

Research on Science Communication: What is Known and What Needs To Be Known

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We have a great deal of research data on problems of science communication, but few deep theories which structure that data into an integrated picture of the nature of science communication and how best to carry it out.

A similar situation confronted the field of communication research in the 1940's and 1950's. Then a great deal of research was done on the effects of communication, but little was designed to construct an integrated theory of communication behavior. Some theorists began their search for deeper, more general theories by constructing the communication models we still use today. Originally, those models were nothing more than attempts to systematically categorize the results of communication research. Most of them were variants of the source-message-medium-receiver-effects model. That is, the models indicated that research has been done on the effects of source differences, message differences, media differences and receiver differences.

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Although science communication researchers today can draw from many more communication theories, few have made consistent use of them and few have done cumulative studies of the same science communication problems. Therefore, a useful way to make some sense out of this research seems to be to construct a model of what goes on in science communication--one that will help to classify the problems that need attention and to look for similarities in the research done on those problems. Then, using the model to analyze research on science communication and what we do **not** know, should start us on the road to a deeper theory of science communication.

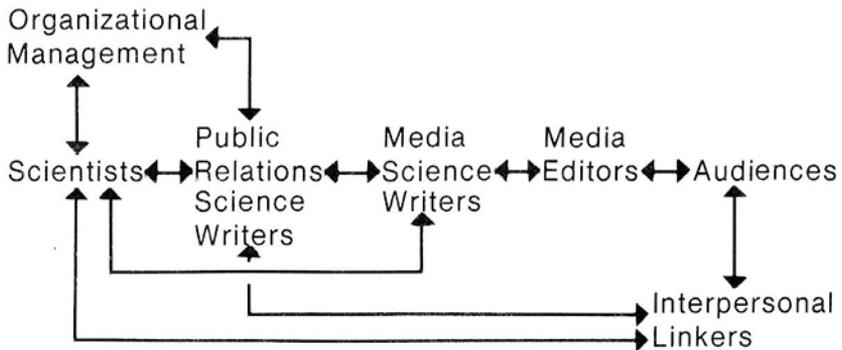
Such a model of science communication appears in Figure 1. It looks like a source-message-medium-receiver model. But actually it is quite different. The two-sided arrows indicate information flows two ways. So Figure 1 depicts the different behaviors and interactions that take place between scientists and audiences, the users of scientific information. The model shows that scientists seldom communicate directly to audiences. Rather, they communicate through public relations¹ and media science writers, media editors, and such interpersonal linkers as extension agents or community leaders. In addition, much of the interaction between public relations science writers and scientists takes place within a context of organizational management.

The model in Figure 1 also serves as a handy device for identifying and integrating the problems that science communication researchers have worked on. These problems fall into two general categories: 1) the individual behaviors of each of the actors in the model--scientists, science writers, management, editors, linkers, and audiences and 2) the interactions between these actors, such as the relationship between scientists and science writers or between science writers, editors and audiences.² I will discuss what I think is representative research related to the problems identified

¹*To me public relations is any professional activity in an organization that facilitates communication between an organization and its publics. That includes university and agency "public information specialists." To equate public relations with propaganda or "selling" is to equate poor public relations with public relations.*

²*Let me acknowledge the use I have made of annotated bibliographies developed by Broberg (1972) and Boews, Stamm, Jackson and Moore (1978).*

FIGURE 1
A Model of Science Communication Behaviors
and Interactions



by the model. And I will attempt to link these different studies together using a new theory of communication behavior (Grunig, 1979b).

EDITOR'S NOTE: To meet space limitations, Grunig's summaries on the research on the actors in the communications model was cut back considerably. Since the studies on management did not specifically mention concepts from his theory, they were not included.

Science Audience Studies

Audience studies far outnumber studies on any other aspect of science communication. They do because the media, professional organizations of science writers, and scientific organizations asked their communications scientists if there is an audience for science information and, if there is, what that audience is like. Scientific agencies want to know if the public has a positive attitude toward science or how such a positive attitude can be created. Other agencies, such as agricultural experiment stations, have developed new technology which they want to diffuse to potential users. So they want to know how to facilitate that diffusion.

But, the audience is not fixed for all types of science stories. Rather, stories about different science issues—situations—bring forth different types of audiences.

Martin Mann, a former president of the NASW, said "science 'readers' and 'nonreaders' won't stand still"; that each group "fluctuates rapidly, wildly, and erratically" with "the story, the time, politics, weather..." in Kriehbaum,

(1967, p. 183). Mann can be interpreted as calling for what I call a situational theory of science audience behavior.

