Scientific Communication as a Social System

The exchange of information on research evolves predictably and can be experimentally modified.

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In 1961, when we began a study of scientific communication in the field of psychology, the "scientific information crisis" within science was generally understood to refer to an increasing literature, especially in the archival journals. Coping with the crisis was usually assumed to be a matter of improving the publication, distribution, and retrieval of this literature. Our experience as laboratory research scientists prior to our association with the American Psychological Association's Project on Scientific Information Exchange in Psychology suggested that the literature was only a portion of a system that encompassed many forms of information exchange. Our change in role from researchers *within* the system of scientific communication to researchers *upon* the system led to an initial impression that scientific communication was both complex and chaotic.

The system we sought to study seemed vast and rapidly changing. Although the system was generally expanding (and had been doing so for years), some meetings and journals were disappearing and many others were markedly changing their function relative to the discipline. Central to the system and to the most general interests of psychologists were approximately 50 channels of exchange of scientific information. However, various specialties within the discipline utilized a wide variety of sources, numbering in the hundreds. In the light of our concern for the efficient functioning of the system, our general impressions were disturbing ones: the elements constituting the system of scientific communication in psychology seemed to compete with one another rather than fulfill any separate, special functions with respect to the whole, and in governing and revising this system the scientist seemed to suspend the objectivity which characterized his approach to his research, and to rely on "folklore."

Such initial impressions resulted in a series of exploratory studies, very general in nature, undertaken to gather data on what actually occurred in scientific communication and to piece together a context within which to describe the relative roles of various media used for exchanging scientific information. These findings led to some initial conceptualizations of the types of lawfulness we might expect to find in the system and then to the development of a program of research encompassing the full spectrum of scientific communication in psychology.

In this article we explore scientific information exchange as a system of social interaction among scientists and also discuss the orderly manner in which information exchange within a discipline evolves. We describe the social and economic dimensions of the dynamics of the system and the special relevance of informal and formal channels of communication to these dynamics. In the final sections we outline the characteristics of an approach for designing and testing innovations in scientific communication and describe innovations which grew directly out of the research on the system and which were undertaken at three critical points in the information-dissemination system in the field of psychology.

Communication within a Discipline

Earlier studies made by the Project on Scientific Information Exchange in Psychology (*1*) describe the mechanics and flow of information from the time it is generated by the reseacher to the time when it can be retrieved from a secondary source. The public portion of the scientific communication system (the portion which involves such formal outlets as journals and national scientific meetings) proves to be small as compared with that part of the system (containing such informal outlets as technical reports and preprint-exchange groups) which distributes information to audiences restricted in size. In addition, not only is the public portion small but the information it conveys is relatively old.

The most significant characteristic of the system, for its overall operation, is the information-exchange *behavior* of the scientists. In their efforts to establish and maintain contact with current work, scientists are continually on the alert for, or actively seeking, scientific or technical information relevant to their ongoing or planned work. Further, they watch closely the performance of the system as it operates to disseminate, display, and store the fruits of their own scientific efforts. If no appropriate channel exists, the producers, or the consumers, of information create new channels or modify old ones in an attempt to improve the performance of the system.

Mainly as a result of the scientist's behavior, the system exhibits impressively lawful features. Information flows through the system in an orderly manner and, although there are various routes, specific kinds of information produced by specific types of researchers seek certain outlets on predictable occasions in predictable sequences and time patterns. The numerous variables that determine the channels of the flow range all the way from the attitudes of researchers to the routines rigorously prescribed by the research institutions at which the work is done or by the outside agency funding the research. Moreover, the outlets chosen by the researcher are very often associated with the specific needs of the user, and the information is shaped and reshaped to fit the characteristics of channels and the needs of audiences.

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Regardless of the flow pattern, the ultimate form of dissemination for by far the greatest part of the *scientific* information produced within the field of psychology is publication in an archival journal, and the limitations of this channel give constant impetus to the creation and maintenance of many of the elements in the domain of informal communication (*2*).

