10 May 1963, Volume 140, Number 3567 SCIENCE

Communication of Science Information

Presentations in the mass media are often based on a misconception of the public's interests and views.

Percy H. Tannenbaum

Beset by the varied and vexing problems of communicating the results of research and scholarship within and across the various scientific disciplines (*1*), many scientists probably prefer not to be concerned with the added problems of communicating scientific fact and opinion to the public. Many others, perhaps more sensitive to their role in contemporary society, are more responsive to this obligation. The abundant concern of the scientific community at large is attested by the fact that its major national organization, the AAAS, now has a program under way to increase public understanding of science, primarily through the mass media. The National Science Foundation has a department with a similar objective, while most of the major scientific societies have full- or part-time public information officers. When two physics publications recently announced a policy of rejecting articles based on research which had already been reported in the public news media, there was a pointed editorial reaction in *Science* (*2*), followed, in turn, by a flurry of reader reactions (*3*).

Like it or not, it appears that scientific enterprise will continue to be featured in the mass media to some degree. The simple fact is that science and technology are too integral a part of our social-political environment to be completely neglected by the news media. With increasing amounts of public funds being spent in support of scientific undertakings and with scientific fact and opinion becoming increasingly significant in national and international political decisions, the wonder—and to some commentators, the pity—is that there is as little science reporting as there is.

In recent years scientists, science writers, news media executives, and even politicians have been heard from on this point; generally they have called for "more and better" dissemination of science news. But few have studied the problem directly or systematically (*4*). Wilbur Schramm recently summarized what little research has been done, in a special memorandum prepared for the AAAS (*5*). In it, he covered a number of survey studies, principally those conducted by the Michigan Survey Research Center (*6*), and investigations of the "image" of science and scientists held by various segments of the public. His analysis suggests a number of conclusions, as follows. Knowledge of science is widely but shallowly distributed and is closely related to the amount of formal education the individual has had. The mass media play a prominent role, but the likelihood that an individual will be exposed to the media that carry science news is largely a function of his education. "Sensational and personalized" news stories generally attract a larger audience than more impersonal accounts (the evidence on this is not entirely convincing). Generally, the mass media —newspapers in particular—tend to apply the same criteria in selecting and featuring a science story that they apply in selecting and handling general news. As for the public image of the scientist, there are indications that this is generally favorable if somewhat stereotyped. The public seems interested in having more science news.

Here I report some additional research on the communication of science information to the public—research recently conducted at the Mass Communications Research Center at the University of Wisconsin (*7*). The principal focus of this research was the encoding behavior of the mass media—the kinds of decisions that are made by the mass media in selecting, preparing, and presenting material and the bases on which these decisions are made. The science-communication situation provided an admirable context within which to pursue this study. Thus, our main concern here is with the factors that govern decision-making about science news. However, those of us who were engaged in the research felt a commitment to consider the substantive material as well. Each of us had had experience, or at least has aspirations, in the field of science writing, and each of us has a personal interest in the flow of traffic along the expressways and cloverleafs of the public dissemination of science information, and in the obstacles that block that flow.

Portrayal of Mental Illness

One of our main studies of science communication stemmed from a program of research that dealt with the public's opinions and conceptions about mental health and mental illness, and the role of the mass media in shaping and nourishing such beliefs (*8*). In the initial phases of this research a questionnaire to reveal attitudes toward, and knowledge about, mental illness was formulated. This questionnaire was subsequently administered to a sample of the public and to a sample of experts (mainly professional psychiatrists and psychologists). When the two sets of data were compared, the investigators were startled to find a high degree of agreement between the judgments of the experts and the laymen.

The author is director of the Mass Communications Research Center at the University of Wisconsin, Madison.

Table 1. Indices of profile similarity, D, between each pair in findings for the mass media (M), the public (P), the experts (E), and the TV communicators (C) and in estimates of public ratings (C_P) made by the TV communicators.

