and unattracted to channels biased in favor of the other side.

Some of the channels, usually the specialized ones, will be clearly biased toward one or the other side of the issue. (This information will be in the input to the computer.) Selective exposure to these biased channels is certainly to be anticipated, and is already built into the simulation (A1, A2, and especially A22). The special feature of B27 is that it postulates a *change* in selective exposure on the basis of change in attitude position (rather than on the basis of experiential reactions to the content of particular channels). At least three possible cases fall under this general rubric: (a) the new recruit to a position, who is given or himself selects propaganda marking his "initiation"; (b) the moderate who slowly becomes more extreme as the campaign progresses and adjusts his exposure habits accordingly; (c) the individual whose position has been weakened by an effective exposure, who then has a somewhat higher probability of exposing himself to the opposition, preparing himself for the possibility that he will be unable to resist conversion.[21]

At the conclusion of the time cycle corresponding to the final week of the campaign, the outcome of the vote may be simulated.

C1. If the individual votes, he will vote in accordance with his final attitude position.

C2. The probability that the individual will vote is a direct function of his interest in the issue and the extremity of his attitude position.

[21] This is an instance of information seeking as a means of dissonance reduction (see Festinger, *op.cit.*, p. 172).

These two propositions have not yet been integrated into the simulation program. In practice, of course, voting turnout will depend upon what other issues are on the ballot and upon other variables extraneous to the issue being simulated. Fortunately, the model does not have to be validated against the "unreliable" criterion of final vote. A simulation of the changes in the assertions, attitude positions, and interest levels in a survey panel is a much cleaner validating design at this stage of development.

WHO TALKS TO WHOM

Nothing has been said thus far about the method of determining a set of potential conversational partners for each individual. This determination is made prior to the first cycle on the basis of survey information, and a list of potential partners for each individual is maintained in storage throughout the simulation. Although individuals are not added to or dropped from this list, flexibility is provided by changes in conversational probability (interest) and attitudes toward the several partners.

Two general schemes are available in the computer simulation of conversational networks. One is to find in a survey individuals who actually mutually converse, as was done in the famous study by Katz and Lazarsfeld,[22] and to represent all individuals in each such cluster in the computer. This might be called the "method of real partners." Unfortunately, it involves extraordinary pursuit tactics in the survey and leaves unsolved how to trim all overlapping clusters of conversants so that the computer population is closed and finite. A second method is to match people within the available thin computer population on the basis of common characteristics, such that it is reasonable that they might converse or at least represent types who might converse. This might be called the "method of pseudo-partners." We use a variant of this method, in which people are matched not directly but indirectly. (Direct matching tends to overemphasize demographic cleavages.)

Each individual specifies on the initial survey the places where he is likely to hold conversations on community issues. For each appropriate place the individual thinks of an *actual conversational partner* (if any), and tells the interviewer the key demographic characteristics of this actual partner. This information then serves as a template in locating pseudo-partners.

Our computer subroutine will attempt to locate individuals in the computer population who approximate the requirements of each template. Each individual may possess from zero to ten templates, and the

[22] E. Katz and P. F. Lazarsfeld, *Personal Influence*, Glencoe, Ill., Free Press, 1955.

program will locate up to a maximum of twenty-four potential partners. Partnership is here asymmetric: X can serve as a partner for Y even though Y does not serve for X.

In actual practice, many individuals may almost never discuss community affairs and thus give no templates in the initial survey. The computer would thus find no potential partners for them. A provision for very occasional "off-chance" partners is then made available, although such individuals will remain, as they should, conversationally quite inactive.

TESTING THE IMPLICATIONS OF THE MODEL

Although the propositions of the model are stated in terms of the detailed responses of single individuals, it is not expected that the model will prove especially useful in individual prediction. Clearly, a number of individual variables are not taken into account in the model. Furthermore, individual responses depend, both in the simulation and in real life, upon many probabilistic events, and it is therefore inappropriate to seek a deterministic matching of the model to the real situation.

Rather, what we do hope for is a *statistical* matching, whereby the model yields good predictions for groups of individuals.