A Dynamic and Orderly Social System

In its response to change, exchange of scientific information appears to be a dynamic social system that is both orderly in operation and ideal for study. Since scientific communication is largely a matter of interaction among scientists, the major activity in the system is social, and, because scientists normally disseminate their findings, much of this activity is public and readily studied. Also, since the major elements within the system are social institutions, the dynamics of the system cannot be described without consideration of social processes internal to these institutions and the probable response of such processes to events in the remainder of the system.

The review of the entire body of data gathered in the project's earlier work and in additional studies on minor communication media seemed to support several assumptions concerning processes within the system, constancies in the scientist's behavior, and the contribution of such factors to lawfulness existing within the system. In the field of psychology, the most important feature of the system is the fact that it is a relatively closed one (*3*): not only is the scientist a generator, disseminator, and user in the very system of which he is a creator but the two gross products of the discipline—its information and its manpower—feed back into the system continuously. Thus, the aggregate information-exchange behavior of scientists within the system may be diverted from one medium to another, but the goals of this behavior, relative either to the scientist's work or to the operation of the system, remain relatively constant and the amount of this behavior does not capriciously increase, decrease, or respond to the environment outside the system. A further constraint is the apparent governing of scientific communication by relatively stable and powerful social norms (*4*). There is some suggestion that many of the norms are very resistant to the influence of time and to influences from outside the scientific community, and there is contemporary evidence in the project's work that a considerable portion of the scientist's behavior within the system is controlled by attitudes governed by such norms.

In summary, the dissemination system was seen as having some degree of orderliness because the dynamic interrelationship of the elements operates under powerful constraints: a tightly bounded system, constancies in the scientist's behavior, and a set of norms dealing specifically with communication. Three major dimensions of the operation of these dynamics—social dimensions, economic dimensions, and the functional characteristics of formal and informal elements of the system—are discussed below.

Social Dimensions

We have mentioned that scientists themselves create elements to fulfill information needs that are not being satisfied by existing media. These newly created elements affect other elements in the system by changing the scientist's information-seeking and information-disseminating behavior. Such behavioral changes in turn alter the roles of other elements within the system and may, in time, effect a shift in norms. Through such changes the discipline becomes a new information environment that sets the stage for further creation of new elements. Since social interaction is the most observable aspect of the dynamics of the system, an example of the way in which modification of the system through these means might occur seems appropriate.

The chain of events, in a fast-moving research area, may begin with publication lag becoming so great that current information needs are unsatisfied. As a result, the exchange of preprints among scientists working in this area will increase. At some point the exchange of preprints becomes unmanageable on an individual basis and it becomes necessary to organize a more formal preprint-exchange mechanism. Often this new mechanism is a preprint-exchange group, organized by an elite few concerned with a single specialty, who invite other active researchers in the field to join the group. As this information medium grows it takes on more and more of the attributes of its formal counterpart—the scientific journal—and it begins in many ways to serve as a substitute for the journal. To maintain some control over the increasing volume of information being exchanged, the informal-exchange mechanism is made more formal; that is, rules are imposed governing the content of the material exchanged and membership requirements are made more restrictive. As this formalization progresses, some of the practices associated with the traditional formal media are adopted by the members of the group. For example, within the group strict enforcement of priority of information disseminated by way of preprint exchange may be established. This process of formalization may continue to evolve until someone realizes that an institution has emerged which has most of the characteristics of an archival journal: a large and increasing input of manuscripts, an existing gatekeeping group, an eager and expanding audience, and growing economic problems. And thus a new journal—and possibly a scientific society—is born. The series of events described here might branch at many of the steps outlined above and, depending upon other forces within the system, lead to a different final outcome. Thus, early in the chain of events the preprint distribution might quickly become so large as to break down and cause the initial group to splinter into smaller specialty groups that take divergent approaches to their information problems.

Economic Dimensions

If one considers the discipline in its national context one finds that funds to support its activities are limited and that an increase in funds for one medium must divert funds from other media or other activities. There are direct and explicit links (for example, subscriptions and page charges) between the flow of information and the flow of resources in the system, and an effective new element in the system often attracts funds from an older, well-established element. This may cause the older element to change its function or to cease operation, even though it might well have continued to serve an existing function which has importance for the overall discipline. By way of illustration, the selective distribution, without charge, of restricted-subject-matter abstracts by government agencies might very effectively serve the

needs of research specialists in a given field and thereby extinguish use of the discipline's general abstracting journal and lead to cancellation of subscriptions to this journal by those so served.

