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Tracking the Flow of Information

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Summary. By using words transmitted and words attended to as common denominators, novel indexes were constructed of growth trends in 17 major communications media from 1960 to 1977. There have been extraordinary rates of growth in the transmission of electronic communications, but much lower rates of growth in the material that people actually consume, representing the phenomenon often labeled information overload. Growth in print media has sharply decelerated, and a close relationship is found between the cheapness of a medium and its rate of growth.

Identification of social indicators that track changes in the human condition have been prerequisite to much of the progress of the social sciences. Early economics focused extensively on foreign trade because of the data that existed in the form of customs records. More recently cost-of-living and unemployment indexes have played a large role in policy analyses. Now indexes of cultural and political trends are increasingly being used. Among those that have had a major impact are Scholastic Aptitude Test scores and polls rating the President. In these instances, the existence of a usable time-series measurement has stimulated research and analysis seeking to explain the observed results.

In this article, some findings from new indexes intended to measure trends in the development of an information society are presented as well as some explanations for what has been found. The trend in modern industrial societies to move toward becoming information societies is most commonly measured by the balance between white- and blue-collar employment (*1*). A Department of Commerce study (*2*) shows the information sector rising from about 1/20 of the work force in 1870 to about a third in 1950 and about half of all employees today. A study by the Organisation for Economic Co-operation and Development (*3*) of nine industrialized countries shows parallel trends in all of them. In Japan the information sector grew from 18 percent of the work force in 1960 to 30 percent in 1975, and in the United Kingdom, it grew from 27 percent in 1951 to 36 percent in 1971.

While white-collar employment is a useful index of information activity, additional insights can be obtained from measures that more directly describe the flow of information itself rather than an important but loose correlate of it. The volume of words flowing through such media as broadcasting, publishing, the mails, and telecommunications might be such an index and might reveal some of the fine structure of what is generally called the information explosion. Such a measure, developed from a "census of communications flows," is discussed below.

Among the major findings from this census are that while there has indeed been a rapid increase in the information being made available to the public, the offering of informational material is growing far faster than what is being absorbed. (The way in which that distinction has been made is described below under methods of measurement.) Although the largest flow of words in modern society is through the mass media, the rate of growth is now fastest in media that provide information to individuals, that is, point-to-point media. The growth in both mass and point-to-point media has been greatest in the electronic ones. Print media are becoming increasingly expensive per word delivered while electronic media are becoming cheaper, and costs seem to predict well what is used. The implications of this finding for the continued health of various media are considerable.

By compiling data on trends in the circulation and in the use of 17 public media of communication, we found that from 1960 to 1977, words made available to Americans (over the age of 10) through these media grew at the rate of 8.9 percent per year, or more than double the 3.7 percent growth rate for the gross domestic product in constant dollars. However, the words actually attended to from those media grew at just 2.9 percent per year. Per capita consumption of words from those media (allowing for population growth) grew at but 1.2 percent per year.

The modesty of that growth in consumption of information, despite the presence of large growth in the information available, is often described as information overload. More and more material exists, but limitations on time and energy are a controlling barrier to people's consumption of words. Given any particular employment and life-style, there is a limited potential for expansion of attention to media as a whole. Much of the small growth that is found can be accounted for by the shift in the population from blue- to white-collar employment and life-styles and the associated rise in educational levels.

For those who are producing information, this difference between trends in supply and consumption means that each item of information produced faces a more competitive market and a smaller audience on the average. People see or hear a decreasing proportion of the total information that is available to them.

The data compiled for our study cover the years 1960 through 1977. The data are incomplete after 1977 since it takes years for some statistics to be published.

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In the period of observation, much of the growth in the flow of information was due to the growth in broadcasting. In 1960, an estimated 58 percent of the words that Americans actually heard or read through the measured media came to them by television or radio; by 1977, the figure was 69 percent. But toward the end of that period the situation was changing: point-to-point media were growing faster than broadcasting. Some data available up to 1980 show that trend to be in most respects continuing, though cable systems are giving a new spurt to television.

Methods of Measurement

The methodology for making our estimates was first developed at the Ministry of Post and Telecommunications in Japan by Tomita and his co-workers (*4*). Our study in the United States was done in association with a revised Japanese study, conducted jointly by Tokyo University and the Japanese Research Institute of Telecommunications and Economics (*5*).