There are many as yet unexplored questions in the realm of the research strategy, philosophy, and metaphysics[23] of complex simulations such as the present one. At the present stage, all we can do is indicate in a general way that it is useful to build the model at the individual level in order to produce more powerful and ramified predictions at the group level and a better "explanation" of group phenomena. After all, the fields of political sociology and social psychology are not so far removed from each other that it is implausible that the former can be partially "reduced" to the latter.[24]

Coming down from this lofty abstract plain to a concrete example, consider the oft-cited case of the cross-pressured voter.[25] At the individual level, the "pure case" might appear in the simulation in something like the following terms: The individual circulates in two distinct social environments that are at cross-purposes with respect to the referendum issue. In one environment, say, his neighborhood, he may

[23] One general principle with which the computer simulation approach seems to be at variance is the law of parsimony. Some scrutiny of what "parsimony" might mean in the simulation context is needed—perhaps Occam's Razor should be replaced by Occam's Lawnmower.

[24] It is, on the other hand, presently implausible, for example, that social psychology could be partially reduced to neurophysiology: the gap is too big.

[25] P. F. Lazarsfeld, B. Berelson, and Hazel Gaudet, *The People's Choice*, New York, Duell, Sloan, and Pierce, 1944.

be exposed to occasional arguments on one side of the issue and in the other environment, say, at the place he works, he may be exposed to occasional arguments on the other side of the issue. He identifies himself as belonging to both social groups and has a favorable attitude toward the particular individuals from whom he hears the particular arguments. Initially, he doesn't know much about the issue but has a slight to moderate stand against the referendum proposal. What very few negative arguments he knows he has picked up at the factory. He talks to a neighbor, who advances an unfamiliar argument in favor of the proposal. Our hero cannot counter the argument, the argument does not itself offend him, and he respects his neighbor; thus, according to propositions B6 and B8, and in spite of proposition B10, he incorporates the argument. The next time he has casual contact with the issue he finds himself confused. He knows arguments on both sides. It is too much of an effort to think it through because the issue doesn't mean that much to him one way or the other. He says to himself, "The heck with it!" and avoids future exposure to the arguments (B14). If he did permit himself campaign exposure, one side or the other might prove stronger and win him over. But since he does not, his interest declines still further (B26), and on election day he stays home (C2). It is unlikely that such "pure cases" will occur very often in the simulation, but enough individuals would probably sufficiently approximate the pure pattern to yield appropriate statistical conclusions about cross-pressured voters, for example, that they are less likely to vote.

The most precise test of the implications and validity of the simulation model is of course to try it in the field. As a preliminary to this necessary step, we have carried out a "dry run" of the simulation, using manufactured data on fifty individuals and a very simplified mock fluoridation campaign with three sources (supposedly two columnists and the mayor), two channels (say, the local newspaper and TV station), and two main assertions per source. The two columnists make opposing assertions for all ten weeks of the campaign. The mayor intervenes in the fourth week and is mildly pro-fluoridation. The data were manufactured from a combination of demographic information, intuition, and actual survey statistics on fluoridation gathered by Arnold Simmel[26] and others. No attempt was made to achieve a precise representation of an actual sample, since data penetrating to the level of detail needed for the computer model do not yet exist. The mock input data were merely made somewhat realistic, for illustrative purposes.

Some of the results are displayed in Tables 1 to 5. Table 1 has to do with position on the fluoridation issue. Position is represented on a

[26] Simmel, *op.cit.*

quantitative scale extending in both directions from a zero point. Before discussing the figures in the table, we should point out that the mock campaign used was extremely minimal. Changes in the dependent variables were therefore slow and generally small. Furthermore, by having two sources be pro-fluoridation and only one be anti-fluoridation, the cards were stacked on the "pro" side, as can be noted from the trend in the third row of the table. (In real campaigns, of course, the anti's usually win.) The first two rows of Table 1 give the average position score of all those whose scores are positive separately from the average score of all those whose scores are negative. The point to be noted is that the average scores on each side become more extreme as the campaign progresses. As we mentioned earlier (A18), it is not easy to devise a mathematical model of large-group social influence that will tend to generate polarization of attitude positions. Most models tend to produce ultimate attitude agreement of all individuals. The simulation model was designed so as to avoid this pitfall of unrealism, and apparently succeeds.