In addition, there are often indirect links between the flow of resources and the functions of various parts of the system. For example, a presentation at a scientific meeting is often made as a means of obtaining travel funds to attend the meeting. Without an understanding of such indirect links and a consideration of the implications they may have for the scientists' behavior and performance within the system, it is difficult or impossible to predict the impact of a new element on the system.

Formal and Informal Media

The formal and informal elements in the system serve distinctive functions relative to both the work of the scientist and the operation of the system. The differences between the formal and informal elements make clear the need for both types within a single subject-matter area. In fact the functions of the two elements seem to counterbalance each other and to constitute a valence system; the lack of either an informal subsystem or of appropriate formal elements is a form of imbalance that leads directly to scientists' undertaking a revision of the system. Some specific contrasts between the two types of elements follow.

1) The few formal elements in the system are public, have potentially larger audiences, and disseminate information at a comparatively low cost per message; the many informal elements are restricted and have smaller audiences (*5*).

2) The information disseminated by formal elements is permanently stored and, typically, retrievable; information conveyed by informal channels is often stored only temporarily and is difficult to retrieve.

3) Formal channels carry information that is relatively "old" as compared with the information disseminated through informal channels.

4) The information carried by most formal channels is monitored, to produce, according to the discipline's standards, a complete, relevant report; informal channels typically are not so monitored.

5) Formal channels appear to be primarily user-selected, whereas the active cooperation of the disseminator is required in the informal domain. Such cooperation is fully granted only if the disseminator believes he can use information that is generated by the exchanges, and in this case the roles of user and disseminator become very blurred.

6) Since the same research is often reported by way of a number of channels and with a variety of emphases, there is considerable redundancy in the overall system. The formal channels are minor contributors to this redundancy, but it is not uncommon to find the same material repeatedly reshaped in various informal media, to fit the characteristics of the channel and the needs of the audience.

7) Informal channels generally include the direct interaction, face-to-face or through correspondence, of scientists—a feature of the greatest importance in the operation of science.

Interaction among Scientists

With regard to point 7 above, the interactive character of informal channels provides for many of those vital aspects of scientific communication which many scientists currently feel are slipping from their grasp. For example, the relevance of information is much more easily established through informal than through formal media. Because of differences in terminology and because there are different fields of endeavor within a science, formal communication is often an inefficient means of providing information necessary for determining the relevance of another's work to one's own. On the other hand, through informal communication a scientist will quickly discover whether he and his colleague are speaking of the same problems, the same variables, the same concepts, and so on, and will guide the exchange to topics of mutual concern and interest.

Informal communication also is more "open-ended." Scientists interacting informally are willing to speculate about their work, to discuss their mistakes as well as their successes, and to range over a broad area of interests. In a more rigorous framework, such as a monitored report, such speculations or discussions may not appear at all or may appear only as minor, unemphasized addenda to specific findings.

Additionally, the flexibility of informal channels allows the scientist to direct the communication process and select for himself specific information he "needs." Every researcher has some specific information needs that he may not always be able to express to, say, an information service, but he can usually recognize the information that satisfies those needs. Such needs, which change from time to time, are determined by the subject matter of the scientist's research, his mode of working, his attitudes toward communicating his own work, and the stage of his research. In the case of most formal channels it is not possible to shape communication to fit the specific and immediate needs of each user.

Finally, informal channels enable a scientist to obtain reinforcement and critical feedback which he may wish to receive rather quickly in order to satisfy his uncertainty about some aspect of his scientific behavior or work. The combination of the requirement that work be well advanced before being reported through formal channels and the long delay typically associated with formal publication tends to render feedback ineffectual when mediated through these channels. In addition, the audience and monitors of the formal channel frequently do not really understand the scientist's objectives because these may not be clearly stated in the formal report.