Category	M	P	E	C	C_P
M	–	8.69	7.63	7.71	2.53
P		–	1.62	1.00	6.48
E			–	1.48	7.35
C				–	6.72
C_P					–

In addition, content analyses of portrayals of mental illness in the mass media (primarily on television and in magazines) were made (*9*). In these analyses there was a set of content categories based upon the main dimensions of judgment revealed by the answers to the questionnaire (these dimensions were isolated by factor analysis). Thus, the views of the public, of the experts, and of the mass media could be compared. The findings were quite clear: The experts and the public tended to agree in their conceptions of mental illness, whereas the mass media presented a different picture (*10*). Instead of being a true mediator between the scientists and the public, the mass media were introducing an apparently dissonant element, featuring the more bizarre, sordid, and frivolous aspects of mental illness.

Subsequently, in the main research program, the regulation of mental health content in motion pictures and television (in fictional portrayals as well as in news and documentary presentations) was investigated (*11*). This was accomplished through interviewing key news-media personnel, examining records and documents, making detailed studies of individual programs, and making further content analyses. These investigations, while not necessarily conclusive, pointed to a consistent and recurrent trend: The dominant considerations behind decisions regarding the inclusion and the exclusion of certain types of subject matter were fundamentally market-oriented. The mass media, being dependent on a consumer audience, are susceptible to pressure from various groups and individuals. The resulting public-relations considerations—this group must be pleased; that group must not be offended—in combination with other market considerations, govern the type of output. Show-business gimmicks abound; the object, apparently, is not to "get the message across" but to cater to their perception of the whims of the viewing audience. Even in an expensive and rather delicately handled mental health documentary—one which won a number of industry and professional awards for the TV network and the producer—the communicators could not resist introducing a dominating movie celebrity ("might get us an award or two") as moderator and taking substantial liberties in editing the final film to "get a more potent ending"—all in the name of showmanship.

Sometime later I was able to extend the study of mental health communicators along more systematic lines. One obvious explanation for the discrepancy between the beliefs of the experts and the public, on the one hand, and the portrayal of mental illness in the mass media, on the other, was that the individuals responsible for the portrayal were merely reflecting their own beliefs. Accordingly, in this phase of the study we asked a sample of individuals engaged, in one way or another, in the production of TV programs with a mental illness theme—writers, producers, directors, performers—to respond to the questionnaire used in the earlier phase. The findings revealed that the beliefs held by these professional communicators were not really different from those of the experts and the public and were just as far removed from the picture presented by the mass media.

Where, then, did the mass-media pattern come from? A likely answer was supplied by the results of the next phase of the investigation. This time the sample of TV communicators was asked to answer the same set of questions not according to their own beliefs but as they thought a typical member of the television audience might respond.

Table 1 presents the results obtained in a comparison of the profiles for the various sources of judgment—the public, the experts, the media, the TV communicators speaking for themselves, and the TV communicators speaking (or so they thought) for the public. In this comparison the generalized distance function D was used to assess degree of similarity: the smaller the value for D, the more similar the profiles (*12*). Here we find that while the judgments of the public, the experts, and the communicators are all quite far removed from the image presented by the media, the communicators' perception of the audience's beliefs corresponds quite closely with that image. Moreover, the communicators' empathy with the audience appears quite low: their view of the public's beliefs and the public's actual beliefs are quite disparate.

Spokesmen for the mass media have long justified their selection and presentation of subject matter by saying that they are "giving the public what it wants." Giving the public what it wants may or may not constitute a legitimate and equitable basis for regulating our cultural industries, but the fact remains that if you are to operate by such a principle you should at least know what the public *does* want. In the mental health area, at least, the mass media gate-keeper may be badly mistaken: The public does not believe what the media people think it believes, and it may not want what the media people think it wants.

The Science Communication Chain

One of the distinctive features of the science communication situation is that we have a fairly clearly defined chain of communication events. The scientist is the initial source of the process. Often there is a professional functionary, the science writer, whose distinctive task it is to translate the scientist's message into terms that the public can understand. However, except in relatively rare instances, it is the newspaper editor (or his opposite number in other media) who is the final arbiter on what goes in and what stays out, on just where the story fits and how it is handled; there is more of this "gatekeeping" in connection with the wire services than there is for staff-produced materials. Finally, there is the reader, who selectively sees what is finally printed. In our research we have found it useful, if not essential, to divide the total "anonymous collection of anonymous individuals" that makes up the public into at least a dichotomy of readers and nonreaders of science news.

