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Trends in science coverage: a content analysis of three US newspapers

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This paper describes a content analysis of science news reporting in three major daily newspapers, the *New York Times*, the *Chicago Tribune*, and the *Washington Post*, during the last three decades. It was found that although science articles represent only a small percentage of the total number of articles printed, this percentage has steadily increased with each time period. The results also show that, at least in the newspapers analysed, science coverage does not differ substantially in terms of the range of topics covered, as well as information that has been both included and omitted from science news accounts. Although there were some differences between articles appearing in the different time frames, in general science news reporting has not changed significantly in terms of the comprehensiveness of accounts. An especially significant finding is that articles frequently omitted methodological and contextual information, features most often mentioned as critical for a complete journalistic account of science.

Through the decades, science and scientific research has had a growing impact, both directly and indirectly, on public life. As a result, the general public has shown signs of an increased interest in science and science policy. Nunn found that newspaper audiences had a high level of interest in science news, particularly among young adults.[1] Miller also found interest in science to be high, with 40 per cent of American adults expressing interest in science and science policy.[2] It is of interest to know, then, how scientific information and the results of scientific research have been reported to the general public, as individuals often use this information to form opinions, as well as to make decisions, that concern public as well as personal issues. That is, the content of science news is important to consider because, in the words of Evans and Hornig Priest, '... presumably we care about content both as an indicator of public thinking and as a source of that thinking,'[3] as science is 'part of common culture, integrally tied to social practices, public policies, and political affairs.'[4] In addition, as an important source of scientific information for the lay public, the content of journalistic accounts of science is a concern because people need adequate information about scientific issues to develop 'practical science literacy,' knowledge that enables them to solve practical problems.[5] This issue is the central concern of this paper. After a brief survey of the relevant literature, a longitudinal content analysis of science articles in three major daily newspapers over three decades will be described. The results of this study shed light on some of the trends that have occurred in science news reporting through the years, and the content of these journalistic accounts.

Because the public has shown an interest in news of science and technology, one might expect that the mass media, especially newspapers, would exhibit an increase in science

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coverage. While in the past that may have been the case, this has changed in more recent years, especially in terms of newspaper coverage of science. That is, while a number of newspapers began featuring weekly science sections and/or employing full-time science writers to write for their daily editions,[6] with the emergence of 18 newspaper sections devoted to science between the years 1974 and 1984,[7] more than half of those science sections have been dissolved in the past few years, falling from a peak of 95 sections in 1989 to only 47 sections in 1992.[8]

Regardless of this drop, however, mass media and news coverage of science has become increasingly important, as it can influence both the public's knowledge and attitudes about a wide variety of scientific issues. For example, in a study by Meissner, Potosky and Convissor, people who relied on print media, including newspapers, as their main source of information on how to prevent illnesses were significantly more likely to have heard of cancer screening procedures than those people who relied primarily on their physician.[9] McLeod, Glynn and Griffin found that higher use of the media was associated with higher rankings of the importance of energy conservation.[10] Thus, today's science journalists report on an extensive range of subjects, including the latest advancements in medicine, energy, environmental issues, and technological developments, and these reports can have an impact on individuals' beliefs, as well as on their behaviour. This variety in subject areas should not be surprising, especially when one considers that the field of science has become increasingly diversified through the years.

Many researchers have examined various aspects of science news. Although studies have been done on various media forms, including magazines[11] and the network news,[12] most studies have focused on science news reporting in newspapers. Newspapers are an important medium to study for a number of reasons. While a study of young adults conducted by Patterson found that people learn most of the latest science news through newspaper accounts,[13] more recent research has shown that television may be replacing newspapers as the preferred source for science news.[14] Still, when one considers that a national survey of scientists revealed that 76.6 per cent of the respondents who had participated in an interview had done so with newspapers,[15] the importance of newspapers as a source of science news cannot be denied. Such aspects of science reporting as accuracy,[16] comprehensiveness[17] and sensationalism,[18] as well as the presence of scientific explanations[19] and coverage of risk,[20] have all been examined as components of newspaper accounts.