Before exploring this situational theory, let's discuss the difference between consummatory use of science news (for pleasure or curiosity) and instrumental use (for solving a problem or dealing with a practical situation). (See Grunig, 1979a.) A science writer I worked for a few years ago, Jack Reniree of the National Science Foundation, told me that people read science news for one of two reasons: because of curiosity or because the news affects them in some way. Science communication research bears him out. For example, in an extensive review of the literature on environmental communication (Grunig, forthcoming), I found a great deal of evidence that most people do not actively seek out environmental information.³ They take in--passively process--information in the media about environmental problems because the media have put it on the public agenda. (See Shaw and McCombs, 1977, for an introduction to the agenda-setting idea.) But the average member of the public seldom makes much use of environmental information unless he is an active environmentalist or unless it relates directly to his own life (such as information on the energy crisis).

One study (Shaw and Van Nevel, 1967) suggested that medical specialists first learn of research news in the mass media and then seek more information from specialized sources.

But the weight of the evidence is that people do not read science news **in the mass media** for its utilitarian value. Rather they read it because it is there and it arouses their curiosity. We may ask, however, whether people read science news in other media, especially in specialized magazines or other specialized publications, for functional purposes. A time budget study of mine seemed to support functional usage, as I found magazine readership correlated with specific uses of times.

³Before citing his own research, Grunig developed patterns of audience studies (Institute of Social Research, 1958; Swinehart and McLeod, 1960; Kriegbaum, 1967; Schramm and Wade, 1967; Tichenor, 1965; Patterson, Booth and Smith, 1969). Grunig's discussion on situational theory was developed from a report by Tannenbaum (1963) and cited by Kriegbaum with Mann's response, as quoted here (Kriegbaum, 1967). His discussion was summarized here, for brevity.

In fact, functional usage can even bridge the literacy barrier. Brown's (1970) study of the effectiveness of pictorial symbols in communicating with illiterate Chilean peasants showed relevance of content to be the most important reason why peasants used agricultural bulletins. Even illiteracy did not stop communication if the bulletin appeared relevant. Most peasants could find a literate neighbor or child to read the bulletin to them if the information was something they needed.

Consequently, the most reasonable answer to the question of whether people read science for curiosity (consummatory) or functional reasons is a synthesis of the two positions. At times a person may read science information simply because it interests him, at other times he may read it because he can use it.

Buy why a person reads a particular article depends upon whether the situation described in an article involves him. Few people read an article on black holes in space or the behavior of polar bears because it relates to their life situations. But they do read about crabgrass for functional reasons if their lawns are infested with the weed. The same is true of agricultural information. Not every piece of information coming out of an agricultural college or in an issue of **Farm Journal** is relevant to every farmer. Thus different articles are read for different reasons.

The use of science information for instrumental vs consummatory purposes also helps to explain what Tichenor, Donohue, and Olien (1970) have called the knowledge gap or what Rogers (1976) has called the communication effects gap. Put simply, the knowledge-gap hypothesis states that people who already know the most about a subject will gain the most from an information campaign or from media coverage of that subject. The "information poor" will learn something but not as much as will the "information rich," thus widening the knowledge gap. Donohue, Tichenor, and Olien (1973) also suggested that the apparent selectivity by the information rich leads to social control because only those who are already knowledgeable about science seek science information.

But later the same research team discovered that the knowledge gap in a local community existed only on scientific issues from **outside** the community. When an issue directly affected the community, nearly everyone was well informed about it (Donohue, Tichenor, and Olien, 1975). These results suggest that when most people in an audience use

science information for functional purposes a knowledge gap does not result. A knowledge gap develops when only a few people find the information functionally relevant, or when only those who are more educated find the information has curiosity value.

These results show that there is no single audience and no single reason why audiences use scientific information on a particular topic. Changing the topic may change the audiences and their reasons for using the information. What is needed, then, is a theory that explains why these patterns emerge and that suggests how a science writer can predict what his audiences for a particular topic will be like and how they will be using that information.

The two theories that have dominated research on the effects of science communication--attitude theory and diffusion theory--do not explain this picture of the audience well, if at all. The domain of diffusion research (e.g., Rogers and Shoemaker, 1971) boasts over 1,500 studies of how people hear about and adopt new ideas and practices. Diffusion studies show that some people (the innovators and early adopters) hear about new technology before others and that people first hear about new ideas from the mass media. At later stages of the adoption process people seek information from interpersonal sources before adopting the new idea. One can deduce from this research that early adopters use information provided by agencies, promoting new ideas and practices, for functional purposes and that later adopters either do not hear about the information until nearly everyone is using it or that they use it for consummatory purposes. But why? Diffusion research really does not say, as it offers little deep explanatory theory.

However, the most important shortcoming of diffusion research is its presupposition that communication is something that a person or agency does to get other people to do its bidding. Agricultural colleges want farmers to adopt hybrid seed corn. Drug companies want doctors to use their products. Educational researchers want teachers to use the new techniques they have developed. Diffusion researchers find out who followed the advice of these agencies. Diffusion studies describe information flow to audiences. They do not **explain** the communication behavior of audiences.