Such chains characterize most systems for communicating with the public, but in nonscience areas they are less clearly defined. One of the "laws" of communication theory is that a chain of this type is no stronger than its weakest link. Another is that, for the entire sequential process to function with any degree of fidelity between original input and ultimate output, the adjacent elements, or links, must be compatible with one another. Since our concern here is with the communication of information, ideas, and opinions—that is,

of meanings—we might do well to look into the degrees of semantic compatibility between the various units involved in the science communication chain.

Kenneth Johnson made such a study in 1961 (*13*). He selected 40 diversified specimens of science writing, ranging from selections from *Science* and *Scientific American* to selections from *Popular Mechanics* and the Sunday supplement *Parade*, and had these judged by available groups of scientists, science writers, newspaper editors, readers of science news, and nonreaders of science news. The judgments were made in accordance with a set of semantic differential scales (*14*) especially selected for this purpose.

The study was designed primarily to determine whether the various groups in the communication chain used the same semantic dimensions in judging science stories. Agreement on this issue would indicate that the various groups had at least the same "frame of reference." Disagreement on this fundamental point would be evidence of disharmony, of "semantic noise" in the system. To index this variable, Johnson subjected the data for each group separately to factor analysis and then compared the resulting factor structures for the various groups.

The results were most revealing. For four of the five groups the sets of semantic factors were highly similar. The one group that deviated from this pattern and exhibited a unique factor structure was the editor group. To cite one example, whereas the scientist, science writer, or science reader considered a science news story valuable independently of whether he considered it exciting, for the editor the judgments of valuable and exciting were highly correlated. It appeared that, for this group, what is exciting is good, almost by definition. Indeed, the dominant dimension (as indexed by the relative percentage of common factor variance) for the editor group—the dimension labeled "newsworthiness" by Johnson—corresponded most closely to the dimension of excitement or sensationalism for the other groups.

Again, then, we find evidence of flaws in the mediating apparatus. This crucial mediator between scientist and reader—the editor—may fail at times because he differs from both in fundamental outlook. In a real sense he is the outsider, removed in basic frame of reference from the sources, from the readers, and even from the nonreaders of science news.

This finding is given added emphasis in another phase of Johnson's study—analysis of the stylistic characteristics and content attributes of the various stories and of the ways in which these attributes are related to the judgments made by the various groups in the chain. Johnson's most telling finding here was that, whereas the scientists generally react more to *what* is being said, the editors are largely affected by *how* it is said. Here the science writers showed a pattern more like that of the editors, though less marked. For the readers and nonreaders of science news, neither style nor content seemed dominant.

At least one additional finding in Johnson's study is worthy of note. Contrary to the rather general assumption that readers are not necessarily interested in science per se but are interested only in results and applications, the study showed that stories that dealt mainly with pure research were evaluated more favorably than those that dealt mainly with applications. This finding held true not only for the scientist sample but also for the readers and, to a lesser extent, the nonreaders of science news.

Language of Science Reporting

J. Robert Oppenheimer stated the dilemma of science communication succinctly when he said some years ago that science is defined in words and phrases which are "almost impossible to translate" into conventional lay language (*15*). Indeed, this is why the various scientific fields had to develop their specialized vocabularies; the existing language was inadequate for expressing new concepts with the necessary specificity and precision. Nevertheless, the problem of translation—not unrelated to the general problems of C. P. Snow's "two cultures" (*16*)—persists.

Faced with this dilemma, science writers have often resorted to the use of standardized, shopworn phrases. Typical is the use of a single, generalized term to cover what, to the scientist, are distinctively different things. In addition, possibly to "sell" their editors, many science writers indiscriminately use such clichés as "major breakthrough" and "giant step forward" in describing theory and experimentation.

The justification offered for the use of such phrases is that they help attract an audience and thus facilitate the transfer of information from the scientist to the public. Thus, they represent important aspects of the mediator's encoding activity. The significant question for evaluation studies is whether they really do further understanding. *Understanding*, as used here, has a connotative as well as a denotative meaning, since a significant part of what is to be transmitted along the science communication chain involves judgments and feelings as well as factual information.

