The Diffusion of an Innovation among Physicians[1]

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Anthropologists and sociologists have long been concerned with the processes through which customs, practices, attitudes, or messages spread. Traditionally, these processes have been studied by examining the ecological distribution of the trait at successive points in time. In a few cases, the actual transmission of messages from person to person has been traced out (e.g., 1, 3, 4, 5, 10). A still different approach to the study of this problem is reported in this paper. The population is physicians in four cities; the item whose use was spreading was a new drug; and the study focused on the ongoing social processes which finally led to widespread adoption of the drug by these physicians.

Data were collected 15 months after a new drug with wide potential use, here called "gammanym," had been placed on the market. By this time almost all the doctors in relevant specialties in the four cities studied had used the drug, some almost immediately, others only after a considerable interval of time. The research problem, stated most concretely, is this: What were the social processes which intervened between the initial trials of the drug by a few local innovators and its final use by virtually the whole medical community? The results reported below concern the effectiveness of networks of interpersonal relations at each stage of the diffusion process. The study is to be reported in full elsewhere (2); a pilot study has already been reported upon (9). A separate article by one of us describes the cumulative research experiences which led to the decision to focus explicitly upon interpersonal relations, using sociometric techniques (6).

METHODS—I

The method of survey research, involving structured interviews with a sample of physicians, was used. But since the problem as defined

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concerned the social structure which linked these doctors together, it was necessary to deviate in two important ways from the customary survey design which, in effect, treats individuals as so many independent units of observation. (a) Each doctor interviewed was asked three sociometric questions: To whom did he most often turn for advice and information? With whom did he most often discuss his cases in the course of an ordinary week? Who were the friends, among his colleagues, whom he saw most often socially? In response to each of these questions, the names of three doctors were requested. This made it possible to trace out the links by which each doctor was connected with the rest of the medical community. (b) It was decided to include in the sample, as nearly as possible, *all* the local doctors in whose specialties the new drug was of major potential significance. This assured that the "others" named by each doctor in answer to the sociometric questions were included in the sample, so that it became possible to characterize pairs or chains of socially connected doctors. Accordingly, 125 general practitioners, internists, and pediatricians were interviewed; they constituted 85 per cent of the doctors practicing in these fields in four Midwestern cities, ranging in population from 30,000 to 110,000.[2]

The dependent variable of the analysis which follows is the month during which each doctor first used the drug. This information was *not* obtained in the interviews; it was obtained through a search of the prescription records of the local pharmacies for three-day sampling periods at approximately monthly intervals over the 15 months following the release date of gammanym. In this way, the month during which each doctor first used the drug was ascertained.[3] The research is thus based on three kinds of data: the month of each doctor's first prescription for the new drug, obtained through a search of pharmacists' files; data about the informal social structure of the medical community, derived from doctors' replies to sociometric questions in an interview; and many individual attributes of each doctor, likewise obtained by interview.

[2] In addition, 103 doctors in other specialties were also interviewed, thus making a total sample of 228, or 64 per cent of all doctors in active private practice in these cities. The analysis presented here is based only on the 125 general practitioners, internists, and pediatricians, except that sociometric designations accorded them by the remaining 103 doctors were included when measuring the sociometric status of the 125.

[3] The date so ascertained will tend to be slightly later than the doctor's actual introduction date, due to the sampling of days. The interval between sampling periods was made to alternate between 32 and 25 days, so that each two successive sampling periods included all 6 days of the working week. Records were obtained from 64 of the 84 drug stores in the four cities. Of the remaining 20, only two had any significant pharmaceutical business.

RESULTS—I

Before presenting the results concerning interpersonal relations, the results concerning other ("individual") determinants will be briefly characterized. As expected, the date on which a doctor first prescribed the new drug was related to a large number of his *individual* attributes, e.g., his age, the number of medical journals he subscribed to, his attachments to medical institutions outside his community, and certain attitudinal characteristics. To illustrate the relationship of drug introduction date to such individual attributes, one of the latter will be singled out: the doctor's relative orientation to his professional colleagues and to patients, inferred from his answer to the following question:

How would you rank the importance of these characteristics in recognizing a good doctor in a town like this?

a. The respect in which he is held by his own patients
b. His general standing in the community
c. The recognition given him by his local colleagues
d. The research and publications he has to his credit

The following rankings were classified as "profession-oriented": cdab, cadb, cbda, cabd; the following rankings were classified as "patient-oriented": abcd, acbd, acdb, bacd. The 14 doctors who gave other rankings were assigned to one group or another by a rank-order scaling procedure which will be described in detail elsewhere (2).