Accuracy is the primary concern of scientists, but the technical nature of science reporting may make it more prone to error than news reports about other topics. Studies investigating the accuracy of popularized accounts of science revealed that scientists often consider inaccuracy to be the major problem with science reporting. Tankard and Ryan found that when evaluated by scientists, only 8.8 per cent of science articles were judged to be error-free, compared to rates of 40 to 59 per cent for other news stories.[21] However, a follow-up study by Pulford, using a shorter checklist of possible errors, found 29.4 per cent of articles were judged to contain no inaccuracies.[22] Tichenor, Olien, Harrison and Donohue found that slightly more than 40 per cent of scientists surveyed disagreed with the statement that science news is generally accurate,[23] whereas Dunwoody and Scott found that 51 per cent of the scientists surveyed criticized science reporting for inaccuracy or distortion.[24] However, while scientists are critical of science reporting in general, the same scientists tend to be more favourable when it comes to evaluating the accuracy of news stories about their own work.[25]

One potential problem with such studies, however, is that they have focused on accuracy as perceived by the scientists, and are therefore limited by subjectivity. That is, according to McCall, accuracy research that is based on the perceptions of the source is limited by

the subjective nature of the evaluative task.[26] To overcome this limitation and to investigate the common errors of science reporting, Singer compared news reports of scientific topics from a variety of media (i.e., newspapers, newsmagazines and television) to the original research reports appearing in the scientific literature.[27] Out of the 42 articles studied, only 7.1 per cent were found to contain no inaccuracies. Common errors found in the accounts analysed included omission of qualifying statements (found in 60 per cent of the accounts), a lack of discussion of the methodology followed (48 per cent of the accounts), a 'change of emphasis' (45 per cent of the accounts), and an overstatement of the generalizability of the research results (36 per cent of the accounts).

Inaccuracies such as those cited by scientists in accuracy studies and uncovered by Singer are primarily subjective inaccuracies,[27] which Dunwoody defines as errors in meaning.[28] In contrast to objective inaccuracies, such as incorrect statements or errors of fact, subjective inaccuracies are dependent on an individual's interpretation and thus are not always recognized by all parties. Indeed, numerous studies have shown that when scientists say a study is inaccurate, they are really referring to errors of omission and misemphasis.[29] Of these two subjective errors, the most commonly cited throughout the accuracy studies is omission of information. Scientists' main complaint about journalistic accounts of scientific research is that such accounts are incomplete because they lack relevant and important information,[30] information needed by the public to make informed judgments. That is, 'the requirement of substantial completeness is satisfied if adequate information is published or broadcast to meet the needs of an intelligent nonspecialist who wants to evaluate the situation being reported on.'[31] Indeed, Rowan echoes this view, asserting that texts that purport to represent some aspect of reality, as science news articles do, imply that their representation is relatively thorough or comprehensive. That is:

> If a popular article reports that a new drug seems to cure some disease but fails to mention its severe side effects, we would not view the article as a sufficiently comprehensive representation of the drug's effects. To represent reality fully, a message must address all dimensions of a topic that readers expect to learn about.[32]

Thus, this problem can be viewed as more of an issue of the completeness or comprehensiveness of journalistic accounts of science, rather than one of accuracy.

One of the most common omissions is the omission of important details of methodology.[33] In the study by Tankard and Ryan, the scientists surveyed ranked 'relevant information about the method of study omitted' as the most serious problem of newspaper accounts of science.[21] The more objective findings of Singer support this view, with 48 per cent of the 42 articles studied having no mention of research methods at all.[27] Furthermore, of the studies that did mention research methods, 15 or 35 per cent gave what was considered inadequate information, while 3 or 7.1 per cent gave erroneous information. Similar results were found in a study comparing science reporting in both the prestige and national tabloid presses. Of the newspaper accounts analysed, only 36.2 per cent of the articles in the *New York Times* and *Philadelphia Inquirer* and 19.8 per cent of the tabloid articles contained a 'more than minimal' discussion of the research design, leading the authors to conclude 'that at neither the prestige nor the national tabloid newspapers is it common practice to include methodological details.'[34] Molitor found that five major national newspapers gave an incomplete description of what turned out to be a highly unrepresentative sample used in an aspirin and heart attack study (reported in the *New England Journal of Medicine*), information that was necessary to interpret the generalizability of the study's findings to the general public.[35] While the omission of methodological information is viewed as problematic, it must be noted, however, that a study by Lordan found that the inclusion of

such methodological details as sample size and a description of the study population did not assist readers in understanding statistically oriented news stories.[36]

Other common omissions include criticism of the research and theory by other scientists, and qualifying statements and/or other information that would limit the findings or conclusions of the research.[33] However, it is important to note that though science journalists increasingly recognize the need to use qualifying or cautionary language in their copy,[37] and thus may write using such cautionary phrases as 'preliminary' or 'early results,' 'many readers do not recognize the implications of these words.'[38]