The key decision was to translate all flows of information into the unit of words. This required ascertainment of the typical word rate for such activities as telephone conversations or the reading of mail, books, and magazines. However, a distinction was made between words supplied and words consumed. Our definition of a word supplied is that it is available at the premises of a person so that all he or she would have to do to hear or read it would be to choose to do so, requiring at most the turning of a switch or opening to a particular page. Thus the number of words supplied by television would grow not only if broadcasters said more words, but also if the number of receivable stations increased (for example, by cable television importing additional signals) so that the listener had more alternatives at hand, or if second television sets came into the home so that different members of the family could choose different stations at once. The data from which the supply time series were calculated were thus primarily data on the activity of information industries; these do not take into account the behavior of the audience.

Words consumed are those that the members of the population actually heard or read. The basic data from which such estimates are derived are behavioral surveys such as time-budget studies. Such data are generally collected by broadcasters in their audience studies but are much less generally available for other communications activities. Television ratings tell us how many people watched TV at a particular hour. Occasional sociological time-budget studies tell us how many minutes a day people spent in reading and other activities, but such data are sparse. For person-to-person media such as telephone calls, first-class letters, or telegrams, words supplied and words consumed probably do not differ greatly; there are no good data on the percentage of inattention. Therefore, no distinctions were made between how many words were spoken or written in such media and how many the receiver heard or read. But for mass media the difference is large and important. The number of words in a book that is brought home is not necessarily the number read. The two different time series have to be distinguished.

In fact, distinctions can be made on four levels. First, there is the act of authoring; each word in a newly composed statement would be counted once if we were measuring that. Second, there is the act of publishing. In a count of words published, the same words would be counted twice if they were published twice, as in different newspapers or different reprints, but the count would not include the number of exemplars that reached individuals. A third level is what we have called words supplied, for which not only is the number of times a word has been published counted, but also the number of individuals to whom it has been made available is counted. And the fourth level is words consumed—namely, how many words individuals choose to absorb. Our study deals only with words supplied and consumed.

If these data turn out to be useful, then no doubt many of our estimates will have to be revised as new, fuller, and better-adapted raw time-series and behavioral measures become available. These first results share many of the infirmities of any work with index numbers, particularly new and unexercised ones. The measures are derived by secondary analysis of data collected for other purposes, and not always consistently. Thus audience measures for TV ratings and for newspapers, each collected by the industry, are not necessarily fully compatible. Nor are all data reported annually, so that interpolations and extrapolations had to be used.