Designing Innovations

The development of an approach for designing and testing innovations in scientific communication stems directly from conceptualization of scientific communication as a social system (*6*). The most important characteristics of this approach are the following.

1) As in any science, or technology, innovations should be preceded by a study of the existing system. It is necessary to determine the timing, sequence, and diversity of information flow and the characteristics of disseminators and users of each of the elements in order to identify those elements which have roles within the system that are critical to, and establish the operational characteristics of, the system as a whole. Additionally, the scope of an innovation should be limited to a particular area and to a subset of users for which data exist. For example, the degree of dissemination appropriate for active researchers in one discipline may not be appropriate for those in another. Even within one discipline one should study the different types of users—researchers, teachers, students, practitioners,

technologists—before attempting to design any innovation for serving several or all of these groups.

2) The selected innovation not only should fulfill a function for which there is a clearly established need but should move the entire system in desirable directions. The elements of the system are dynamically related and a modification of one element will affect the functioning of others; this interrelationship should be used to advantage in obtaining as broad and beneficial an effect throughout the system as possible.

3) Selected innovations need not be directly associated with the specific elements which are in most obvious need of modification. Some elements which are rigorously bound by long-standing traditions can be modified indirectly through changing elements which precede them in the information-flow pattern of the system. In fact, given the rigidity of some of the existing elements, this indirect approach may be the only feasible way to effect modification of some media.

4) Innovations should lead to effective coupling of formal and informal elements within a single body of scientific knowledge. Too often the only informal channel available is the inefficient and expensive one of one person's seeking out a source, discovering the originator, and arranging to meet him face-to-face. Frequently it is possible to develop an informal element into one with some of the functional attributes of formal communication and, at the same time, preserve important characteristics of informal communication (*7*).

5) In making innovations, one should give consideration to the direct and indirect links between information flow and the flow of resources—that is, to the economic factors involved and their effect on the system.

6) Innovations should be so designed as to generate behavioral and economic measures of their efficiency and effectiveness.

7) An innovation should be designed as a genuine trial, with built-in mechanisms for modifying or terminating it when the results are evaluated. Any predictions of the effects resulting from a given innovation are, at best, approximate, and all too often a poor innovation, once instituted, has a slow death.

The communication system in psychology which existed at the beginning of this study had three features which seemed to call for innovation: (i) the long lag, often exceeding a year, between submission of a manuscript and journal publication; (ii) the 15-month lag between publication of an article in a scientific journal and publication of its abstract in *Psychological Abstracts*, psychology's major secondary source; and (iii) the holding, annually, of the national scientific meeting of psychologists, which has many special functions within the system.

The long lag between submission of a manuscript and journal publication not only seemed inefficient but effectually buried from the public the complete report of scientific work at a time when it might be most useful. (Once an author submits his manuscript to a journal for publication, dissemination of information about that piece of work is usually slight, limited to members of his "invisible college.") In recent years, distribution of preprints, which partially corrects this situation, has been rapidly increasing. Aside from burdening the author with responsibility for providing and distributing the preprints, this type of communication has various practical disadvantages. The most disturbing of these is the fact that those who need preprints most—young scientists, workers at small institutions, and researchers in less developed countries—are frequently not the recipients. To open this inaccessible store of "final" reports of scientific work to the scientific public, several journals which had long publication lag started publishing listings of accepted manuscripts, giving titles and authors' names and addresses. Thus a formal channel was utilized to enhance informal scientific exchange during the period of several months in which the work discussed in the manuscripts would not otherwise have been announced to the vast majority of workers in psychology's research community. The listing of accepted manuscripts has continued for more than a year and the data clearly indicate that this early public announcement of research completed and accepted for publication has caused a variety of interested persons—many of whom normally would have been unable to communicate with authors about their research until from 9 months to more than a year later—to become actively involved in exchange of scientific information on a person-to-person basis.