Figure 1 shows the relationship of the resulting classification to the date of introduction of the new drug. The solid curve represents those doctors who were classified as profession-oriented, and shows the cumulative proportion of gammanym users among them for each month. Thus, for example, by the fourth month 40 per cent of these doctors had used gammanym; by the sixth month over 50 per cent. The lower curve similarly represents the doctors who were classified as patient-oriented; by the sixth month only 42 per cent had used the drug. Thus the more profession-oriented doctors in these cities generally used the drug earlier than the less profession-oriented ones.[4] Similar results were obtained for many other individual attributes—i.e., attributes describing individuals without reference to their social relations with one another.

[4] The difference between the mean adoption dates of the two groups in Fig. 1 is 2.8 months, which is significant at the .01 level, using a standard two-tailed test of difference between means of normally distributed variables. It should be pointed out, however, that the argument of this report does not rest on the statistical significance of isolated findings so much as on the consistency of the results of several diverse approaches with one another and with prior theoretical notions. It is doubtful that significance tests in the usual sense are meaningful in situations like the present. For a detailed statement of our position in this matter, see (8, p. 427).

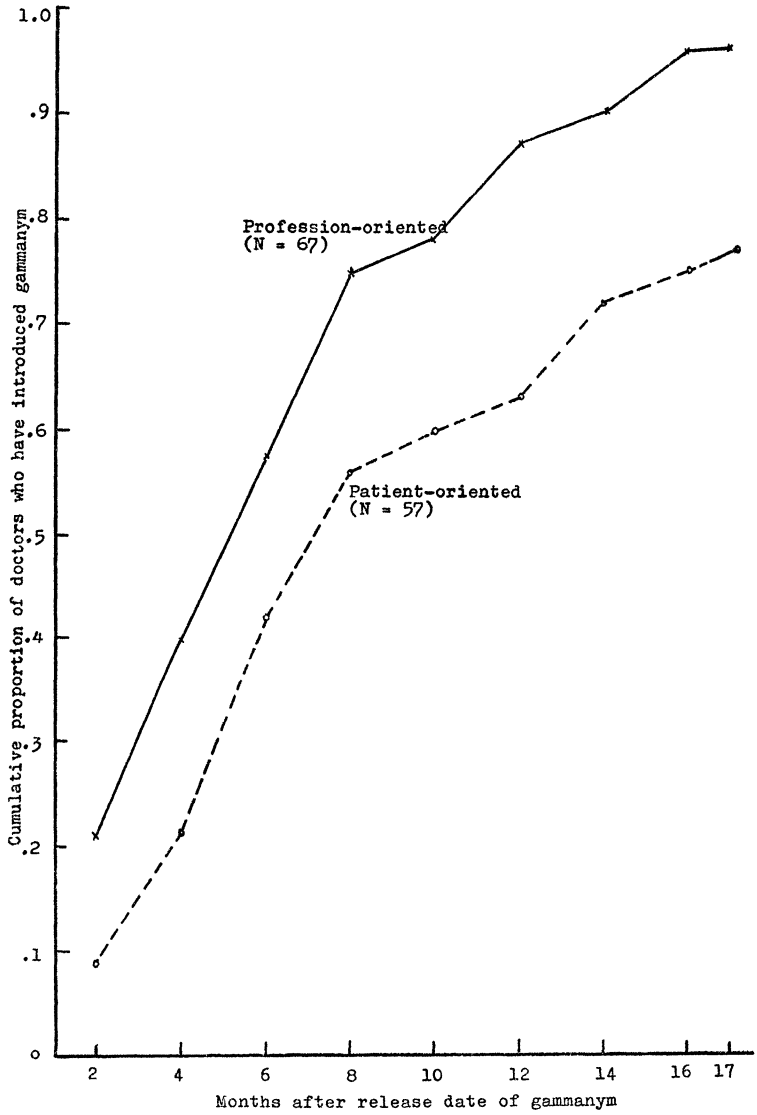

FIG. 1. Cumulative proportion of doctors introducing gammanym: profession-oriented *vs* patient-oriented.

But even stronger relations were found when we turned to *social* attributes—those characterizing a doctor's ties to his local colleagues. Doctors who were mentioned by many of their colleagues in answer to any of the three sociometric questions used the drug, on the average, earlier than those who were named by few or none of their colleagues. More generally

speaking, the degree of a doctor's integration among his local colleagues was strongly and positively related to the date of his first use of the new drug. Figure 2 shows, for example, the results with regard to the network of friendships. The "integrated" doctors—those named as "friends" by three or more of their colleagues—were much faster to introduce gammanym