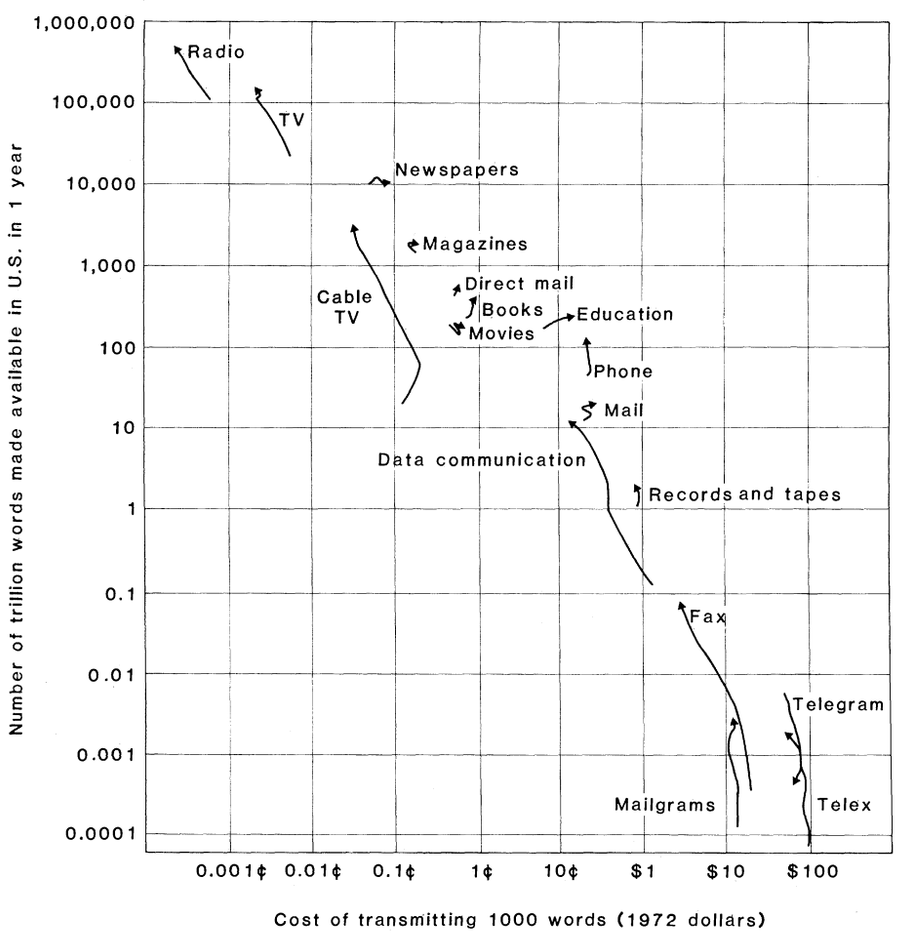

Fig. 1. Trends in volume and costs of communication for 17 media, 1960 to 1977 (plotted on log by log scales).

In general, with use of these data, as of any index number, more credence should be given to trend changes than to comparisons of different situations. Many decisions go into the construction of any index number, and these apply differently in different situations. Thus comparisons of the unemployment indexes of different countries or even of different population segments in a country (for example, students, old persons, and middle-aged persons) is likely to be less valid than comparisons of the unemployment index in one situation as it changes over time. Unemployment means different things in different systems. So too, a spoken word is not exactly the same thing as a written one, and the records kept on the circulation of newspapers, which are thrown away at the end of the day, are not exactly comparable to any records kept on books, many of which are passed along informally. Yet a standard operational definition can provide a basis for stable comparisons over time.

We were able to compile data in the United States on 17 different mass or point-to-point media (Table 1). The most important omissions are conversation and internal memoranda. These were omitted because usable time-series data were not available. In general, in corporate offices, more than 90 percent of the documents that circulate are distributed within organizations and do not go outside into the mails (*6*). Thus, the so-far omitted informal means of communication are important flows that must be examined further.

Table 1. Media in the United States for which censuses of communications flows were tabulated, 1960 to 1977.

Mass media
Radio
TV
Cable TV originated
Records and tapes
Movies
Classroom education
Newspapers
Magazines
Books
Direct mail
Point-to-point media
First-class mail
Telephone
Telex
Telegrams
Mailgrams
Facsimile
Data communication

Growth Trends: Mass versus Point-to-Point Media

The use of any medium, as of any commodity, is a function of its cost. In Fig. 1, an arrow for each medium that we examined tracks a trend from 1960 to 1977. On the horizontal axis is plotted the cost of transmitting 1000 words to a single potential audience member in constant dollars, and on the vertical axis is plotted the number of words so supplied. Broadcasting, measured in this way, is extraordinarily cheap (*7*). For 1 cent, a thousand words are made receivable by radios belonging to families encompassing more than a thousand individuals, which is understandable in the light of the fact that a radio transmission is potentially receivable in an area inhabited by hundreds of thousands or millions of persons. Broadcast words are cheap enough to be given away free, which they are. At the other extreme, a telegram costs about 10 cents a word, which accounts for its low and vanishing use.

In the upper left quadrant of Fig. 1, at costs below a penny a thousand words supplied, are the mass media. In the lower right quadrant are the point-to-point media. People are willing to spend one or two orders of magnitude more to communicate with the specific individuals with whom they wish to interact than they are to put out or receive messages "to whom it may concern."

Data communication represents an especially interesting case, particularly if one projects the curve, which has in fact continued, up to the present. The growth in computer networks and the fact that they are used as messaging facilities has undercut telegraphy and even its more efficient form, Telex. The volume of domestic Telex use grew at a rate of 18 percent per year from 1960 to 1970 and then declined at 14 percent per year through 1977; international Telex has continued to grow, for it reaches many subscribers abroad, but in the United States computer networks are replacing it. Computer networking is for the first time bringing the costs of a point-to-point medium, data communication, down to the range of costs characteristic of mass media.