A second innovation was undertaken in an effort to reduce the 15-month lag between publication of a journal article and the appearance of its abstract in *Psychological Abstracts*—a lag considered entirely too long for most retrieval purposes (the "half-life" of the active use of journal articles in psychology appears to be about 2 years). An additional purpose was that of discovering a more effective way of utilizing the information obtainable from this element of the communication system on (i) the content of psychological work, (ii) the activity of scientists and laboratories, and (iii) dissemination outlets in psychology—all critical to our understanding of the discipline. As a result of studies of the operation and use of *Psychological Abstracts* and through a series of innovations in the operational structure of that journal, the 15-month publication lag has now been reduced to 4 months for material abstracted from the leading journals, and a comprehensive information service is in process of development (*8*).

A third innovation, developed in connection with the national scientific convention of psychologists, illustrates most of the special features of the approach to innovation, thus we describe it here in detail. The annual meeting is an early and important outlet in the dissemination process, occurring about 15 months prior to journal publication of the work presented and including approximately 1000 presentations, covering a sizable proportion of the yearly scientific output of American psychologists. It is the largest of all psychological meetings and the broadest in scope of subject matter, and since attendance at the convention may be as high as 14,000, such presentations command a large potential audience. The convention presentations have already received some screening for quality and are generally interim reports of work that will later be published in some archival form; at least two-thirds of all presentations at recent annual conventions have eventually been published (*9*).

Of all channels within the system, the convention offers the greatest range, both in degree and number, of opportunities for scientific communication. A participant can respond to a presentation and establish contact with its authors to almost any degree he chooses, from merely glancing at the abstract in the program to attending the session and approaching the authors to discuss specific questions or pursue common scientific interests. This elaborate informal subsystem of the convention was a feature of particular interest for the design of innovations in scientific communication. This and the fact that the convention program included many *brief* research reports (over 500 per

year) and that the convention already possessed mechanisms for screening such contributions led to the choice of a *preconvention* publication of a portion of contributed papers (*Proceedings of the 73rd Annual Convention of the American Psychological Association*) as the innovation to be instituted and tested. Its selection and design focused on three specific objectives.

1) To establish an early and widely accessible means of disseminating current research reports in psychology. Such a publication should provide a researcher with findings more current than those provided by most other media and should be broadly used.

2) To offer an alternative to journal publication and thus relieve somewhat the pressure on psychological journals by lessening the number of manuscripts submitted. It was hoped especially that publication of these brief research reports would permit the journals to move toward a policy of reserving traditional archival publication for long reports of major research efforts. In addition, a convention-connected publication might be a particularly effective and economical medium for disseminating the work of the many persons in every discipline who publish a single article and then move into teaching or applied work.

3) To publish and distribute the details of research prior to the convention in order to establish a basis for more effective informal exchange of information during the convention sessions. A series of effects of preconvention publication of papers could be predicted. Such publication would furnish fairly complete information on the author's work and allow convention participants to arrive at an early and accurate judgment as to the relevance of the work to their own; it would give the interested scientist sufficient detail concerning the work to enable him to discuss specific questions and problems with the author at the convention session or through correspondence; and it would encourage the speaker to discuss the implications of his research, and his more recent work, more freely than he otherwise would, since a reasonably public and complete record of his study would be in existence.

We can review the rationale for planning and testing innovations in scientific communication within the context of this trial of preconvention publication of contributed papers presented at a large scientific meeting. We see that (i) a comprehensive study of the existing system was undertaken; (ii) the results were used in designing the innovation; and (iii) a baseline was provided against which the innovation's effects could be evaluated. This innovation furnished an early public outlet for a large portion of the annual output in the field of psychology (a necessary and specific function that is important to the operation of the communication system) and it clearly modified other elements in the system: the format of the presentation at the meeting, the distribution of copies of the presentation, the submission of manuscripts to journals, and so on. Although not *directly* associated with one of the specific elements (journals) that it was designed to affect, provision of an interim archival outlet for a large number of convention papers, 80 percent of which would ordinarily have been submitted to journals for publication within a year or so after the convention, indirectly lessened the load of manuscripts received by journals during that period. Also, the innovation effectively coupled formal and informal elements; the creation of a formal publication of contributed papers which was directly linked with an informal element of the communication system (the convention presentation) gave the latter many of the advantages associated with formal elements without destroying or diminishing any of the benefits associated with informal communication. In fact, this innovation enhanced informal interaction among participants at the convention sessions. It further provided effective coupling between the convention presentation and another formal element of the system, *Psychological Abstracts*. Information presented in the papers published in advance of the convention, in the *Proceedings*, in contrast to information in the unpublished contributed papers, could be retrieved from the *Abstracts* as early as 3 months after the convention.