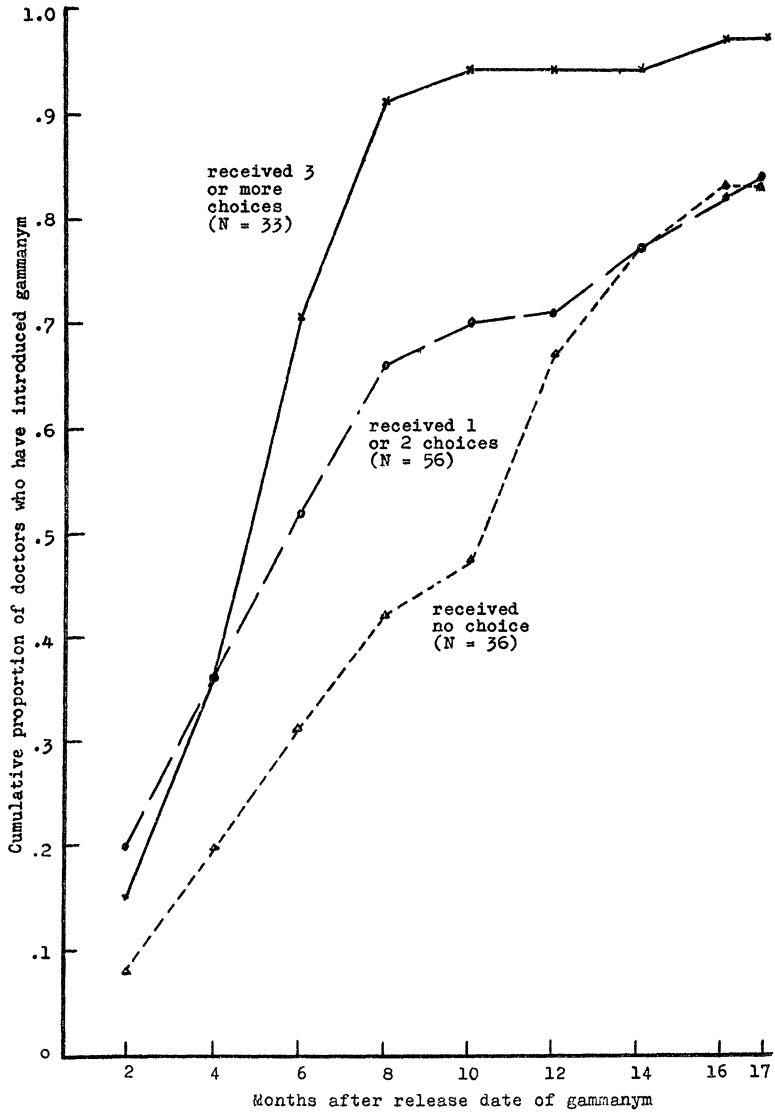

FIG. 2. Cumulative proportion of doctors introducing gammanym: differences in integration on friendship criterion.

into their practices than the rest. The networks of discussion and of advisorship yielded similar findings.

Two important contrasts differentiate Figure 2 from Figure 1, and, more generally, social attributes from individual ones, in their relation to gammanym introduction. First, the relationship in Figure 2 (as measured, for example, by the difference between the mean drug introduction dates of the extreme groups) is greater than that in Figure 1; greater, in fact, than the relationship of the introduction date of gammanym to all but one of the many individual characteristics which were examined. (The single exception is the doctor's total prescription volume for the general class of drugs which includes gammanym: the greater his use of drugs of this type, the earlier did he introduce gammanym.)[5] This emphasizes the importance of social contacts among doctors as a crucial determinant of their early use of the new drug.

But it may reasonably be questioned whether the relationship shown in Figure 2 may not arise merely because the measures of social integration are themselves associated with some personality or other individual differences which predispose a doctor to early introduction. It is in answer to this question that a second contrast between Figures 1 and 2 is relevant.

Notice that the two curves in Figure 1 are roughly parallel, differing from one another only in vertical displacement. This is true as well in most of the remaining charts (not shown) which relate individual characteristics to gammanym introduction. The curves in Figure 2, by contrast, differ from each other in shape as well as location: the curve for the more integrated doctors, although not starting out much higher than the other curves, rises steeply upward with a slight gain in slope at the fourth month, while the curve for the more isolated doctors rises at a moderate and almost constant slope. To put it differently, the integrated doctors were little different from their isolated colleagues at the very beginning; but then their rate accelerated to produce an increasing gap between the curves. In contrast, the profession-oriented doctors in Figure 1 differed from the patient-oriented from the very start almost as much as later on.

The constant difference between the profession-oriented and patient-oriented doctors suggests that they differ individually in their receptivity to new developments in medicine. On the other hand, the accelerating difference between the integrated and isolated doctors suggests a kind of "snowball" or "chain-reaction" process for the integrated: They are

[5] The difference between the mean drug introduction dates of those high and low on integration according to the 3 sociometric questions used is 3.1, 4.1, and 4.3 months. The difference between those with high and low total prescription volume for this general class of drugs is 5.0 months. Only one other individual characteristic (number of journals read) produced a mean difference of as much as 4.0 months.

individually little different in receptivity from their more isolated colleagues, but as their fellows come to use the drug, they pick it up from these doctors themselves; and as more of their fellows come to use it, their chances of picking it up are greater.