Another commonly recognized problem with science news reporting is that previous research is often ignored. This omission can lead to misemphasis within science stories and sensationalized accounts of new developments, with research findings presented as discrete events or 'breakthroughs' and tentative findings treated as scientific fact.[39] Indeed, the scientists in the Tankard and Ryan study cited 'continuity of research with earlier work ignored' as one of the nine major problems of science reporting.[21] Thus, it has been asserted that science should be treated as 'more of a motion picture and less of a snapshot,'[40] emphasizing the continuity and cumulative nature of research, as there is as much a need for the general public to understand the internal processes by which scientific knowledge is generated and validated as there is for them to know the content of specific areas of science.[41] LaFollette echoes this view, asserting that:

> Effective modern citizenship demands a higher level of 'knowing about' science. . . . Acknowledgment that all sciences have histories is part of this type of knowledge. Research knowledge about any one subject at any one time represents an accumulated body of information, as science continually reconstructs itself. To 'know about' science then, is to know about that reconstruction and reconstitution.[42]

Though opinions are often expressed about the adequacy of various kinds of coverage by facets of the media, this presents a problem when casual observation, rather than careful documentation, becomes a basis for serious suggestions for major changes in the mass media.[43] The issue of the quality of newspaper coverage of science, and how that coverage may have changed through time, can be looked at in this framework. While scientists' impressions indicate a lack of comprehensiveness in many respects, formal documentation is needed. In addition, differences of opinion exist on whether the rise of the professional science writer or journalist, which began in the 1920s–1930s, has been associated with an improvement in the quality of science reporting.[44] Though it has been suggested that because these journalists are trained in science many may adopt the values of scientists and lose their ability to be critical,[45] others associate the rise of the professional science writer with improvements in the comprehensiveness of science reporting.[46] Content analysis, especially a longitudinal approach, is useful and valuable in analysing trends and changes in content over time,[47] and thus provides a particularly useful tool to examine any changes in the comprehensiveness of science reporting that may have resulted from these historical trends in science journalism. Such an approach allows for the careful documentation necessary to assess newspaper coverage of science and the trends that occurred in this coverage through the years.

Focus of this study

While many models have been utilized to study the communication of scientific information, a number of these approaches 'have focused on specific media or process effects' of science communication.[48] For example, Mazur found that with increased media coverage of a

controversial science and/or technology issue, public opinion tended to indicate that not only were people inclined to recognize the controversy, but also that there tended to be increased opposition to the technologies in question.[49] This finding then provided support for an agenda-setting account of the effect of the media on public understanding of science. However theories or models such as agenda setting do not appear to enlighten the issue of the content of science articles, nor do they allow specific predictions about the content and quality of such communications and how these may have changed through time.

We may, however, have some pre-theoretic conceptions about newspaper coverage of science, and some expectations about how this coverage may have changed through time, based on prior research reviewed earlier. In this study, content analysis was used to uncover and compare trends in science coverage in three major daily newspapers during three time periods of 1966–1970, 1976–1980 and 1986–1990. While this study attempts to address a number of issues surrounding science news reporting, the primary focus of this content analysis is on the omission of important and relevant information from journalistic accounts of science. This area was emphasized because many of the discrepancies both cited and observed in science reporting in past studies[50] involve omissions of such critical information as qualifying statements (for example indicating limitations in the research), methodological details, or significant findings. The importance and implications of the omission of such critical information cannot be overlooked. That is, in the words of Singer:

> Whether such omissions and alterations should be regarded as inaccurate reporting depends on how we define accuracy. If readers and viewers are not made aware of [any] contingencies, if mass media accounts do not reflect limitations in the data or research methods used, and if conflicting findings are presented without interpretation or evaluation, then flaws exist in the communication process, whether we call these flaws 'inaccuracies' or not.[51]

With this in mind, this study attempted to answer three questions:

1 Has overall coverage of science by newspapers become more frequent, and does it cover a broader range of topics? Because public interest in science has increased and the scientific community has become more diversified, one might expect to find broader and more regular coverage during the latter periods.

2 Have articles become more complete and comprehensive as time has progressed? In this study, comprehensiveness concerns the inclusion of pertinent factual information. Since more reporters covering science are professionally trained science writers, it may be expected that more comprehensive articles appear in the latter time frames.

3 Do methodological citations,[52] or descriptions of the research design employed, appear more frequently? Furthermore, are these descriptions more thorough in articles from particular time frames? As lack of 'relevant information about the method of study omitted' was ranked as the most serious problem by the scientists surveyed in the Tankard and Ryan study,[21] this seems to be an especially significant area to analyse. Such statements of methodology are considered important features of science news articles as they might influence opinion about the merits of the study and provide readers with enough information to assess the validity of the research for themselves. It might be expected that such methodological descriptions appear more frequently in articles in the latter time periods.