That fact helps us to understand certain developments in communications which are currently the subject of much popular speculation. Information retrieval from data bases (or its popular version, videotex) is perceived as a revolutionary challenge to ordinary publishing, and indeed it may be that. Computer data processing and digital communication seem likely to allow information to be provided in response to individual inquiries at costs competitive with mass production of information products. If the functional relation represented by the rather tight diagonal corridor on the graph in Fig. 1 continues to hold, that suggests approximately what volume of data communication is likely to occur at such costs.

The rapid growth of data communication (27 percent per year) and the continued growth of telephony (just below 6 percent per year) has produced a continuing growth of point-to-point media, with the rate of growth rising for these media as a whole from a general level of 5.5 percent for the entire period since 1960, to a rate of 7 percent in the last 3 years of the time series.

In the 1960's, and one would assume in the 1950's too, the dominant trend was toward a society in which a relatively few sources of mass media material—particularly broadcast entertainment—were occupying an unprecedented portion of national attention. The preeminent force in shaping that trend was the growth of television. In the 1970's a reversal began that in two ways led to less massive domination of the flow of communication by a few mass media. First, some fragmentation of the mass audience was taking place because of an increase in the number of channels (for example, by cable systems and added broadcast stations); second, the growth of individually addressable point-to-point media became more marked. The growth rate of television was 11 percent in words supplied and 4 percent in words consumed for the entire study period 1960 to 1977 but was 7.5 percent in supply and 3 percent in consumption from 1972 to 1977. In the years from 1972 to 1977, the aggregate rate of growth for mass media words consumed was 2 percent per year, and in words supplied only 5 percent per year, while the rate of growth in point-to-point media was 6 percent per year.

Aggregate figures are subject to domination by a few media since there are order-of-magnitude differences between media in the sizes of their flows. Still the generalization about the mid-1970's slowdown in the rate of growth of mass media words supplied holds up individually for radio, television, records and tapes, education, newspapers, and magazines. It does not hold for movies, which were recovering from their post-television slump, books, direct mail, or of course, cable television (*8*). The generalization about the sustained growth of the point-to-point media holds for data communication, telephones, facsimile, and Mailgrams but not for first-class mail, telegrams, or Telex.

Print versus Electronic Media

Closely related to these changes in both the mass and point-to-point media is the striking trend from print to electronic media (Fig. 2). The supply of words in print grew but slowly from 1960 for a decade and then entered a plateau or even slight decline. At the same time the flow in electronic media was growing rapidly.

There is a widespread impression that there has been a decline in reading in America. Television is usually blamed, but the evidence is somewhat more complicated. A number of studies in several countries (*9*) show a significant drop in reading when television is first introduced and then a gradual recovery, though not necessarily to pretelevision levels. Our data do not cover the period of the first introduction of television. In the period that we observed, the aggregate of words supplied in print grew steadily until about 1968 after which there is no uniform trend. The growth for the whole period was half a percent per year, but for the years after 1968 it was zero. This change in the later years holds for magazines and first-class mail as well as for newspapers, which are the dominant medium in the group; it does not hold for direct mail or books.

For the purpose of evaluating reading by the public, the relatively reliable figure on words supplied is far less relevant than the figure on words consumed, for which we are dependent on scarce sociological time-budget studies. Our data support the impression of a decline in reading from printed media, though how far this would hold up if reading from screens or reading at work were included, is an open question. Consumption habits are much more stable than the supply of information material. For the most transient material (for example, weather reports) there is perhaps some shift away from use of newspapers, magazines, and books toward obtaining such material from radio and television, while there may be continuing use of print to obtain less evanescent material. Our data on this are too weak, however, to reach a confident conclusion. Insofar as our consumption data are reliable, they indicate that the per capita volume of words taken in by reading of print as a whole seems to be declining. Both in 1960 and in 1977 we have an estimate of 1.5 trillion words a day read from print media in the United States. But in that period the population was growing, and per capita the number of words read per day from the tabulated media seems to have declined from an average of 11,000 to 8,500 words for adults.

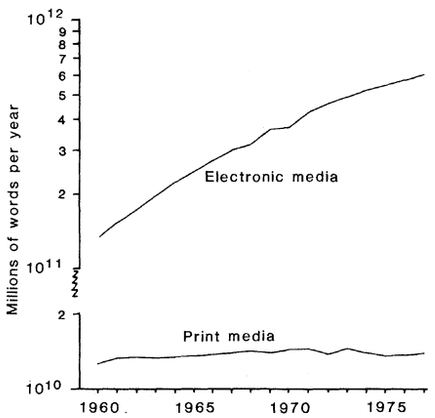

Fig. 2. Growth trends of print and electronic media, 1960 to 1977.