The difference between the two kinds of relationship to drug introduction is also shown by Table 1, which compares the individual variables and the social variables in their relation to gammanym introduction at two points in time: 1 month and 7 months after the drug was introduced. For each of these dates, the table shows the average difference in per cent of gammanym users (a) between those measuring "high" and "low" on each of twelve individual variables and (b) between those measuring "high" and "low" on three measures of social integration. The latter are based on choices received in response to the three sociometric questions mentioned earlier. The twelve individual variables include all those examined which showed a difference of two or more months in mean date of introduction between the high and the low groups.

The size of these differences measures the size of the relationship at the two times. As is evident, the social integration measures show a slightly *smaller* relationship than do the individual variables after 1 month, but a much *larger* relationship after 7 months. Thus, as exemplified by the comparison between Figures 1 and 2, the socially integrated doctors "pull away" from their isolated colleagues, while the doctors differing in some individual attribute simply maintain their intrinsically different receptivity as time goes on.

Figures 3 and 4 show the difference between two corresponding theoretical "models" of the introduction process. In Figure 3, the upper and lower curves both express a model of "individual innovation"; the difference between the two is simply that the receptivity is greater for the upper. This difference in individual innovation rate or receptivity corresponds, we suggest, to the difference between profession-oriented and patient-oriented doctors (and between doctors who differ in other individual attributes as

TABLE 1

The Average Relation of Twelve "Individual" Variables and of Three Measures of Social Integration to the Rate of Gammanym Introduction at Two Points in Time

	Average Difference in Per Cent of Gammanym Users between High and Low Groups		Ratio of Differences
	After 1 Month	After 7 Months	
Individual variables	9.2	27.4	2.98
Social integration	8.7	40.3	4.64

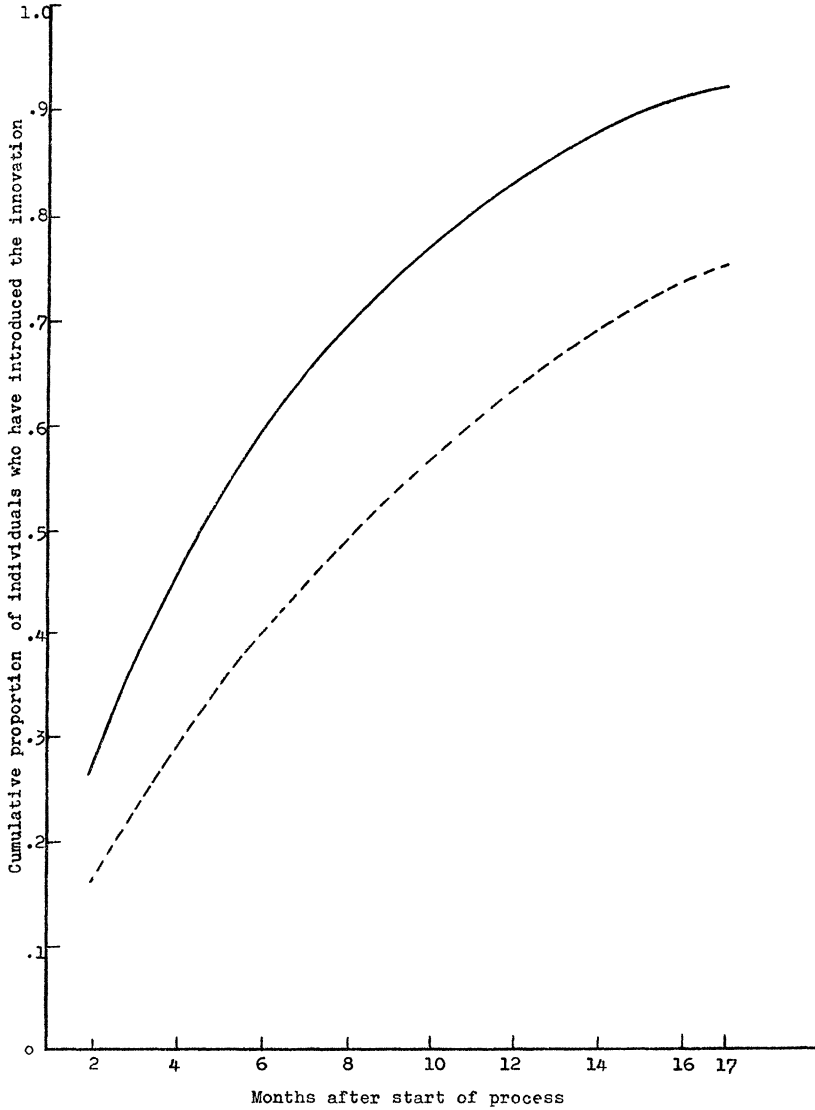

FIG. 3. Model of individual innovation, showing effects of differences in individual receptivity, k.