The three time periods examined in this study were chosen because they reflect periods marked by a growing interest in science and technology in the general public, as well as an increased effort by the mass media in general, and newspapers in particular, to meet those interests. It was during the period of the 1960s that an increase in the public interest in science and technology can be readily seen. For example, Swinehart and McLeod found increased interest in science and technology following the launch of the first space satellite, Sputnik 1, in 1957.[53] This interest continued to grow throughout the 1960s and the so-called space-race era. The period of the middle to late 1970s then saw the breakthrough of popular science into the media, including the development of specialized science sections in a number of major daily newspapers.[7] This, according to Lewenstein, can be attributed in part to maturation of the World War II baby-boom generation that grew up 'with Sputnik, the environmental movement, the war on cancer, the Space Program and the energy crisis,' and thus had 'an explosive hunger for more information on science and technology.'[54] Finally, the period of the middle to late 1980s was marked by a further strengthening of weekly science sections in newspapers, with a threefold increase in the number of such sections from 1984–1986,[7] reaching a peak of 95 sections in 1989.[8]

Methodology

According to Stempel[43] and Ogles[47] analysts should employ coding systems already developed and previously used by other researchers, as some measure of their usefulness will be known. Thus, this was the approach utilized in this study. A coding scheme to answer all three questions was developed using schemes from four previously published studies,[55] all of which used content analysis to investigate various aspects of science reporting in newspapers.

Coding scheme

Cole's definition of science news was used in this study to identify those stories to be analysed.[56] Using this definition, science news was defined as all news stories that have substantial subject matter concerning the results and interpretation of empirical research in the sciences, applied science or development, technology, engineering, medicine and public health. Stories provided by staff writers, news services and wire services were analysed. Stories by syndicated or local columnists, editorials, or other articles printed on the opinion-editorial page were not considered to be science news.

To further clarify what constitutes scientific research, the scheme of Evans, Krippendorf, Yoon, Posiuszny and Thomas was applied.[57] Thus, an article was considered to deal primarily with scientific research 'if its major focus was on specific findings of a scientific research endeavour.' According to this scheme, then, while an article may merely cite a scientist, or may incidentally report on the planning of scientific projects, it was not coded as science news unless it discussed specific research findings. As in the Evans, Krippendorf, Yoon, Posluszny and Thomas study,[57] only articles that focus on the results of completed scientific studies were analysed. Following the coding scheme of Hinkle and Elliott,[58] stories identified as science news were divided into three categories:

1 Medicine and health. Stories in this category focused on news of research in health-related areas. Some examples of items in this category included research on new drugs, surgical procedures and diseases, as well as research in health, nutrition and fitness. Articles on psychology were also included if

they were the result of scientific research conducted by a researcher affiliated with a hospital or university.

2 Technology. This category included stories that focused on developments in the fields of engineering and applied sciences. Stories falling in this category included news of the space programme, computer technology and superconductor research.

3 Natural and physical science. This category contained theoretically oriented stories from the areas of astronomy, physics, chemistry, biology, zoology, marine biology and environmental science.

Question 1, which focuses on the amount of science coverage in the different time frames and the range of topics covered, was investigated by answering the following questions:

(a) Are there differences in the types of science covered by the newspapers during the time frames analysed? Differences were determined by comparing the number of stories falling within each category.

(b) Do newspapers in the different time periods differ in the amount of science covered? Differences in amount of coverage were indicated by differences in the number of science stories per issue.

(c) Do the newspapers from the different time periods differ in the emphasis they place on science stories? Utilizing the scheme of Hinkle and Elliott, 'emphasis' was operationally defined as the percentage of science stories as a percentage of all news stories.[58]

To determine this percentage, all news articles in each of the newspaper issues analysed were counted. To be counted as an article, a news story had to be at least 75 words long. The following items were not counted as news articles: obituaries, social and business announcements (i.e., engagements, weddings, promotions, etc.), pieces on the opinions and editorial pages, stockmarket listings, calendars of events (or other announcements of meetings, recitals, lectures, etc.), any regularly occurring column, and any reviews.