The relationship between flow of information and financial resources received consideration in the planning of the innovation. For example, since in many cases an individual cannot afford all the costs of attending the meeting and presents a contributed paper by way of obtaining travel funds, and since the complexion of the meeting could be seriously changed if such persons were excluded from attendance, preconvention publication of the *Proceedings* did not eliminate oral presentation of contributed papers at the meeting but only changed the format of the sessions. Additionally, the *Proceedings* volume was not a redundant publication of reports later to appear as journal articles; a working agreement was made with editors of journals whereby a paper published in the *Proceedings* would be eligible for subsequent publication in a journal only if the manuscript submitted to the journal discussed additional work not covered in the earlier version. As a result, the *Proceedings* should assume most of the functions of short-lag publication of brief research reports, while the journals are allowed more leeway to publish articles reporting a series of studies organized around a central theme or theory.

Further, the innovation was designed to generate behavioral and economic measures of its effectiveness. A comprehensive investigation was made of the ways in which preconvention publication of the *Proceedings* influenced behavior relative to exchange of scientific information. Questions such as the following were studied: Who read the *Proceedings*? Who attended the presentations? Who were the authors of the papers? Who requested copies of papers from authors? Who purchased the *Proceedings*? What modifications of scientific and other related work resulted from familiarity with the reports in the *Proceedings*? These studies yielded the results already briefly described (*10*).

Finally, preconvention publication of the *Proceedings* was a genuine trial. Since only a portion of the contributed papers were included in the initial trial, the papers that were not included constituted a control group. A comparison of the findings for the two groups led to modifications in a second trial. Preconvention publication of the *Proceedings* is still not a permanent feature of APA conventions.

Planned Research

The program of research described in this article continues in psychology. The American Psychological Association project is gathering descriptive data on the use of information sources in psychology by teachers, graduate students, and clinical psychologists to supplement the data gathered thus far on researchers. At the same time the structure of research interests and the relation of this structure to informal information-exchange practices among active scientists is being analyzed in several special fields of psychology.

There is a continuing interest in in-

novation, and new work is being done in order to determine the limits for innovation and to establish the essential functions which a communication system must fulfill for the discipline. A program of innovation directed at a wide range of users is planned. A further goal of the project is that of preparing and evaluating a continuing program to monitor data on the function of the communication system in psychology. Ideally, this plan should coordinate such data with data gathered by the American Psychological Association on manpower, productivity, and educational and research facilities and furnish a rationale for the management and future development of communication programs in psychology.

In response to the concern of many disciplines that have information problems and an interest in studying and improving their systems of communication, this approach has now also been introduced into other scientific areas with the establishment of the Johns Hopkins University Center for Research in Scientific Communication. An emphasis of this Center is the recognition that the information systems of different scientific disciplines have developed more or less independently, frequently function differently, and can involve different elements which are utilized in varying ways and to varying degrees.

Comparative studies seem particularly necessary, so that communication innovations and system modifications may be widely useful and so that a coordination of effort, firmly grounded upon and guided by data from the social sciences, the natural sciences, and engineering and technology, can develop. Cooperating with the Hopkins Center in this program of research are the American Sociological Association, the American Institute of Physics, the Optical Society of America, the American Geophysical Union, the American Meteorological Society, the American Institute of Aeronautics and Astronautics, the American Institute of Mining Engineers (a member group of the Engineers Joint Council), and the Association of American Geographers.