Attitude research has the same problem, (Oskamp, 1979, provides a summary of that research). It is designed for agencies with a fixed model of how others should behave and who look at communication as a "quick fix" for eliciting

that behavior. According to attitude theory, communications change attitudes which in turn program people's behavior. Thus, a researcher with a surefire method for changing attitudes would seem to have a solution for many of the behavior problems scientific agencies face--people not using their new ideas, not buying their products, not accepting nuclear power, opposing taxes for science, etc.

Research suggests that attitude theory has little explanatory power. It does show that people who communicate about an issue are more likely to have **an** attitude on that issue and are more likely to do **something** (behave) about that issue (Grunig and Stamm, 1979). But one message seldom leads to one attitude and one behavior. People have free will. They control their communication, their attitudes, and their behavior. We cannot control all three with a quick communication fix.

I have worked for over 10 years on a theory I believe overcomes the faulty presuppositions of diffusion and attitude theory and which explains the communication behavior of science audiences.

The theory assumes that people can control their own behavior and that, in some situations, they communicate in an effort to improve that control--that is, they communicate for functional reasons. In other situations, communication is the behavior they control. That is, people may simply communicate because they enjoy it--they communicate for consummatory purposes. The theory is a situational theory because it assumes that people communicate about specific situations or issues. It assumes that attitudes, personality traits, and similar cross-situational concepts do **not** explain the reasons why people communicate. Attitudes and personality traits do not program people to communicate. People communicate when a situation arouses their interest or when they must deal with a problem in the situation. The theory states that how a person perceives a situation affects **whether** he communicates about a situation and **how** he communicates. Thus, the theory seems to explain when audiences will communicate about science topics and whether that communication will be instrumental or consummatory. Note that the theory explains communication behavior. It does not explain attitude change or adoption. This is not a shortcoming of the theory, however, as the responsibility of science writers and other professional communicators is to facilitate communication, not to manipulate people. Thus,

the theory seems admirably suited to problems of professional communicators.

Three variables of the theory explain **when** a person communicates. These are called "problem recognition," "constraint recognition," and the presence of a "referent criterion."

Problem recognition represents the extent to which a person recognizes that something is missing or indeterminate in a situation so that he stops to think about it. The concept essentially derives from John Dewey's (1938) idea that people do not think or inquire (communicate) about a situation unless it is problematic to them. Thus problem recognition increases the probability that a person will communicate about a situation and will need information about it. In actual studies, problem recognition has been measured by presenting survey respondents with a list of 8-20 situations related to an organization or problem and asking them if they often, sometimes, rarely, or never stop to think about each situation.

Constraint recognition represents the extent to which a person perceives constraints that limit his freedom to construct his own behavior. If a person realizes that his freedom to do something about a situation is limited, then information that helps him to plan and make decisions about what to do has little value. Constraint recognition has been measured by asking subjects, for each of the same 8-20 situations, whether anything they might do, personally, would make great, some, little, or no difference in the way the situations are handled.

A referent criterion is an "attitude" which a person can use to decide what to do about a situation. However, it is a different kind of attitude from that described by social psychological theories. In contrast to the attitude concept in those theories, which assume that attitudes control the behavior of people in different situations, the referent criterion is a guide learned in previous situations which the person uses with discretion in a new one. In a new situation the person may apply the referent criterion as an initial guide for resolving the situation. If the old criterion seems to work the person will use it. If it does not, he develops a new solution--a new criterion--to guide his behavior in the new situation. The referent criterion influences a person's communication behavior because it subsumes what he has learned in previous, related situations and thus reduces his need for new information to deal with a new situation. Presence of a re-

ferent criterion has been measured by asking whether each respondent had a very clear, somewhat clear, hazy, or no idea of what to do about each situation.

The fourth variable in the theory, level of **involvement**, also explains **when** a person will communicate. But, more importantly, it explains **how** he will communicate. Level of involvement is defined as the extent to which a person perceives a connection with the situation. It is measured by asking if the respondent sees a strong, moderate, weak, or no connection with the situation. The stronger the connection with a situation, the more probable it is that the person will communicate about it.

Level of involvement also predicts whether a person's communication behavior will be active or passive. I define passive communication behavior as **information processing** and active communication behavior as **information seeking**. A person purposively seeks information which has functional utility for him in deciding what to do in a situation. Thus, information seeking occurs when the perceived level of involvement is high. In contrast, a person does not look for and generally does not need information which he processes. It is used for consummatory reasons. He may take it in, however, as a means of passing time—such as watching TV or reading a magazine while waiting for an appointment—or for enjoyment—such as reading a novel or human interest story, watching some TV programs, or even reading agricultural or science magazines.

The distinction between information seeking and processing is important in choosing a medium and a communication strategy. If a public seeks information, specialized media such as booklets, magazines, seminars or interpersonal contacts are most effective.