TABLE 1

POLARIZATION OF ATTITUDE POSITIONS
(*average position scores*)

Group	*Week 0*	*Weeks 1-3*	*Weeks 4-7*	*Weeks 8-10*
Pro	+112	+124	+154	+193
Anti	−126	−127	−138	−145
All	−3	−1	+4	+22

Table 2 displays another manner of partitioning the sample so as to shed light on the trend in attitude positions. Age is known to be one of the potentially important demographic factors in fluoridation controversies.[27] In particular, elderly people are often concerned about their health and might be expected to become more negative toward fluoridation under repeated exposure to assertions questioning the safety of fluoridated water for general health. This effect does not take place in the simulation run.[28] The "Over 50" group starts out negative (because that is the way they were put in) and becomes less negative with time. Table 2 shows that the trend toward the "pro" side is general over all

[27] Cf. B. Mausner and Judith Mausner, "A Study of the Anti-scientific Attitude," *Scientific American*, Vol. 192, 1955, pp. 35-39. The relationship of age to fluoridation position is by no means unambiguous, however.

[28] In a way it is fortunate that not everything comes out the way it is supposed to, for this illustrates the capacity of computer simulations to develop unexpected consequences.

three age groups. The youngest group is politically the most inactive and changes hardly at all. The "31 to 50" group is the most active, and carries the general trend most markedly. What happens in the "Over 50" group is the following:

Health-related anti-fluoridation assertions do indeed tend to reach

TABLE 2

AVERAGE ATTITUDE POSITION BY AGE

Age Group	*Week 0*	*Week 5*	*Week 10*
Over 50	−53	−37	−13
31-50	+28	+50	+97
21-30	−1	+3	+4

somewhat older individuals. (The average age of those who come to believe the "Fluoridation is poison" argument during the campaign is 45, whereas the average age of those who come to believe that "Fluoridation is *not* poison" is 36.) However, the "Over 50" group as a whole is so politically inactive that anti-fluoridation arguments tend not to diffuse much. The minority of older people who *are* active tend to be well-educated individuals interested in community charities and the like, and these individuals are generally pro-fluoridation in this hypothetical sample. Thus the "pro" side is helped in this case more than the "anti" side as the campaign develops.

Table 3 displays a well-known social psychological effect, an effect made most recently familiar by Newcomb's work on the acquaintance process.[29] Table 3 shows for three time points the average attitude positions for friends of individuals in three groups defined in terms of attitude positions themselves. The "Strong anti" group consists of all individuals whose positions are more negative than the average negative position prevailing at the time. The "Strong pro" group consists of all individuals whose positions are more positive than the average positive position prevailing at the time, and the "Moderate" group consists of all remaining individuals. A "friend" in the present context means an individual toward whom the person has a positive attitude and with whom he sometimes discusses fluoridation. (Some people in the simulation have no friends in this sense because they never discuss the issue.)

The initial relationship between own position and the average position of friends is scrambled. The average position of friends of strong anti's is +14, for example. As the campaign progresses the

[29] T. Newcomb, *The Acquaintance Process*, New York, Holt, Rinehart, and Winston, 1961.

TABLE 3

ATTITUDE POSITIONS OF FRIENDS
(*average position scores*)

Own Position	*Week 0*	*Week 5*	*Week 10*
Strong pro	+46	+220	+261
Moderate	−15	− 13	+ 53
Strong anti	+14	− 6	− 42

relationship sorts itself out, so that after ten weeks the strong anti's are predominantly friendly with anti's and the strong pro's friendly with pro's. This effect is clear even though it is superimposed upon a strong general trend favoring the pro side.

At least three effects are conglomerated in this tabulation. People exposed in conversations to extreme positions on one side of an issue will tend either to become more extreme themselves (B20) or, if this is uncongenial, then to grow less friendly toward the individuals involved (B21). A less direct phenomenon is that friends tend to be exposed to similar external influences and thus will often tend jointly toward one or the other side of an issue. These different effects all occur in the simulation, although the most appropriate tabulations would show each effect separately to be weak owing to the minimal intensity of the campaign.