References and Notes

1. *Reports of the American Psychological Association's Project on Scientific Information Exchange in Psychology*, vol. 1 (American Psychological Association, Washington, D.C., 1963); *ibid.*, vol. 2 (1965).
2. For a description of the dissemination system for scientific information in psychology and of the scientists' information-exchange behavior within this system, see W. D. Garvey and B. C. Griffith, *Science* **146**, 1655 (1964).
3. We are speaking about a communication system that is relatively closed but not static, somewhat analogous to physical systems that conserve energy. A discipline's being a closed system seems to require identifiable membership or a membership that changes in predictable ways. Since this requirement generally develops from some degree of institutionalization, much of this discussion might not apply to the early stages of a discipline or to newly formed "aggregates" of scientists (for example, in oceanography or communications) largely based upon scientists trained in other disciplines.
4. "The discovery and dissemination of scientific information among psychologists in two research environments," in *Reports of the American Psychological Association's Project on Scientific Information Exchange in Psychology*, vol. 2 (American Psychological Association, Washington, D.C., 1965), gives a detailed description of some scientists' values relative to dissemination. The reader is also referred to *Science* **153**, 695 (1966); *ibid.*, p. 1468; *ibid.* **154**, 843 (1966) for the correspondence on IEG's (Information-exchange groups). A classic article in this area is R. K. Merton, *Amer. Sociol. Rev.* **22**, 635 (1957).
5. Students of science seem to disagree as to the relative efficiency and expense of informal channels of information exchange. However, it is clear that informal media require considerable amounts of the individual scientist's time and are, in that sense, somewhat expensive on a per-message basis. Their functional characteristics may make their efficiency very high indeed in terms of expediting the scientist's work.
6. See B. C. Griffith and W. D. Garvey, "Systems in Scientific Information Exchange and the Effects of Innovation and Change," *Proc. Amer. Documentation Inst.* (1964), pp. 191–200, and W. D. Garvey and B. C. Griffith, *Amer. Psychologist* **20**, 157 (1964) for earlier conceptions of this approach.
7. A more complete formulation of the approach to "formalize the informal channels" and "informalize the formal channels" is given by W. D. Garvey and B. C. Griffith in *The Foundations of Access to Knowledge*, D. Berger, Ed. (Syracuse Univ. School of Library Science, Syracuse, N.Y., 1967).
8. These studies were conducted, and the innovations were planned and executed, by Philip J. Siegmann, editor of *Psychological Abstracts*, with the assistance of APA's Project on Scientific Information Exchange in Psychology. For a more detailed description of this effort see P. J. Siegmann and B. C. Griffith, *Amer. Psychologist* **21**, 1037 (1966).
9. See B. E. Compton, *Amer. Psychologist* **21**, 176 (1966) for a review of some findings relative to this meeting; see B. C. Griffith and W. D. Garvey, *Amer. Behavioral Scientist* **10**, 3 (1966) for an analysis of certain behavioral processes relative to scientific meetings.
10. A full report of the data on the trial of the second and third innovations is given in *Innovations in Scientific Communication in Psychology* (American Psychological Association, Washington, D.C., 1966). This report may be obtained by writing the Project on Scientific Information Exchange in Psychology, 1200 17th Street, NW, Washington, D.C.

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NEWS AND COMMENT

Civilian Technology: NASA Study Finds Little "Spin-off"

One of the most persistent arguments on behalf of the space program is that it has a beneficial "spin-off" effect on processes and products that are remote from the problems of working in space. At this relatively early point in space history it is difficult to ascertain the validity of the argument. There is no doubt that the forced-draft development of space hardware underlies many products in the civilian marketplace. On the other hand, it is doubtful that the ceramic nose cone is the most expeditious route to new frying-pan technology.

Nevertheless, since space research is big and booming, interest is high in maximizing its spin-off, as well as the spin-off from the other billions of federal dollars spent on noncivilian R & D. The latest manifestation of this interest is an illuminating report produced by the Denver Research Institute (DRI) under a NASA contract. Titled *The Channels of Technology Acquisition in Commercial Firms, and the NASA Dissemination Program*,* the report is based on a study conducted over a 14-month period by a group headed by John S. Gilmore, senior research economist of DRI's industrial economics division. It is modest in scope, confining itself to an examination of the methods, or work habits, that govern the acquisition of new technology in 62 firms in four industries—electric batteries, printing and reproduction, industrial controls, and medi-

*Available for $3 from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.