When a person processes information, the most effective media are mass or generalized media which people use when they have available time. Style and creativity are important in facilitating information processing, because a message must get a person's attention and keep his interest if he is to process the information.

Style and creativity are not as important for information seeking because then the person makes an effort to obtain and understand the message.

This theory seems to explain the communication behavior of audiences for science information. Level of involvement, in particular, seems to explain how people use science information—for instrumental (information seeking) rather

than consummatory (information processing) purposes. A person who perceives a high level of involvement in a situation seeks science information for instrumental use. If crabgrass, for example, invades his lawn, the person will search for information on how to control it. But few people perceive an involvement with such scientific problems as black holes, whale populations, or animal genetics (especially if they are not farmers). If they have time available, these people will process such low-involvement information when it comes to them randomly without any effort on their part. But they will internalize little of that information unless they are curious about the scientific problem—that is, recognize it as a problem. Those with high problem recognition, research shows, will seek out information related to the scientific problem and will remember the information they process. The theory also provides an explanation for the knowledge gap because research also shows that people who recognize abstract science problems usually are more educated and have taken coursework related to science.

The four independent variables of this theory have been developed not only as basic theoretical concepts which explain communication behavior, but also as key indicators which a professional communicator should measure and use when preparing science information for different audiences. I have used it for several such studies. In those studies we have generally measured each concept for 8-16 different situations. For example, in a study of environmental communication (Grunig, forthcoming) we applied the model to eight environmental issues: air pollution, the energy shortage, flood control projects, extinction of whales, strip mining, pesticides, fertilizer run-off, and nuclear power plants. Then we used a series of multivariate techniques (factor analysis, canonical correlation, and discriminant analysis) to locate specific combinations of perceived situations which define different publics. For example, the environmental study showed that extinction of whales, air pollution, and the energy crisis each brought about separate publics whereas the other five situations brought about the same publics.

We have used the combination of the four variables for each public to develop probabilities that different kinds of publics will seek or process information (Grunig and Disbrow, 1977). These probabilities indicate the likelihood of successful communication—either seeking or processing of information—with each public as well as the topics most li-

kely to bring about an audience large enough to make communication worth the professional communicator's effort. Most recently, I have developed the theory into a mathematical model that shows interactions between variables. That model indicates when it might be possible to use communication to intervene in communication behavior. That is, it shows when to use information processing that occurs randomly to increase problem recognition and level of involvement to in turn increase the probability that a person will seek or process information (Grunig, 1979b). The results show that a professional communicator does not always have to be content with an existing audience and that under certain limited circumstances he may enlarge his audience through communication.

Of the most interest here, however, are the results of studies based on this theory which involve science communication.

Research on environmental publics using this theory (Grunig, forthcoming) showed that most people think about environmental problems but feel constrained from doing anything about them. In addition, all but active environmentalist publics perceive a low level of involvement with environmental issues. Only when an environmental issue directly involves everyone does the nonactivist public actively seek information about it. Thus these measures of the variables of the theory explain why most people have only a superficial knowledge of environmental issues but still know the issues are important to society. They process the information prominent in the media, but, because of low level of involvement, do not seek it out or think much about it.

In these environmental studies, Stamm and I (Stamm and Grunig, 1977; Grunig and Stamm, 1979) also developed a situational definition of attitude: It states that people develop and change attitudes to fit situations. That is, people control their attitudes; the attitudes do not control them. Using this definition of attitude, we found that members of the public tended to use a pro-environmentalist attitude—to believe that the waste or deterioration of scarce resources should be simply stopped (what we called a “reversal of trends” position)—until their perceived level of involvement in the situation increased, as it did with the energy issues. (See Levy and Kilburn, 1979, for further evidence of the high involvement of people with the energy shortage.) On the involving issues people combined a “reversal of trends” attitude with a “functional substitutes” attitude that favors the

use of an equivalent resource when a scarce resource is depleted.

In our terminology, people "hedged" seemingly incompatible attitudes when the situation was one in which no single solution--"attitude"--seemed to resolve it.

Recently, we conducted a comparative study of university journalism and business students to determine whether the two groups fell into different kinds of publics for corporate economic education programs (Grunig, 1979c). Rightly or wrongly, corporations believe that the media are biased toward business and that the way to resolve the problem is to "educate" journalism students, thus changing their attitudes and behaviors when they become working journalists. We thought this presupposition could best be tested by comparing journalism students with business students. We did find a difference in the two groups, but the difference was not attitudinal. Using our situational definition of attitude, we found that students in both groups were both pro and anti-business, depending upon the issue. If anything, the business students were more anti-business on more issues than the journalism students.