Table 4 tells something of the interest levels during the mock campaign. Interest levels are given in terms of conversational probabilities (see B1). The distribution over the fifty individuals of these probabilities at three different time points are shown. In the first three weeks of the campaign, the interest distribution sags at the lower end while not much happens at the upper end. Eight or nine people with only a tepid interest, aroused, let us imagine, by the initial announcement that a referendum is to be held, are found after three weeks to have virtually no interest at all. At this point, the mayor enters the cam-

TABLE 4

INTEREST INDEX DISTRIBUTIONS

Index	*Week 0*	*Week 3*	*Week 10*
Over .30	0	0	5
.20-.29	4	3	3
.10-.19	6	8	2
.05-.09	19	10	10
.00-.04	21	29	30

paign. Gradually, over the next seven weeks, interest increases at the top of the distribution while remaining fairly constant and minimal at the bottom, until the distribution shown for week 10 is reached. This behavior of the interest distribution seems intuitively plausible.

Table 5 in this illustrative excursion shows a cross-tabulation of change in interest level between weeks 3 and 10 against change in attitude toward the mayor. Our mythical mayor is the major campaign influence in the last seven weeks, and is therefore the stimulus most calculated to arouse interest. Beyond sheer interest, he will offend some people and please others by what he says, and there will be some consequent shifts in attitude toward him.

TABLE 5

CHANGE IN ATTITUDE TOWARD MAYOR VS. CHANGE IN INTEREST
(*weeks 4-10*)

Change toward Mayor	*Change in Interest*		
	Less Interest	*No Change*	*More Interest*
Like less	2	1	3
No change	18	16	6
Like more	0	0	4

In the cross-tabulation of this attitude change and interest change the most notable cells lie in the corners. The numbers are all small (the total sample is only 50 here), but the implications are provocative. Of the 13 people with increased interest, 7 change their attitudes toward the mayor, liking him either more or less. Only 3 people of the 37 people with constant or decreased interest change their attitude toward the mayor. Thus the mayor, who no doubt might expect trouble by entering a partisan campaign, will find that new opinions about him are arising in individuals newly recruited toward higher levels of campaign interest. A controversy about the mayor may arise in consequence, with its locus in unexpected quarters, and develop thence into a full-blown side issue irrelevant to the referendum itself.

We will not pursue this line of speculation further here, since we only mean to illustrate the wide assortment of variables and phenomena that can be addressed by means of the computer simulation model, and in any case a single dry run of an unvalidated model on hypothetical data does not constitute evidential proof.

In some respects the model does not yield satisfactory results. In particular, there is not enough "turnover" in attitude positions in

comparison with the typical finding from panel studies.[30] Only 1 individual out of 50 crossed over the neutral attitude position during the simulation. The proposition which most contributes to attitudinal inertia is B25, and a modification of this proposition is planned. In the present version, too much emphasis is placed on consistency and thoughtfulness. In the new version, each individual (regardless of the number of exposures he has had) will after each cycle randomly select one assertion he has accepted and adjust his position in the appropriate direction. This feature will create a good deal of oscillatory behavior in those individuals who accept roughly equal numbers of assertions on both sides.

Other adjustments in the model will be required as field evidence becomes available. Present plans call for a panel study in three waves. This design permits adjustment of the model on the basis of predictive discrepancies at the second wave before simulating the projected final result for the third wave.

RELATION TO ANOTHER TYPE OF SIMULATION

Among the modest number of social science simulations that have been designed,[31] a few have been in the public opinion field.[32] One of these merits special comment because it constitutes an alternative general approach to public opinion simulation.

One may make a distinction between two types of simulations, prognostic simulation and process simulation. Both of these involve projection forward in time. However, the former type, exemplified by the Pool and Abelson analysis of the 1960 presidential campaign, is exclusively oriented toward detailed specification of future outcomes, while the latter type, exemplified by the present model, is concerned in addition with the details of the process.