A preliminary study in this area was conducted by Edward Aebischer on what he called "science-ese." Aebischer culled from various samples of science writing expressions ordinarily used as general descriptive phrases that are also used with considerable frequency in writing on a variety of scientific subjects. Ten such phrases were isolated—expressions such as *exploring the unknown, dramatic achievement,* and *bold new theory*. These ten expressions were then rated on a set of semantic differential scales by a group of scientists, a group of science writers, and a sample of the public divided into three groups —regular readers, occasional readers, and nonreaders of science news—on the basis of answers to a special questionnaire.

The first finding of note was that the widest range of perceived connotations and the sharpest distinctions between the ten expressions were found in the science writer group. There was substantially less differentiation for the groups representing the public, the differentiation becoming progressively less as one proceeded from the regular-reader to the occasional-reader to the nonreader group. Interestingly, the scientists tended to use only a single evaluative factor, failing to make any other distinctions.

Agreement and disagreement, between groups, in the range of connotations for the ten phrases were also examined. When the judgments of the scientist group were used as the standard, Aebischer found that the judgments of the science writers showed the highest agreement; he found little difference in the degree of agreement for the three groups representative of the public. However, when the judgments of the science writers were taken as the standard, the judgments of the regular and occasional readers of science news showed the highest correspondence with the standard; those of the scientist, the next highest; and those of the nonreaders of science news, the least.

From this preliminary study, then,

it appears that the general "science-ese" units are most meaningful to the group who invented them. They do appear to play some role as communication devices. However, they seem to be of rather limited usefulness, (i) because the scientist finds them to have limited meaning, and (ii) because the scientist and his audience read different meanings into them.

Translation of Scientific Terms

A more direct approach to the basic question of whether the special language of science reporting contributes to understanding is illustrated in a number of our investigations, originally conducted by Malcolm Laing (*17*) and subsequently replicated in a variety of situations. In these studies, specimens of science writing were examined for instances where a special scientific term had been "translated" into more conventional lay language—for example, *particle accelerator* into *atom smasher, nucleus* into *heart of an atom*, and so on. Thus, pairs of terms—each pair containing a scientific word (or words) and its allegedly more meaningful lay equivalent—were isolated. Scientists, science writers, science news readers, and science news nonreaders each performed two tasks: they matched terms presented in two randomized lists, and they rated each term, scientific and lay alike, on a set of semantic differential scales. It was reasoned that the matching operation would provide an index, admittedly crude, of general denotative correspondence, while the semantic differential data could be analyzed in terms of relative similarity in connotative meaning.

While the findings were not uniform for all pairs of terms in all replications, the evidence was clear enough. On denotative identification, all groups did quite well, with the science writer and the science reader groups somewhat ahead. As for connotative judgments, the scientist, science writer, and science reader groups showed similar differences in the meanings of the paired terms; the nonreaders of science news displayed considerably fewer differences, between connotations of scientific and lay terms. The regular science reader found most of the original scientific terms at least as meaningful as the lay terms. Moreover, his judgments for the scientific terms were more similar to those of the scientist and science writer than were his judgments for the lay terms. For the nonreader of science the lay terms were somewhat more meaningful, but the differences were not large.

An implication of these findings is that the writers may be writing more for people who are not attending to them than for their more regular readers. This seems a strange *modus operandi*, and it appears even more strange when we consider the results of our other research on specialized newspaper language, which demonstrates a substantially different pattern for categories other than science reporting.

Consider, for example, a study dealing with "sportugese," the specialized language of the sports page (*18*). A sample of newspapers was analyzed for reports of basketball games, and the verbs used in the report of each game, along with the point spread between the winning and the losing teams, were noted. The list of verbs was then presented to groups of readers and nonreaders of the sports page and to a group of sports writers, and each respondent was asked to list what he thought was the point spread in the game referred to by a given verb. Thus, we had a set of expected point spreads for each group, and, of course, the actual point spreads. When the predicted and the actual data were correlated we found high and significant correlations for the sports writer and the sports reader groups ($r = .81$ and .86, respectively) but a low correlation ($r = .33$) for the nonreader of the sports page. The latter just could not relate the jargon to the event, while the encoder and his regular reader were both semantically attuned to the situation and to one another.