$$\frac{dy}{dt} = k(1 - y)t.$$

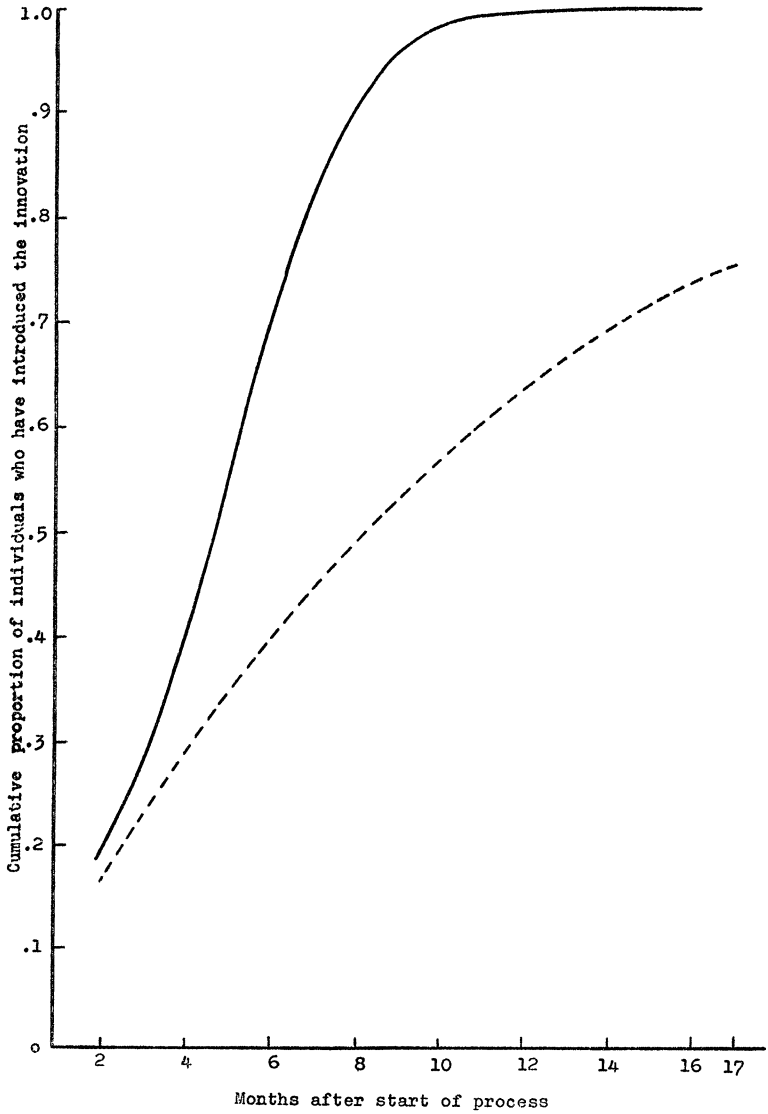

FIG. 4. Comparison of model of "chain-reaction" innovation with model of individual innovation.

$$\frac{dy}{dt} = ky(1 - y)t.$$

well). In contrast, in Figure 4 the upper curve (which is roughly similar in shape to the curve for the integrated doctors) represents a snowball process in which those who have introduced pass on the innovation to their colleagues. (This curve is described by an equation which has been used to characterize rates of population growth, certain chemical reactions, and other phenomena which obey a chain-reaction process.) The lower curve in Figure 4 is still the individual innovation process. (Technically, the individual and snowball processes are described by equations on the graphs, which can be paraphrased as follows: *Individual process*—the number of doctors introducing the new drug each month would remain a constant percentage of those who have not already adopted the drug. *Snowball process*—the number of doctors introducing the new drug each month would increase in proportion to those who have already been converted.)

In short, these comparisons suggest that the process of introduction for those doctors who were deeply embedded in their professional community was in fact different from the process for those who were relatively isolated from it. The highly integrated doctors seem to have learned from *one another*, while the less integrated ones, it seems, had each to learn afresh from the journals, the detail man (drug salesman), and other media of information.

METHODS—II

This result called for a more detailed investigation into the ways in which the networks of relations among the doctors affected their introduction of the new drug. Such an investigation required a shift of focus from doctors to relationships among doctors or to the networks themselves as the units of analysis. Various methods could have been devised to do this. We chose to record the behavior of *pairs* of doctors who were sociometrically related to one another, reasoning that if the networks of relations were effective, then pairs of doctors who were in contact must have been more *alike* in their behavior than pairs assorted at random. That is, if there was a snowball or chain-reaction process of drug introduction from one doctor to another, then adjacent links in the chain—pairs of socially related doctors—should have introduced the drug about the same time.