To answer question 2, concerning the comprehensiveness of accounts, all science news articles contained in the newspapers analysed were coded for a variety of content. Many of these features have been identified as important for media coverage of science, and include:

- length of coverage. This feature was operationalized as the number of lines and number of words per science story.[58] The number of words was estimated by adding the number of words in the first five lines and the last five lines of the article. This sum was then divided by ten to give the average number of words in each line of the article. Finally, this average was multiplied by the number of lines in the article. This method of calculating the number of words was found to yield estimates that were within 5 per cent of the actual values.
- identification of the original forum or source of the research, such as journal article, conference or symposium paper, book, etc.;[57]
- identification of the researcher(s) by name;[59]
- identification of the researcher(s)' institutional affiliation(s) (e.g., university, government, hospital, private firm, etc.);[57]
- frequency of comments from the researcher(s) who conducted the study(ies);
- frequency of comments from other scientists, in support of the findings;
- frequency of comments from scientists with opposing viewpoints;[60]

- contextual factors. According to Evans, Krippendorf, Yoon, Posiuszny and Thomas these include comments that place the research in context with prior research, as well as comments regarding the limitations or generalizability of the research findings.[57]

According to surveys conducted through the years by the Scientists' Institute for Public Information, while the *New York Times* was the only newspaper that had a weekly science section in 1978, this number rose steadily for nearly a decade, with 19 sections in 1984, 66 in 1986, and finally reaching a peak of 95 sections in 1989.[8] The introduction of such sections has been found to affect newspaper science coverage by increasing both the number of science stories and length of such stories elsewhere in the newspaper.[61] Therefore, individual articles were also coded for the following:

- news source of article (i.e. wire, staff writer, etc.);
- appearance in weekly science section or in other section.

Question 3 investigates differences in the appearance of methodological citation, or a description of the research design used in the study being discussed. Therefore the unit of analysis was 'statement of methodology.' Using the scheme developed by Caudill and Ashdown, statements or descriptions of methodology were analysed by counting the number of words used to explain the research method.[52] As operationalized by these authors, an explanation of less than 30 words was considered brief, and thus inadequate. In addition methodological descriptions were also coded for the manner in which the statement characterized the research, for example 'method specific' (referring to a specific research methodology such as experiment, survey, etc.) or method nonspecific (for example phrases such as 'study,' 'research,' or 'report').

Sampling

Three major US daily newspapers, the *New York Times*, the *Chicago Tribune* and the *Washington Post* were analysed in this study. These newspapers were chosen because they are prominent and widely distributed on a national level. Analysis of such 'prestige' newspapers also offers another advantage. That is, in the words of Moyer, Greener, Beauvis and Salovey, 'selecting newspapers that are presumably of better quality than, for example, smaller local papers handicaps against finding errors and provides a representative picture of the quality of information that Americans typically consume.'[62] All copies of the newspapers were accessed on microfilm.

A constructed week for each of the three time periods being examined was generated using a computer program written in MicroSoft Quick Basic. In addition to this constructed week, a random Tuesday from each of the time periods was also generated using the same program. This was done to increase the number of science news articles to be analysed, as Tuesday is the day that science sections appear in many newspapers. Indeed, of the newspapers used in the sample, the *New York Times* and the *Washington Post* both have a science and/or health section in their Tuesday editions. Thus, a one-week plus one-day period for each of the three time periods was analysed for each of the three newspapers. This resulted in a sample of 72 newspapers and 107 individual articles to be coded.

Coding

Each newspaper edition in the drawn sample, as well as the individual articles therein, was coded by the author. To provide reliability estimates, a randomly selected subset representing 10 per cent of the newspaper editions and of the science articles was independently coded

by one trained coder. Intercoder reliability was calculated primarily using Scott's pi, which measures the percentages of agreement, taking chance into account.[63]

Results

Research Question 1: amount and range of coverage

The results show that although science makes up a small percentage of articles in each period, there was an increase in emphasis on science issues in the later decades. As can be seen in Table 1, the percentage of science articles increased the later the time period.

Table 1. Total number of news articles, science articles, and percentage of science articles.

Time period	Total articles/issue	Total science articles	Percentage of science articles as % of all articles
1966–1970	3478	18	0.42
1976–1980	2709	33	1.22
1986–1990	2741	56	2.04

Table 2. Categorization of science articles (%). Significance test results: $\chi^2[4, N = 107] = 4.42$, ns (significance determined at 0.05 level, ns = not significant).

Category	1966–1970	1976–1980	1986–1990
Medicine and health	72.22	75.76	71.43
Technology	11.11	0	3.57
Natural/physical science	16.67	24.24	25.00

To determine if there are differences in the types of stories covered during the different periods, categories of science articles were analysed (Table 2). In terms of the diversity of coverage, there was little difference in the range of topics covered in each of the three periods. Rather, coverage was very similar in each of the time frames studied, with an emphasis on medical and health-related issues. More than 70 per cent of the articles in each period were classified as dealing with medicine and health. Articles on natural and physical science were the next most frequent article type, whereas those dealing with technological issues and developments were the least frequent in all three time periods. There was no significant difference between the three time periods in terms of the subject matter covered in the articles analysed. Scott's pi for the measure of story type was 0.85.