The shift from printed media to electronic communications can be observed in both the mass and the point-to-point media. If we compare radio and television on the one hand, with newspapers, magazines, and books on the other, we find that in 1960 67 percent of the words consumed from those five media came from the two electronic ones; that rose to 79 percent by 1977. If we compare use of telephone and first-class mail among the point-to-point media, we find that the postal service was the source of 22 percent of the words from these two media in 1960 but only 14 percent in 1977.

Many factors enter into how choices are made among media. One factor is gratification. Some people enjoy spending many more hours watching television than reading. Another obvious factor is the adaptability of a medium to particular functions; a letter serves for sending a bill, a telephone call for an urgent reminder. Communications researchers have studied extensively such topics as the relative effectiveness of different media for changing a vote, for making a purchase, or adopting health practices. One factor that has received little attention is cost. There is a good reason for that neglect. How, in the absence of a common denominator, can the cost of a magazine and a movie be compared or the cost of a facsimile and a classroom presentation?

A Common Denominator

It was to address the issue of costs, among others, that we adopted a common denominator, the word, although it is not the relevant common denominator for all purposes. If one is interested in producing a particular effect, such as persuading someone to buy a product or to adopt family planning, one does not care how many words are used in different media; the common denominator one cares about is sales or births. Without any illusions about having established a universal common denominator, it is worth considering how far cost per word enters into some of the differences in trends among media. Indeed there turn out to be striking variations in cost trends, most notably between electronic and print media.

Between 1960 and 1977, there was a marked decline in the cost of supplying words through the aggregate of all the media that we measured, but an increase in the cost per word actually consumed. This is not a matter of inflation; we used constant 1972 dollars for the comparison. Setting the number of words supplied per dollar in 1960 at 100, we find that the productivity of each dollar spent in supplying words rose to 180 by 1977, while the productivity of each dollar spent, evaluated by whether the words achieved attention, fell to 70. In short, the technology for putting out information greatly improved, through electronics, and as a result much more material was put out. Indeed much more was spent in total in putting information out even though the cost per word went down. However, with the audience only modestly changing its attention, the net input of words to the audience that was achieved by the greater output of words, coupled with the greater expenditure, showed diminishing returns.

A few media showed a pattern of rising costs per word supplied (Fig. 1), and for each of these there were consequences, including restricted growth or in some instances even decline. Education showed the most striking increase in cost. Education is defined in our study as words in the classroom and is estimated by contact hours, students present, and rate of word passage in a classroom situation. We used the words consumed per dollar in 1960 as the base and set that at 100; the index in 1977 had fallen to 46. This index is obviously not a measure of quality of education; it could even be considered the inverse, for smaller classes cause that index to fall. But it is an index that has some relevance to the concerns that exist in American society about the efficiency of educational expenditure.

In all the print media the productivity of expended dollars in achieving consumption of words has declined but most notably in newspapers and the postal service. With 1960 as the base

year and the productivity index (words per dollar) set at 100 for each medium, the index in 1977 for newspapers is 62 and for first-class mail is 76. (For magazines, direct mail, and books the 1977 figures are 93, 90, and 84, respectively.) These figures reflect the rising costs of paper beyond the general level of inflation and the rising costs of labor intensive delivery systems. Indeed, when these media are excluded, we find that for most media the cost of achieving consumption of words of information has remained fairly constant. For all media together, excluding education and newspapers, the index of productivity of expenditures in producing consumption of printed material was 101 in 1977.

It is in the electronic media that dramatic declines in cost have offset the increased costs in print media and education. For point-to-point media as a whole, the index of productivity of expenditures in producing a flow of words was 105 in 1977 compared with 100 in 1960. (Recall that for the point-to-point media the distinction between words supplied and words consumed is not made.) That figure includes first-class mail that showed a declining index. If we look only at the media used for telegraphic record transmission (telegrams, Telex, Mailgrams, facsimile, and computer networks), though some have been displacing others, the advances in electronics have moved the aggregate index of words supplied or consumed per dollar from 100 in 1960 to 1425 in 1977.