In order to test this hypothesis for the discussion network, Figure 5 was constructed. (Similar figures were constructed for the networks of friendship and advisorship.) Each sociometric pair was assigned to a column of this matrix according to the gammanym introduction date of the chooser, and to a row according to the gammanym introduction date of the doctor chosen. (A mutual choice constitutes two pairs in this tabulation, since any chooser and his choice constitute a pair.) Pairs of doctors who introduced the drug during the same month (interval zero) fall

Date of first use by chooser (months after release)

Date of first use by chosen	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	17+	T
1	3				1	2	4				1		1						12
2	1	4			1		1	4			1				1			2	15
3		2	1	3	2	1	1	3		1				1	2			2	19
4	1		1	2	2	1		3						2				2	14
5	1		1	1	1	2	3	1	1	1	1					1		4	18
6	4	3	1		3		1		1								1	1	15
7	4			1	2	2	2	1			1		1	1				1	16
8	1	2	4	4	2	2	1	1			2		1		1	1		3	25
9				1	1	1					1			1					5
10																			0
11				1					1										2
12																			0
13											1							1	2
14				1			1					1							3
15		1																	1
16																			0
17																		1	1
17+		2	2		3	1	1		1									3	13
T	15	14	10	14	18	12	15	13	4	2	8	1	3	5	4	2	1	20	161

FIG. 5. Chart showing dates of adoption of each member of discussion pairs.

in the main diagonal; pairs of doctors who differed in introducing the drug by an interval of one month fall into cells adjoining the diagonal; and so on.

The resulting distribution of these intervals for the sociometric pairs was then compared to the corresponding distribution of intervals for a set of "random pairs" which has the following characteristics. If a pair is selected at random: (a) the probability that the chooser-member of the pair introduced gammanym during a particular month is the same as in the actual sample but is independent of the introduction date of the doctor chosen; (b) the probability that the chosen member introduced gammanym during a particular month is the same as in the actual sample but is independent of the introduction date of the doctor making the choice. Thus, for example, among the random pairs, those who introduced gammanym in the first month and those who did so in the seventh gave equal portions of their choices to other first-month introducers. Similarly, those who introduced

gammanym in the first month and those who introduced it in the seventh *received* equal portions of their choices from first-month introducers. Operationally, a set of "chance" frequencies satisfying these criteria can easily be obtained by computing for each cell of Figure 5 the product of the associated marginal totals, divided, for convenience, by the grand total.[6]

Contrary to expectations, the proportion of pairs whose members had introduced gammanym during the same month, one month apart, two months apart, and so on, according to the chance model proved to be almost identical to the proportion of actual discussion pairs who had introduced gammanym simultaneously or with varying intervals. The results for pairs of friends and for advisor-advisee pairs were similarly disappointing. This meant the rejection of our original hypothesis that pairs of doctors in contact would introduce the drug more nearly simultaneously than pairs of doctors assorted at random.

There was, on the other hand, the earlier evidence that the doctor's integration was important to his introduction of gammanym. This dictated a more intensive look at the behavior of pairs of doctors. Accordingly, we raised the question whether the networks, though ineffective for the *whole* period studied, may have been effective for the *early* period, immediately after the drug was marketed. An inspection of Figure 5 suggests that this could easily be the case. If only the upper left-hand portion of the matrix, representing the first two, three, or four months, is considered, then there appears to be a tendency for both members of a pair to introduce the drug in the same month.

In order to describe this tendency more precisely, it was decided to eliminate from consideration those associates of each doctor who used the drug only after *he* did. That is to say, the following question was now asked of the data: How closely did the drug introduction of each doctor follow upon the drug introductions of those of his associates who had introduced the drug before him? The answer is: very closely, for early introducers of the drug; not at all closely, for late introducers of the drug.

This result is based on a measure for each month, obtained by dividing up the total matrix of pairs of doctors as shown in Figure 6. The single cell in the upper left-hand corner represents those pairs both of whose members introduced the drug in the first month. The L-shaped section next to it contains the pairs which consist of one doctor who introduced the drug in

[6] A complication arose from the fact that the study was carried on in four different cities, with sociometric choices between cities excluded. This could spuriously raise any measure of pair-wise similarity of behavior, if there are large differences in behavior between the cities. (This fact was called to our attention by Jack Feldman of NORC). In order to avoid such a spurious relation, "chance" frequencies, as above described, were calculated separately from the marginal totals for each city, and only then summed over the cities.

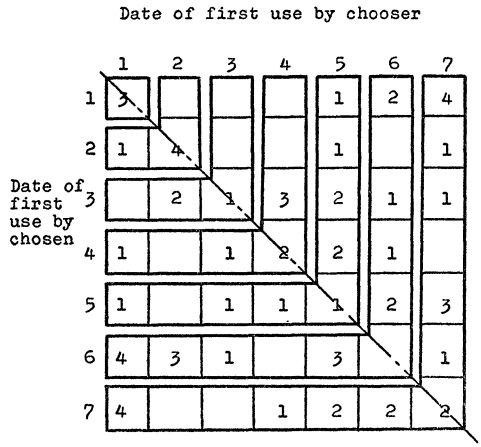

FIG. 6. Exploded view of portion of Fig. 5, showing monthly segments.