However, the level of involvement and problem recognition variables showed that journalism students would seek information only about business issues which directly affect the public, such as pollution and product price and quality. On the other hand, the results showed that business students would be more likely to both seek and process information on business issues which are not likely to involve the public, such as government regulation, taxation, or size of corporate profits. Therefore, the study suggests, that business-media conflict is not so much a difference in attitude as a difference in views of which issues are salient. The media want to report the consequences of business actions on the public, whereas business executives want the media to cover their pet issues even though the public is not interested. I suspect the same also is true for scientific agencies which dislike media coverage of the impact of such technology as nuclear power plants, fertilizers, or pesticides.

Jenkins (1976) also used the theory in a study of the use of science news in the mass media by university students. His results were much like those found in other science audience studies, and they fit the theory in the way hypothesized here. The active information seeking students—with more problem recognition, etc.—were non-science students with some science background. The science students

did not seek science information from the mass media, presumably because they get it from more specialized sources such as journals or their major courses.

Jenkins' results link directly to the results of three studies of how scientists use the information provided to them by internal publications of the organizations for which they work (Grunig, 1977b; Pelham, 1977; Schneider, 1978). These three studies, as well as a study by Dunwoody and Scott (1979), showed that scientists have a high level of involvement only in science topics within their own narrow specialization. On other science topics scientists are as much laymen as are nonscientists. Scientists would seek information related to their own research from technical publications and seminars. But they spend little time with internal media, reading other research done by the organization. We found that scientists will process information about the work of other scientists only if it is easily available and they have time available. Thus, ease of access, timing, and brevity are especially important in preparing publications, newspapers, or exhibits designed to facilitate communication among scientists doing different kinds of research within the same organization.

Science Writing Studies

Situational theory can help researchers understand the role of writing techniques and the reader's ability to understand the information presented. In three studies of rhetorical devices (Grunig, 1974), I used Richard Carter's signaled stopping technique (Carter et al., 1973) to try to get at understanding. With the signaled stopping technique, experimental subjects read different versions of articles on economics, placed a slash mark at the points in the article where they felt like stopping, and indicated their reason for stopping--to agree, disagree, ask a question, to think about implications, to think because of confusion, or other reasons. Then I reasoned that thinking about implications would be a logical antecedent to understanding and used the number of stops for that reason as my dependent variable. The more times someone stops to think about implications of what he is reading, I reasoned, the more likely he would be to reconstruct the idea being communicated. I also asked the subjects, in a direct question, how well they thought they understood the articles they read. Initial results of these studies showed very little difference between stories containing

analogies, examples, and parables and an article containing none of these devices.

However, as the research progressed, I began to control for level of problem recognition and constraint recognition—two of the variables from my situational theory. Then significant results began to emerge. Subjects who had high problem recognition and low constraint recognition, which the theory predicted would be seeking and processing information, stopped to think about implications more and reported a higher level of understanding than subjects the theory predicted were less likely to seek or process information, regardless of what kind of writing device was used. For the actively communicating subjects, analogies and parables stimulated thinking and understanding. Examples, however, stimulated less thinking than did writing using none of these devices.

Bartholomew (1973) replicated this study using analogies only. He had a group of journalism students and a group of physics students read articles on physics taken from Isaac Asimov's **Understanding Physics**. He found that analogies caused physics students to stop to think and to report more understanding, but the same was not true for the journalism students. He traced the cause to lack of communication by journalism students which he attributed to constraint recognition--fear of mathematics.

The results of these studies indicate that the style of a science story is less important than whether the content is relevant to the perceived situation of the reader. Thus the studies indicate that a science writer should be most concerned with story selection if he hopes to achieve understanding of science. But the findings also show the difficulty of communicating with people who do not perceive a problem to which the scientific topic relates or who cannot apply the information because of constraints in their situation. The students in these studies did not stop to think about the information even when an attempt was made to make the information more understandable and when the experimental condition forced them to read it.

The results of these two studies (Grunig, 1974; Bartholomew, 1973) seem to be explained by the research described above. In it I fit a mathematical model (a set of simultaneous equations) to data from environmental and economic studies to determine interactions between variables. The results of this effort (Grunig, 1979b) showed that random information processing could increase problem recognition which could

in turn stimulate more information processing and seeking. At this point in our research we really do not know what communication techniques, if any, are most likely to get the interest of people who are randomly processing information. We know that analogies and parables help people who are actively communicating about science to understand it better. Yet we do not really have an adequate theoretical explanation of why.

Editors

Research on editor behavior in dealing with science articles has not been extensive, although editors have often been accused of being the weak link between scientists and the public. Editors supposedly doom many science stories to the oversight, write the misleading headlines scientists complain about, and fail to see the news value in science stories. Their lack of interest also would explain why newspapers devote less than 5 percent of their space to science (Nunn, 1977).