Similar studies on other phases of special newspaper language—for example, stock market reports and election results—have yielded similar findings. In each case there was clear evidence that the communicator and his specific audience had a common understanding of the jargon that was not shared by the nonreader in the field in question. Thus, for each of the special kinds of newspaper content, with the exception of science news, there is both a specialized language and a select audience that is expected either to know or to learn the jargon. In the case of science writing, on the other hand, there seems to be a leaning-over-backward to cater to the individual who is not a reader to begin with, perhaps at the expense of the regular reader.

The Science Writer

Of the various individuals in the science communication chain there is only one whose *raison d'être* is his specific function within this process—the newspaper or magazine science writer, or his equivalent in the broadcasting or motion picture industries. For the others, involvement in the chain is at best secondary to their principal pursuits. For this reason, if no other, the science writer is deserving of rather special scrutiny. Some of our studies, while not restricted to this group, did contain data particularly relevant to the role and function of the science writer as a mediator.

In the Johnson study (*13*), it may be recalled, judgments of actual stories were obtained from the various groups. While the judgments of the editors deviated from the pattern for the other groups, the judgments of the science writers were highly similar to those of the scientists and the science readers. Indeed, when these data were further analyzed, it was found that the science writer group was closer to the scientist, science reader, and editor groups than these groups were to each other. As compared to the general news editor on this criterion, then, the science writer emerges as the better mediator. In part this may be due to the editor's lack of fit, but in part it is due to the science writer himself.

Similar support for the science writer as mediator is apparent in the Aebischer study. With respect to judgment of "science-ese" terminology, the science writer is again the middleman between scientist and science reader. However, he is closer to the reader than he is to the scientist. While this, too, may enhance his value as encoder for the layman, it may also impose some barrier between the news source (the scientist) and the news carrier (the writer).

Two parts of the Laing project (*17*) also focused on the position of the science writer vis-à-vis the other groups. In one phase of the study, scientists, science writers, science readers, and science nonreaders judged each other; the results provided indices of mutual perception. In another phase, each group responded in terms of how they thought each of the other groups would react; the results provided indices of relative empathy. Again, on the basis of these indices, the science writer emerges as an appropriate mediator. In fact, contrary to findings based on the Aebischer

data, here we find the science writer and the scientist quite compatible semantically—they agree in their estimation of the distance between their views, there is evidence of a kind of "empathic bond" between them, and they even agree in their estimates of the distance between the views of the science reader and those of the scientist.

These various findings, considered together, indicate that the science writer is quite well suited to the role of mediator between the scientist and the science reader. Of course, such evidence is restricted to similarity of connotative judgments. But since semantic compatibility may be considered at least a prerequisite for effective communication, our findings do suggest that the science writer can potentially fill this role.

Conclusions

There are obvious limitations to normative studies of the kind described. Many of the studies dealt with special content areas—for example, mental health—and thus may not provide a sound basis for generalization. Selection of the various samples presented still greater problems. In some cases, the universe was so ill-defined (for example, that of science writers) that conventional sampling procedures were of doubtful significance. There were also limitations of subject availability and funds. Thus, we tended to proceed on an ad hoc basis, using more-or-less intact groups where we could find them —a group of scientists or a group of science writers attending an NSF-sponsored seminar; news editors from papers in the State of Wisconsin; and so on.

Even so, there is a notable consistency in the findings as they relate to flaws in the mediating apparatus of the science communication process. We now have some evidence other than personal and anecdotal accounts which points to the gatekeepers of the mass media as the weak links in the chain. The television people have apparently badly underestimated the public's awareness of, and information about, mental health problems. Similarly, the newspaper editor, who as we know can exercise a good deal of control in the processing of science news copy, appears to be out of tune both with his sources and with his audience. Even the special vocabulary may be misdirected.

Thus, a good deal of the science communication problem may stem from ignorance about the science-reading public—about who it is, what it knows, what it really wants, how it should be addressed. Because the specific science audience has not been differentiated from the gross audience, the same criteria have been used in selecting and handling science news and general news. While the "exciting" may be an appropriate criterion for the selection of news stories about accidents, crime, and economics (there is even some doubt about this), it is not a good basis for selecting science news. Similarly, the "show biz" traditions of vaudeville and Hollywood may still be relevant to the Saturday night TV variety shows; when applied to the Sunday afternoon documentary they become frivolous, if not downright disrupting.