Considering the growing diversity of the scientific community, such similarity in coverage across the three time periods is contrary to what might be expected. Rather, based on these results, science reporting over the decades has not reflected this increased diversification. However, the emphasis on medicine and health issues should not be surprising, considering that biomedical issues have been a dominant theme in the newspaper coverage of science.[64] These findings then, are in agreement with those of Hinkle and Elliott who found an emphasis on medicine and health-related issues in their analysis of three newspapers and three tabloids.[58]

Research Question 2: comprehensiveness of science articles

Articles were coded for a variety of content that reflect the comprehensiveness of the coverage. These measures reflect content that has been identified in past research as necessary features of a complete, comprehensive and accurate journalistic account of science. Table 3 contains the information on these various article measures for each of the three time periods.

Table 3. Comprehensiveness measures for individual science articles. Significance tests were determined at the 0.05 level (ns = not significant).

Comprehensiveness measure	1966–1970	1976–1980	1986–1990	Significance test results
Mean lines/story	108.83	100.58	117.70	$F[2, 104] = 0.38$, ns
Mean words/story	487.09	561.75	607.50	$F[2, 104] = 0.49$, ns
Percent identifying source of research	72.22	60.60	69.64	$\chi^2[2, N = 107] = 1.28$, ns
Percent identifying researcher(s) by name*	94.44	72.73	89.29	$\chi^2[2, N = 107] = 7.41$, $p < 0.05$
Percent identifying researcher(s)' institutional affiliation*	100	69.70	94.64	$\chi^2[2, N = 107] = 29.41$, $p < 0.05$
Mean comments from researcher	4.11	3.73	4.05	$F[2, 104] = 0.58$, ns
Mean comments from other scientists (favourable)	0.16	0.36	0.64	$F[2, 104] = 1.29$, ns
Mean comments from other scientists (critical)*	0	0.15	0.71	$F[2, 104] = 3.62$, $p < 0.05$
Percent articles citing prior research	55.55	51.52	44.64	$\chi^2[2, N = 107] = 0.44$, ns
Percent articles citing limitations in research	38.89	48.48	41.07	$\chi^2[2, N = 107] = 0.81$, ns

To get an indication of the length of coverage, articles in each time frame were coded for both the number of lines and the number of words contained in the story. The results show that while the articles in each of the three time periods contained a similar number of lines per article, the number of words in articles increased the later the time period. However, a one-way ANOVA revealed no significant difference among the means for either the number of lines or the number of words per article. The percentage agreement for number of lines per article was 98.6 per cent, and for words per article was 92.8 per cent.

Articles were additionally coded for a variety of other variables. These variables reflect what have been referred to by Evans, Krippendorf, Yoon, Posluszny and Thomas as 'minimal details' that should be included in science news accounts.[57] In terms of identification of the original research source (i.e., a journal article, conference presentation, etc.), there was no significant difference among the three time periods for inclusion of such information, as the percentages of articles that identified the research source were similar in all three time periods. Scott's pi for this measure was 0.80.

In another measure of comprehensiveness of reporting, articles were coded for whether the researchers who conducted the study were clearly identified in the article by name (Scott's pi = 1.00). As can be seen in Table 3, there was a significant difference among the three time periods in the tendency to include this information. That is, while the majority of articles in this study tended to include this information, there was a decline in this practice during the period of 1976–1980 in the articles analysed, with roughly 73 per cent of the articles including this information compared with almost 90 per cent or more of the articles in the other two time frames analysed. Scientists have cited the omission of researchers' names as a relatively common characteristic of print coverage of scientific research.[21] Indeed, Evans, Krippendorf, Yoon, Posluszny and Thomas found that only 70.3 per cent of articles from the *New York Times* and *Philadelphia Inquirer* analysed identified any researchers by name.[57] Additionally, chi square analysis yielded a significant difference between the time

periods for identification of the researcher(s)' institutional affiliation (Scott's pi = 0.80). Once again there was a decline in the percentage of articles including this information during the period of 1976–1980, and a subsequent rise during 1986–90. The reasons behind such a pattern of results remain unclear.

Articles were also coded for the presence of comments made by the researcher(s) who conducted the study. A one-way ANOVA yielded no significant difference in the number of comments from the researchers contained in the article, with a mean of roughly four comments per article for each of the three time frames analysed. Percentage agreement for this measure was 78.4 per cent.