In fact, the research does show that editors recognize different problems than scientists and science writers and apply different referent criteria, as I have defined these two terms (Tannenbaum, 1963; Johnson, 1963; University of Missouri 1973; Patterson, Booth and Smith, 1969). Scientists see science stories from the standpoint of scientific interests, while editors see them from what they perceive as the public interest. Science writers see science more like scientists than do the editors. These studies also show that scientists pay more attention to what is said, whereas editors pay attention to how it is said.

Although editors evaluate science stories from the perspective of what they think is the public interest, they are not very adept at predicting what will interest the public. Studies of editors show that the scientist, science writer and public have similar views about science, but that the editor is out of tune with the others (Tannenbaum, 1963; Patterson, Booth and Smith, 1969). We can infer that the misperception of editors leads to media science content that is not of interest to the public. Thus, research on editors suggests that editors may be the source of such inaccuracies as omissions and misleading headlines that accuracy researchers have found to be common in science stories.

In theoretical terms, we might hypothesize that the editor's unique science communication behavior results because he does not share the referent criteria of the science

system. The editor could be the one actor in the communication link from scientist to public—or public to scientist—who forces science writers to provide “knowledge about” science to the public and to ask scientists socially relevant questions. Too often, however, editors do not understand the public’s interest in science. Their gatekeeping decisions are based more on competition, deadlines, and writing style. To understand why, we need more studies of the science communication behavior of editors similar to those of the science communication behavior of audiences.

Scientists

Scientists communicate with each other as well as with the lay public, and there have been studies of both types of scientist communication behavior. Studies of scientists communicating with other scientists (Garvey, 1967; Garvey, 1970; Crane, 1972; Nelson and Pollock, 1970; Garvey, Lin, Nelson, and Tomita, 1970) show that scientists communicate within specialized communities or “invisible colleges,” although Garvey (1970) found that social scientists communicate more randomly than physical scientists. In addition to this literature from the sociology of science, a great deal of literature in the philosophy of science discusses the difficulty scientists from different research traditions have in communicating with each other (e.g. Kuhn, 1970; Bohm, 1977, Popper, 1970).

I believe most of this literature can be explained with my theory of communication behavior. Scientists are most likely to communicate with other scientists who are **involved** in research from the same scientific domains and who recognize similar **scientific** problems within those domains. Also, scientists communicate best with scientists who have the same theories (referent criteria) and who are constrained by the same research techniques. This is an area of research that I would like to pursue further in order to test these hypotheses. It is an area of research that would be useful to science writers who need to know how to identify scientific communities, compare and contrast different schools of thought, and locate sources of scientific information.

Of more relevance to the model in Figure 1, however, is the communication of scientists with the public. Kriegbaum (1967: 160-177) has described some of the **constraints** that discourage scientists from communicating with the public, such as the priority of journal publication, peer pressure against popularizing, and the necessity of peer review. Goo-

dell (1977: 19-38) studied seven “visible scientists” who actively communicate with the public on controversial issues. Her results also fit into my explanation of why a person actively communicates—in this case by actively **giving** information. Her results suggest that a scientist must first free himself of the constraint of peer pressure by establishing himself as a credible researcher before he can be involved in public issues. (Boltanski and Maldidier, 1970, reached the same conclusion from a study of French scientists.)

Goodell’s research suggests that actively communicating scientists recognize broad public problems (what she calls “hot topics”) related to their area of expertise, and perceive a high level of involvement in the consequences of these problems on the public. Finally, she found that these scientists are articulate—able to communicate science in the language of the layman. One could interpret the inability to communicate as a constraint facing the average scientist and conclude that the visible scientists are more likely to communicate because they are free of that constraint. In addition, Goodell’s research indicates that visible scientists are controversial and have a colorful image. Thus, they are likely to get the attention of people randomly processing information from the media—editors and casual readers of science in the media.

The assumption behind Goodell’s research is that visible scientists are different from the average scientist. The average scientist, according to much of the literature on science communication, avoids contact with the media because of the constraints identified by Krieghbaum and others. However, a recent study by Dunwoody and Scott (1979) showed that 75 percent of a sample of Ohio State and Ohio University scientists **said** they welcome contact with the mass media.

The scientists in the Dunwoody and Scott study also said they preferred making contact with magazine journalists rather than newspaper journalists. This difference seems to reflect a preference for coverage by the instrumental media rather than the consummatory media. Consummatory coverage of science appears to be the source of the complaints of scientists about sensationalism and humorous treatment of science in the media.

Linkers

We will not do too much damage to the organizational concept of a linker if we apply it to individuals who serve a bridg-

ing function between scientists and publics. Examples of such linkers are agricultural extension agents, salesmen for technical products or medical supplies, community leaders, or specialized teachers such as physical education or health teachers. The relevant research question about linkers is, "How do they communicate?"