the second month and one who introduced it in the first *or* second. The next L-shaped section contains all pairs which consist of one third-month adopter and one third-month-or-earlier adopter, and so on. It was now possible to determine the average interval for the sociometric pairs in each L-shaped section; likewise the average interval for the corresponding random pairs. On this basis, a measure of simultaneity was computed for each section, according to the formula:

Measure of Simultaneity (positive) =

$$\frac{\text{(avge. interval for random pairs)} - \text{(avge. interval for sociometric pairs)}}{\text{avge. interval for random pairs}}.$$

This measure expresses the difference between the random and actual intervals as a fraction of the difference between the random interval and complete simultaneity (i.e., an interval of zero). The measure thus has a maximum of 1, and is zero when pairs are no closer than chance. In those cases where the actual interval exceeded the random interval, a different denominator was used.[7]

[7] Measure of simultaneity (negative) =

$$\frac{\text{(avge. interval for random pairs)} - \text{(avge. interval for sociometric pairs)}}{(s - 1) - \text{(avge. interval for random pairs)}}$$

s being defined as the number of the latest month included in the particular L-shaped section. (E.g., $s = 4$ in the case of pairs consisting of one fourth-month adopter and one fourth-month-or-earlier adopter.) When the index has a negative value, it therefore expresses the difference between the random and actual intervals as a fraction of the difference between the random interval and the maximum interval that is possible.

RESULTS—II

The values of the index are plotted in Figure 7 for the second through the sixth months. Separate curves are plotted for pairs of friends, discussion pairs, and advisor-advisee pairs. The interpretation of these results must be tentative because of the small numbers of cases; on the other hand, the patterns which emerge are rather consistent.

Figure 7 suggests, first of all, that the networks of doctor-to-doctor contacts operated most powerfully during the first 5 months after the release of the new drug: such influence as any doctor's drug introduction had upon his immediate associates evidently occurred soon after the drug became available. (Figure 7 omits the later months during which the index is negative or very small.) Second, the three networks did not behave identically.[8] The discussion network and the advisor network showed most pair-simultaneity at the very beginning and then progressively declined. The friendship network shows initially less pair-simultaneity than the other two, but—with some instability—appears to reach its maximum effectiveness later. Finally, after the fifth or sixth month following the release of the new drug, none of the networks any longer showed pair-simultaneity beyond chance.

These results, however tentative, suggest that there may be successive stages in the diffusion of this innovation through the community of doctors. The first networks to be operative as chains of influence appear to be those which connect the doctors in the professional relationships of advisors and discussion partners. Only then, it seems, does the friendship network become operative—among those doctors who are influenced in their decisions more by the colleagues they meet as friends than by those whom they look to as advisors or engage in discussion during working hours. Finally, for those doctors who have not yet introduced the drug by about 6 months after the drug's release these networks seem completely *inoperative* as chains of influence. The social structure seems to have exhausted its effect; those doctors who have not responded to its influence by this time are apparently unresponsive to it. When they finally use gammanym, they presumably do so in response to influences outside the social network, such as detail men, ads, journal articles, and so on, and not in response to their relations with other doctors.

But one further phase in the social diffusion of gammanym can be discerned by examining separately the sociometrically integrated and the

[8] Many of the sociometric ties reappear in two or three of the networks. The three sociometric questions yielded a total of 958 "pairs" within the sample of 125 doctors; but since some of these pairs were identical in answer to two or all three of the questions, there were only 704 *different* pairs. This overlap is still small enough to allow differences in patterns to emerge, as shown in the text.

relatively isolated doctors. One would expect the networks of doctor-to-doctor contact to show their effectiveness first among the more integrated doctors and only then among those who are less integrated in their medical community. It has already been seen (Fig. 2 and text) that the more isolated doctors, on the average, introduced gammanym considerably later than the socially more integrated doctors. We now propose, however, that when more isolated doctors *did* introduce the drug early, it was not with the help of the social networks. While the networks were operative as channels of influence *early* for the integrated doctors, they were operative

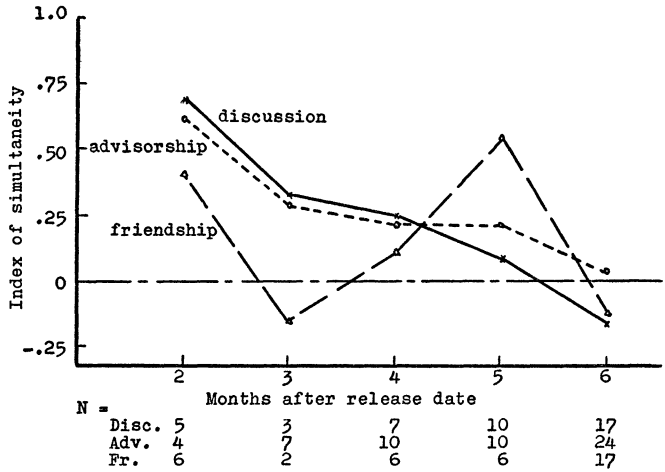

FIG. 7. Index of pair-simultaneity for three networks at different times.