In addition to comments by the researchers, it has been asserted that one of the ways science writers can exercise 'clinical judgment' in the stories they cover is to include comments from other scientists who are unconnected to the reported research.[60] Thus, any complete and comprehensive journalistic account of science should also contain comments from other scientists who support the research findings, as well as from those who are critical of the findings. Such unfavourable comments might be especially important, since they can often act as disclaimers and thus may serve to qualify the findings. In light of this then, articles were coded for the presence of both favourable and unfavourable comments from other scientists, in regard to the research. A one-way ANOVA revealed no significant difference between the number of favourable comments from other scientists included in articles from the three time periods. However, in terms of including comments from scientists critical of the research being discussed, there was a significant difference between the time frames, with an increase in the number of comments included in the later time periods. Thus, in terms of including what might often be important 'qualifying' comments, coverage has improved over the three decades. Percentage agreement for these two measures was 66.7 per cent and 85.71 per cent respectively.

One important characteristic of scholarly science writing is that research results are reported in terms of whether they are in accordance with, or deviate from, previous findings. In addition, suggestions for future research endeavours are often proposed, based on the obtained results. One consequence of such an approach is that scientific inquiry is acknowledged to be an ongoing process where results are continually scrutinized and validated, rather than one where isolated findings immediately become 'facts.' Because it has been asserted that the tendency in the media to treat tentative findings as 'breakthroughs' results in sensationalized accounts of new developments, the inclusion of such contextual information becomes a critical feature of science news articles.

Among the articles in the three time periods, there was no significant difference in the tendency to include such contextual information (Scott's pi = 0.80). As can be seen in Table 3, less than 60 per cent of the articles analysed in each of the three time frames had any mention of prior and/or future research studies. Additionally, there was no significant difference among the articles in terms of including comments regarding the limitations or generalizability of the research findings. That is, in all three time periods, less than 50 per cent of the articles analysed contained any statements that express any limitations to the research being reported and the generalizability of the results to the public. Scott's pi for this measure was also 0.80. The importance of such information cannot be underestimated, as it is the omission of this kind of information that may lead to the misemphasis and sensationalism in science stories so often complained of, as well as to a misunderstanding of any implications the results may have for the general public.[65] However, these results suggest that this important feature of science stories has failed to become more prominent during the last three decades, at least in the three newspapers analysed.

Research Question 3: the presence of methodological descriptions

A one-way ANOVA was performed to determine if differences exist in the adequacy of methodological descriptions, as a function of the number of words employed, appearing in science news articles. Results indicate that there was no significant difference among the articles in the three time periods in the number of words utilized in such methodological descriptions (see Table 4). It is interesting to note that only the mean from the earliest time period analysed meets the 30-word operationalization employed as criterion for an 'adequate' description.[52] The means from the two later periods fell well below this standard. Percentage agreement for the number of words in the methodological descriptions was 96.9 per cent. It is important to note, however, that this percentage agreement was calculated for the overall subsample. However, if each article is examined separately, percentage agreement for this measure is considerably lower on average, at only 45 per cent. It appears that it is difficult for coders, despite training, to identify what exactly constitutes a methodological description of research design. This raises the question of whether such descriptions would be recognized by the average reader who has received no such training.

Table 4. Methodological description measures. Significance tests were determined at the 0.05 level (ns = not significant).

Measure	1966–1970	1976–1980	1986–1990	Significance test results
Mean words in description of method	30.50	19.09	22.25	$F[2, 104] = 0.86$, ns
Percent articles having 'adequate' description (i.e. > 30 words)	38.89	33.33	25.00	$\chi^2[2, N = 107] = 2.00$, ns
Percent articles using method non-specific terms to describe research	50.00	72.73	76.79	$\chi^2[4, N = 107] = 7.63$, ns
Percent articles using method specific terms to describe research	38.89	15.15	12.50	

Furthermore, there was no significant difference among articles in the three time periods in terms of including such 'adequate' research descriptions. Once again, in all three time periods less than 50 per cent of the articles analysed contained descriptions of 30 or more words, thus indicating that when descriptions of the method utilized in the study were included, they tended to be brief.

Methodological descriptions were also coded to see if method specific terms (i.e., experiment, survey, etc.) or method non-specific terms (i.e., study, research, report, etc.) were used to characterize the research endeavour. As can be seen in Table 4, there was no significant difference among the articles from the three time periods in their utilization of such terms. That is, the majority of articles in all three time frames characterized research designs primarily using method non-specific terms instead of method specific terms. Scott's pi for this measure was 0.85.