Early diffusion research (Wilkening, 1956) showed that farmers most often communicate with agricultural extension agents and salesmen at the stage of decision making when they are trying to put a change into effect. Media, on the other hand, make farmers aware of possible changes, and other farmers help farmers decide whether to adopt a change. It is reasonable to conclude from diffusion research that members of the public are the active communicators, not the linkers.

I have theorized that people communicate most effectively with one another when their perceived situations are similar—when they recognize similar problems, face similar constraints, perceive involvement in similar situations, and have similar referent criteria. This hypothesis would explain research by Jain (1970) which showed that extension specialists whom their peers rated as most effective were those who engaged in **diverse** communication behaviors rather than in large **amounts** of communication behavior. The effective linkers, it would appear, perceive diverse situations in a way that stimulates communication, even if their communication behavior is only information processing. Then when farmers or other members of the public with more specialized interests come to the linkers for information, the linkers will be able to provide relevant information to diverse client groups. Research related to the "opinion leaders" by Atkin (1972) also supports this conclusion. Because of their role as an information source in a social system, opinion leaders recognize many different problems which in turn stimulate them to seek out information relevant to these problems. Opinion leaders recognize diverse problems because the social system expects them to.

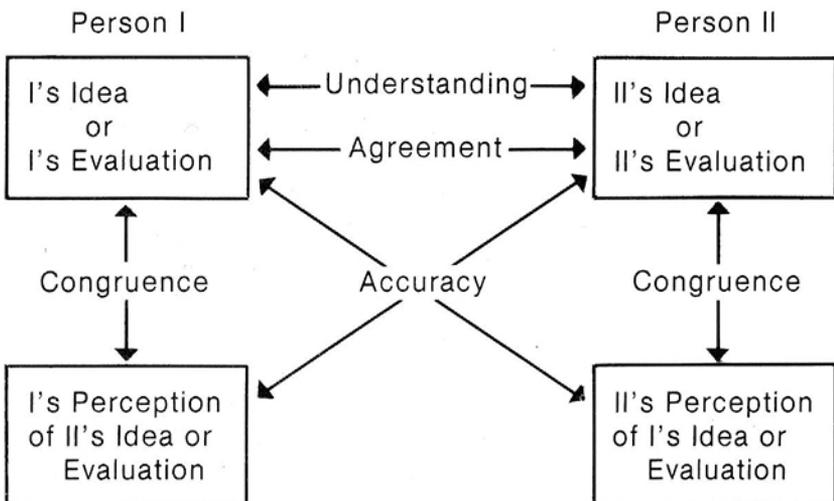
Research on linkers suggests that if we want linkers to be good sources of information sought by others they should be able to perceive these problems and the constraints of the people they serve that will motivate them to seek out relevant information (see Grunig, 1978). If we want them to be active disseminators of information to the public we should define their role in the organization as that of a communicator so that they perceive communication with the

public as a problem and feel involved with that communication process. We also should eliminate their perceived constraints to communication by teaching them how to communicate.

Interactions

Most of the research on interactions between the actors has been based upon, or can be interpreted in terms of, McLeod and Chaffee's (1973) coorientation model. Coorientation simply means that two actors simultaneously orient to and communicate about the same problem, topic or situation. The McLeod and Chaffee model as I have reconstructed it in Figure 2 assumes that each actor has an idea (cognition) about the situation and a positive or negative evaluation of that idea (an "attitude"). He also has a perception of the other person's idea and evaluation of that idea. The variables in the model can be interpreted as effects of communication. Congruence is the extent to which each person thinks the other person's idea or evaluation is similar to his own. Accuracy is the extent to which one person's perception of the other person's idea or evaluation approximates the other person's actual idea or evaluation. Understanding represents the extent to which the two ideas are the same. Agreement represents the extent to which the evaluations are the same.

FIGURE 2
A Reconstruction of
the McLeod-Chaffee Coorientation Model



Several studies of science communication have measured levels of congruence, accuracy, understanding, or agreement between actors in Figure 1, such as the accuracy with which science writers can predict the interest of audiences in different science topics or the understanding and agreement between scientists and science writers on the news value of scientific topics. Many of these studies have been designed to test out common assumptions of working professionals.

Most of these interactional studies have not provided a theoretical explanation for the presence or absence of one or more of the coorientational variables. For example, they have not explained why scientists and science writers do and do not understand each other. One possible theoretical explanation is Rogers and Shoemaker's (1971) concepts of homophily (similarity) and heterophily (dissimilarity). They maintain that two people who are more alike in attitudes, values, or demographic characteristics will communicate more effectively. To me, however, Rogers and Shoemaker's concepts are too broad to provide meaningful explanations. In what ways should people be similar? What similarities are most likely to lead to effective communication?