Prior to the 1960 presidential campaign Pool and Abelson assembled a large collection of national survey data on issues relevant to the presidential campaign. On the basis of cross-classifications of demographic characteristics, 480 voter types were constructed. For the members of each type, machine tabulations were made of the proportions

[30] S. M. Lipset, P. F. Lazarsfeld, A. Barton, and J. Linz, "The Psychology of Voting: An Analysis of Political Behavior," in Lindzey, *op.cit.*, Vol. II, pp. 1152-1162.

[31] A. Newall, J. C. Shaw, and H. A. Simon, "Elements of a Theory of Human Problem Solving." *Psychological Review*, Vol. 65, 1958, pp. 151-166; H. Guetzkow, editor, *Simulation in Social Science: Readings*, Englewood Cliffs, N.J., Prentice-Hall, 1962; S. S. Tomkins and S. Messick, editors, *Computer Simulation of Personality: Frontier of Psychological Theory*, New York, Wiley, 1962.

[32] I. Pool and R. P. Abelson, "The Simulmatics Project," *Public Opinion Quarterly*, Vol. 25, 1961, pp. 167-183; W. McPhee, "Note on a Campaign Simulator," *Public Opinion Quarterly*, Vol. 25, 1961, pp. 184-193; also, James S. Coleman and his students have a number of public opinion simulations in progress.

of respondents occupying each identifiable position on each of a number of relevant issues or kinds of behavior, for example, willingness to vote for a Catholic for President or recall of own vote in the preceding congressional election. The one particular assumption that seemed of greatest relevance in August 1960 was that the so-called "Catholic issue" would dominate the campaign relative to other influences that might alter people's votes from what would be predicted simply on the basis of previous allegiances. Groups of voter types were examined in turn, and by straightforward reasoning the nature of the probable impact of this issue on each voter type was assessed. Quantitative assessments of probable impact were made for all groups of voter types; the computer then weighted each type by its prevalence in the voting population and worked out the specific numerical consequences. This latter step constituted the simulation.

We have labeled this kind of simulation "prognostic simulation," in contrast to "process simulation." In prognostic simulation the computer carries present statistics into anticipated future statistics in one leap, without concern for the details of the intervening process. For example, the cross-pressured voter is assumed more likely to stay at home on election day, and the computer simply puts a fraction of cross-pressured voters statistically at home, as it were. This reckoning is actuarial; specific individuals are not traced toward the polling booth or away from the polling booth. Nor does the computer represent the state of intention of any group of individuals at any time point intervening between the start of the campaign and election day. This one-giant-step statistical connection between time point 1 and time point 2 is characteristic of prognostic simulation at the level of both detailed assumptions and gross over-all outcome.

The general data requirements for prognostic simulation might be summarized as follows: It is possible to use secondary data, provided certain stringent requirements are met. A "survey bank" must be available with a very large number of cases covering the range of potentially relevant issues. Information from several time points is sometimes desirable to identify trends which might guide prognosis. On the other hand, interviewing need not be in depth on each topic.

Prognostic simulation must be used when process simulation is not feasible. In particular, for national public opinion situations, as opposed to local or possibly state situations, prognostic simulation is usually the only feasible type of simulation. Process simulation is ideal when data from a substantial (though not gigantic) number of cases can be gathered in depth in special-purpose studies of the variables necessary to specify continuing processes.

TECHNICAL NOTE ON THE COMPUTER PROGRAM

The simulation program was written for the IBM 7090 using the FAP programming language. The program comprises approximately 5,000 instructions. Each individual's characteristics are packed into 32 computer words, so that 500 people would take up 16,000 words. The channel input requires 2,000 additional words. (The capacity of the 7090 is 32,000 words.)

During the actual simulation each individual who is being considered is unpacked from his 32-word location to an area comprising 307 words, each word containing a different quantity describing the individual. After the individual undergoes his channel and/or conversational exposures and the transformations which may change some of the 307 quantities, he is repacked in his 32-word slot, and the program continues on to the next individual. During the conversational routine, of course, two individuals are unpacked at the same time.

Presently, the output is written on a binary tape in the same form as the unpacked region, so that for each week of the simulation there will be one file on the output tape, each file containing as many records as there are individuals, and each record containing 307 words. In its present form, one time cycle takes approximately five seconds for fifty individuals.