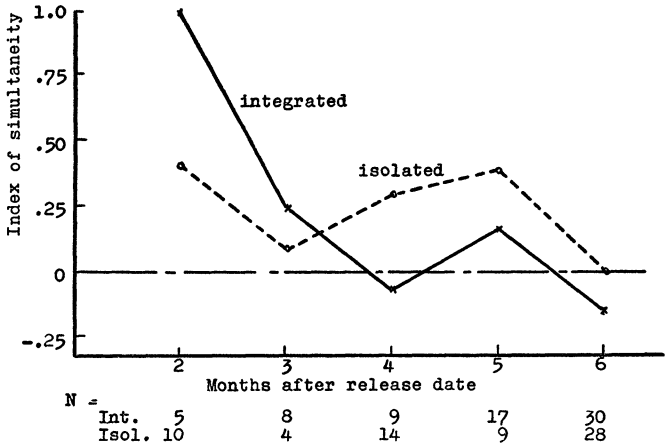

FIG. 8. Index of pair-simultaneity at different times for doctors differing in integration.

only later for the more isolated ones. This is what seems to have occurred. Figure 8 plots the index of simultaneity separately for more and less integrated doctors. (The graphs show weighted averages for all three networks; separately the numbers of cases would be so small as to produce erratic trends.)

The peak of effectiveness of doctor-to-doctor contacts for the well-integrated doctors appeared in the earliest month for which it can be plotted—the second month—after which effectiveness sharply declined. For the relatively isolated doctors, by contrast, the networks were not so effective at first as were those for the integrated doctors, but they maintained their effectiveness longer. Thus it appears that the networks of relations were effective not only for the more integrated doctors but also for the relatively isolated doctors who introduced the drug during the first 5 months of the drug's availability.

CONCLUSION

The above results, taken together, suggest a process which may be summarized as follows: At first the influence of these social networks operated only among the doctors who were integrated into the community of their colleagues through ties of a professional nature—as advisors or as discussion partners. Then it spread through the friendship network to doctors who were closely tied to the medical community through their friendship relations. By this time, social influence had also become operative in the more "open" parts of the social structure—i.e., among the relatively isolated doctors. Finally, there came a phase during which most of the remaining doctors introduced gammanym but did so in complete independence of the time at which their associates had introduced it: the networks now showed no effect. For the integrated doctors, this phase began about 4 months after the drug's release; for the isolated doctors, it began about 6 months after the drug's release. This picture is of course a tentative one, for the small size of the sample introduces variability, and there may be factors which produce spurious results.

There remains the question: Why should these sociometric ties to colleagues who have used the drug be influential during the first months of the drug's availability, but not later? One possible answer lies in the greater uncertainty about the drug that must have prevailed when it was new. (Data not reported here show that those doctors who introduced gammanym early did so far more tentatively than those who introduced it later.) We know from work in the tradition of Sherif that it is precisely in situations which are objectively unclear that social validation of judgments becomes most important.

More generally, this explanation implies that a doctor will be influenced more by what his colleagues say and do in uncertain situations, whenever and wherever they may occur, than in clear-cut situations. This explanation was confirmed by further data from the study which show that doctors influence each other more in treatments whose effects are unclear than in treatments whose effects are clear-cut. This topic will be dealt with in detail elsewhere (7).

CONCLUDING METHODOLOGICAL NOTE

A word should be added about the significance of research of this kind, aside from the possible interest in its specific substantive findings. It exemplifies a methodological approach which will, we feel, assume a larger role in the social research of the next decade: namely, making social relationships and social structures the units of statistical analysis. To be sure, the analysis of social relations has always been the sociologist's business. Nevertheless, most empirical studies have either treated and described a community, a factory, a hospital ward, or any other large grouping of people as a single unit, or else they have statistically analyzed data collected on hundreds or thousands of single inividuals, as in the typical "survey" study. What has been missing until recently is study designs which would explicitly take into account the structuring of single persons into larger units, and yet allow sophisticated quantitative treatment. The techniques of sociometry can meet this purpose, but have, with some notable exceptions (e.g., 4, 11), been applied chiefly to small closed groups and primarily for descriptive purposes.

The attempt reported here has been to carry out a design and analysis which would effect a marriage between sociometric techniques and survey research, in order to investigate quantitatively problems of the sort which community studies have ordinarily investigated by qualitative means. The attempt, of course, points up many more problems than it even partially solves: e.g., how to integrate an analysis of formal social structures with an analysis of informal ones; how to proceed from pair-analysis to the analysis of longer chains and complex networks; and so on. A set of methodological and substantive problems awaits the researcher. It is suggested that the solution will give sociologists important new tools with which to investigate social dynamics.

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