Thayer (1968) theorized that two people will communicate more often and more effectively when **symbiosis** is possible—when both gain something from the exchange. I have added to that concept by arguing that people will be most likely to communicate and to communicate effectively when they have symbiotic **problems** and **constraints** (Grunig, 1976). Under those conditions, a person can seek or give information that will help the other to solve his important problems and to operate within his constraints. Involvement in the same situations would stimulate communication, but it is not a necessary condition for communication. As long as two people are involved in symbiotic situations, communication can occur. Having similar referent criteria may make communication easier, but it is not a necessary condition for coorientation. Obviously, a person who does not recognize any science problems (as do editors) or who face constraints (such as fear of mathematics) will not communicate often with those who recognize science problems and who are not similarly constrained.

With this theoretical explanation in mind, we can now turn to specific interactional studies of science communication.

Tannenbaum described a study which compared the semantic compatibility of scientists, science writers, editors,

and science readers. He found all the groups to be compatible, except the editors. The editors generally preferred "exciting" science news, the others did not. This study thus would explain why the editors are the weak link in the science communication chain. They are not involved in science or do not recognize science problems. Thus they process consummatory science news which gets their attention while the others seek utilitarian science news or, at least, do not have to have their science news sensationalized before they will process it.

Lassahn (1967) did a similar study on actors in the agricultural science communication system. She compared the ability of university extension specialists, information service editors, county extension directors, and county newspaper editors to predict how farmers would rate science news items that might appear in the newspaper. The county newspaper editors and the information service editors were best at predicting farmer preferences, thus showing their value as mediators in the science communication chain. These two mediator groups would more likely have symbiotic relationships with both farmers and scientists than the farmers and scientists would have with one another. That is, the professional communicators can recognize the problems and constraints of both scientists and farmers.

Scientist-Linker-Audience Interactions

Studies of coorientation between scientists and the public cited above confirmed the ability of science writers to perform a mediating function. Similar studies have been done on the mediating ability of interpersonal linkers. Groot (1970) found that extension workers in the Phillipines fell between farmers and the scientists in agreement, congruence, and accuracy—thus confirming that they do indeed serve as effective intermediaries.

However, Bowes and Stamm (1975), found that local community leaders were ineffective mediators between the public and agencies promoting resource development in North Dakota. Agency personnel could predict public cognitions of the development projects better than the community leaders—indicating that community leaders are not a good source of information about public opinion.

These two studies provide no indication of why some linkers are effective and others are not. We can only hypothesize that linkers serve as effective mediators only when they are able to recognize the problems, constraints, and

involvements of both scientists and the public and are able to find a symbiotic relationship in those two sets of perceived situations. Presumably, training in how to accurately perceive the situations of their clients is the secret to successful linkage.

Some Conclusions

I have presented a model of the science communication process and have fit the results of science communication research into it. For each of the communication behaviors and effects of communication behaviors in the model, I have used a situational theory to explain individual behaviors and the effects of communication interaction. The result, I believe, is a coherent picture of how the science communication process works.

This literature review shows that we do know a great deal about science communication. But many of the theoretical explanations which I have presented are speculative. They have not been substantiated by research. Science progresses when researchers take what is originally a vague, general idea (a theory), test that idea, and then reconstruct the theory to improve the originally vague idea (Suppe, 1977). I believe I have presented some reasonable theoretical ideas in this paper. But they need to be tested. We need to know whether these ideas can be improved further. In addition, there are some specific areas of the science communication chain where the most research is needed:

1. We must develop a typology of agricultural publics and of consumer publics. We also need a typology of publics for energy issues, which should be a top priority because of the severity of the energy problem. We need to know what kinds of publics develop on issues like nuclear power, solar energy, synthetic fuels and conservation of gasoline. We also need studies of the communication behaviors of governmental officials who make decisions on scientific matters. We have little idea of what their information needs are.

2. We need an adequate explanation of how to communicate well enough so the reader can gain understanding of unfamiliar, scientific ideas. We know that simplification alone does not solve the problem. We know that traditional, writing techniques generally work, but not why they work. I believe it is time to delve into cognitive psychology and the philosophy of language in the search for a solution.

3. We need to further analyze the behavior of the commun-

icators, using the same techniques we have used to analyze the behavior of audiences.

4. We have a few studies of the communication behavior of scientists. But we need more. The sociology and philosophy of science offers some rich resources for understanding the communication of scientists with one another. We should make use of it in designing future research. In addition, I think we should test out the theoretical explanations I have provided for the communication of scientists with the public.

5. The coorientational studies have provided useful tests of many of the common assumptions of science communication, and research has proven many of those assumptions to be wrong. I have suggested a theoretical explanation for the communication effects isolated by these coorientational analyses. Again, however, that explanation needs to be tested.

6. Research has made it clear that science writers often, but not always, identify more with the science system than with the public. Editors identify with the public but do not recognize their true information needs. Therefore, we need more research on how professional communicators can become true mediators, able to interact with both scientists and the public.

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