Should the news media try simply to please and maintain the present audience for science news? This audience may be too small to justify preferential treatment in a system where the size of the consumer audience and other such market considerations predominate, although the available survey data suggest otherwise. Should the news media concentrate on trying to woo the present nonreader or nonviewer of science news? Such an attitude is one apparent explanation of much that the media have been doing. The success of this effort has been spotty at best, and there is serious doubt that it can ever succeed.

Perhaps it would be best to give up the idea that the mass media can become reliable disseminators of science information, simply because they are not equipped to supply such information and their audience is not equipped to handle it. For example, Thistle (*19*) has estimated that, because of inherent barriers of semantics, security considerations, competition with social news, and other factors, only 0.0001 of what scientists know can be communicated to laymen. He may have had tongue in cheek in offering this estimate, but his point may be well taken. A real understanding of science on the part of the layman requires a rich diet of content, and the public media must necessarily offer a bland one.

Even so, the present system will probably continue to present some science news for some of the public some of the time. Is there some way of improving the system? There are indications in our research results that the professional science writer has some of the qualities needed for the role of mediator. Certainly many of the better science writers now fill this role with distinction. Those who do, however, are usually the ones who have been delegated the gatekeeping responsibility—who function as science editors.

Such individuals are few but not far between; they are concentrated, for the most part, on the staffs of metropolitan dailies, weekly news magazines, and the like. That we need to train more good science writers is evident. How they should be trained is another matter. And back of that are the ultimate questions of whether the media executives will accept them and—equally important—grant them the appropriate authority. Perhaps the accumulation of further research findings will make those in key positions—scientists and news-media executives alike—increasingly aware of these problems.

References and Notes

1. "Science, Government, and Communication," *Report by the President's Advisory Committee* (1963).
2. *Science* **139**, 177 (1963).
3. R. L. Garwin, *ibid.*, p. 1098.
4. There have recently been some promising signs in this area. The National Association of Science Writers has formed a council to support "research on the presentation of science news to the public," and the AAAS committee on public understanding of science has held some initial meetings to stimulate such activity.
5. W. Schramm, *Science and the Public Mind*, issued for the AAAS by the Institute for Communication Research, Stanford University (1962).
6. See H. Krieghbaum, *Science, the News and the Public* (New York Univ. Press, New York, 1958); H. Krieghbaum, *Science* **129**, 1092 (1959 → S. Withey, *Public Opinion Quart.* **23**, 382 (1959).
7. This research was supported in part by the Research Committee of the Graduate School, from funds supplied by the Wisconsin Alumni Research Foundation; it was aided by the facilities of the Wisconsin Numerical Analysis Laboratory. My associates in the investigations were several graduate students, principally Kenneth Johnson, Edward Aebischer, and Malcolm Laing.
8. J. C. Nunnally, Jr., *Popular Conceptions of Mental Health* (Holt, Rinehart & Winston, New York, 1961).
9. W. L. Taylor, *Journalism Quart.* **34**, 191 (1957).
10. J. C. Nunnally, Jr., *Behavioral Sci.* **2**, 222 (1957).
11. G. Gerbner and P. H. Tannenbaum, in *Studies of Innovation and of Communication to the Public*, W. Schramm, Ed. (Stanford Univ. Press, Stanford, Calif. 1962); *Gazette* **6**, 365 (1961).
12. C. E. Osgood and G. J. Suci, *Psychol. Bull.* **49**, 251 (1952).
13. K. G. Johnson, thesis, University of Wisconsin (1961).
14. C. E. Osgood, G. J. Suci, P. H. Tannenbaum, *The Measurement of Meaning* (Univ. of Illinois Press, Urbana, 1957).
15. Cited in *Editor and Publisher* **91**, 120 (1958).
16. C. P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge Univ. Press, Cambridge, England, 1959).
17. M. M. Laing, thesis, University of Wisconsin (1961).
18. P. H. Tannenbaum and J. S. Noah, *Journalism Quart.* **36**, 163 (1959).
19. M. W. Thistle, *Science* **127**, 951 (1958).