Concluding Remarks

The shift in the 18th and 19th centuries from a largely agricultural to a largely industrial society was of profound historical significance; the shift now taking place from a largely industrial society to one in which most effort goes into, and most value is produced by, information-processing activities may be of equal importance. Experience of the social sciences is that prerequisite to the effective analysis of such macrosociological phenomena is the construction and collection of measures of the processes taking place. The efforts to conduct communications flow censuses in Japan (*4*) and the United States are initial attempts to create such indicators of the flow of informational material (*5*). Collection of viable social indicators, however, generally requires sustained effort by social institutions. A great deal of refinement of design and expensive data collection goes into any maintained and useful social indicator.

The initial communications flow censuses have used publicly available time series that were constructed for purposes quite different from those to which they were put in the census. The calculation of words supplied by a medium generally starts with a standard series of circulation or program production figures and applies factors to the basic data relating to secondary distribution or receivers available in households. To the availability figures thus derived, one then applies estimates of the number of words per issue or per minute. In calculating consumption of words, one starts with time-usage data on people's reading, listening, or viewing habits and applies factors derived from studies of talking or reading rates. Few of these figures are very reliable. However, constant errors will have less impact on conclusions about time series than on conclusions about absolute values, since most of the series used are collected in the same way year after year.

Trends that have created the widespread feeling of information overload are supported by these series. So too is the fragmentation of the audience. Mid-20th-century sociological generalizations about the growth of a mass society are contradicted by the data that show recent trends toward the use of more diversified and point-to-point media. Also shown by the data is the shift from Gutenbergian to electronic media. The significance of that trend may be reflected in new styles of use of information media, including interactive retrieval, long-distance communication, and intelligent processing of records.

References and Notes

1. See F. Machlup, *The Production and Distribution of Knowledge in the United States* (Princeton Univ. Press, Princeton, N.J., 1962); see also Porat *et al.* (*2*) and Organisation for Economic Co-operation and Development (*3*). While the most commonly used index of the growth of the information society is the structure of employment, the goal of such economic analyses is not just to measure trends, but also to use national income accounts to explain the causes of these trends [see C. Jonscher, in *Information Economics and Policy* (North-Holland, Amsterdam, in press)].
2. M. U. Porat *et al.*, *The Information Economy* (OT Special Publication 77-12, Department of Commerce, Washington, D.C., 1977).
3. Organisation for Economic Co-operation and Development, *Information Activities, Electronics and Telecommunications Technologies: Impact on Employment, Growth and Trade* (OECD, Paris, 1981).
4. T. Tomita, *Telecommun. J.* **42**, 339 (1975); *Information Census Flow* (Ministry of Posts and Telecommunications, Tokyo, 1975).
5. H. Inose, N. Takasaki, I. Pool, in preparation.
6. Since we compiled our original data, we have gained access to some significant new data on paper flow in offices with the cooperation of the Xerox Corporation and are extending our data.
7. Programming costs are not included in the data in Fig. 1 or elsewhere, nor do we include the investments consumers must make to receive communications, such as the cost of television sets. All costs mentioned are costs of causing a message to be transmitted to its receivers.
8. Our definition of cable television was limited to material that was not relayed from the standard broadcast stations, the transmissions from which continued to be tabulated in the TV series, regardless of whether picked up over the air or from a cable system. In the period since 1977, the added stations and programs provided by cable systems have resulted in an increase in television viewing time by cable subscribers.
9. H. Himmelweit, A. N. Oppenheim, P. Vine, *Television and the Child* (Oxford Univ. Press, London, 1958), pp. 335–336; W. Schramm, J. Lyle, E. Parker, *Television in the Lives of Our Children* (Stanford Univ. Press, Stanford, Calif., 1961), p. 15; J. P. Robinson, in *Television and Social Behavior* (Government Printing Office, Washington, D.C., 1974), vol. 4, pp. 410–428; J. Lyle and H. R. Hoffman, *ibid.*, p. 135; D. P. van Vuuren, in *Proceedings of the 4th International Conference on Experimental Research in TV Instruction,* St. John's, Newfoundland, Canada, September 1981, p. 10; T. Furu, *The Function of Television for Children and Adolescents* (Sophia Univ. Press, Tokyo, 1971).

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