Discussion

Overall, the results show that, at least in the three major daily newspapers analysed, newspaper coverage of science over the last three decades does not differ substantially in terms of the range of topics covered, as well as information that has been both included and omitted from science news accounts. Although science articles represent only a small percentage of the total number of articles in the newspaper, this percentage has steadily

increased with each time period. This increased coverage by newspapers might be in response to, as well as reflect, the public's growing interest in science.[66] In terms of the diversity of coverage, however, there was little difference in the range of topics covered in each of the three periods. Rather, the range of topics covered was very similar in each of the time frames studied, with a large percentage (i.e., 72–75 per cent) of the articles covering medicine and health-related issues. Natural and physical science accounted for 17–25 per cent of articles in each of the time frames. Technology was clearly the least covered category in all three time periods.

In terms of the comprehensiveness of science articles appearing in the three newspapers analysed, it appears that, in general, coverage has not become more rigorous with the passage of time. While a number of variables were coded for in this study, it seems especially significant that two features recognized as crucial to any complete journalistic account of science, that is contextual factors and methodological details, are still frequently omitted.

The fact that there is no significant difference between articles in the three time periods in terms of the inclusion of these two types of vital information can be viewed as problematic. Indeed, Burnham has argued that the mass media tends towards a 'bits-and-pieces' approach to popularizing science, presenting uncontextualized facts and paying little attention to the process of scientific research.[67] This apparently has not changed significantly over the three time periods analysed, as these results suggest that newspapers still tend to report primarily on the findings of scientific research without mention of relevant contextual factors. This may be a cause for concern considering that it has been asserted that a 'contextual approach to science communication has never seemed more important for developing public support for and intelligent use of science.'[68]

It is also noteworthy that in over three decades of coverage, at least in the three newspapers analysed, there has been little change in the inclusion of methodological details. This seems especially significant when one considers that a survey of scientists conducted over twenty years ago listed the omission of information about the research method as the most serious problem with newspaper accounts of science.[21] Based on the results of this study, this problem has not been remedied.

According to Evans, Krippendorf, Yoon, Posluszny and Thomas, the image of science presented in the press is one of a 'disembodied enterprise,' with accounts containing very little discussion of research procedures, reported findings rarely linked to earlier findings, and limitations of those findings rarely noted.[57] This study suggests that this has been the case during the last three decades of science news reporting. While there has been a movement among newspapers to include science and health-related information as part of regular news coverage, it may be considered surprising to see so little change in the way science has been and continues to be reported, especially considering the growth in science journalism from a historical perspective. That is, with the appearance of weekly science sections as well as specialized science reporters, it seems logical to expect a concomitant change in the comprehensiveness of these journalistic accounts. However, as Nelkin asserts, and as these findings demonstrate, 'the style of reporting has been remarkably consistent over time.'[69]

If one considers the differences that exist in both the goals and the methods of journalists and scientists, however, then perhaps these findings are not entirely surprising. That is, if one considers the purpose of a science news article, especially from a rhetorical perspective, both the function and importance of various article features become clearer, and thus may help to explain both the inclusion and the omission of specific content in journalistic accounts of science.

One potentially useful framework is offered by Fahnestock, who examines the changes that occur as scientific observations are 'accommodated' or popularized from a scientific journal article intended for scientists to a news article written for a lay audience.[70] Comparing the rhetoric of articles that appear in journals such as *Science* and the *New England Journal of Medicine*, with that of related stories appearing in such popular US magazines as *Newsweek*, Fahnestock notes that as scientific observations become popularized, a shift in genre occurs between the original presentation of a scientist(s)' work and its popularization. That is, while a scientific paper has primarily a forensic purpose and is concerned with establishing the validity of the reported observations, 'scientific accommodations are overwhelmingly epideictic; their main purpose is to celebrate rather than to validate' a particular scientific finding.[71] This shift in genre is necessary, because it enables a non-expert audience to recognize the significance of the information being conveyed.

To make these epideictic arguments, science accommodators, including journalists, emphasize the uniqueness of individual observations and events, in an effort not only to gain the interest of the audience, but also to convince their editors about the newsworthiness of science and technology. Rowan echoes this view in her discussion of the differences between professional and popular science writing.[72] That is, in their effort to represent reality and inform their audience (a goal shared with professional scientists and their texts), popular science writers concern themselves most with the sub-goal of establishing the novelty, and thus the relevance, of their topic. In order to convey this newsworthiness, textual features such as caveats, statements of limitations and qualifications, long recognized as an important feature of scientific papers, will often be omitted from popularized accounts. That is, 'the public will be interested in these subjects only if they are significant and there is simply no way to address the public with the significance of findings that are so carefully hedged that their reality seems questionable.'[73] This difference in purpose may also help to explain the absence of statements that put a study and its particular findings into the context of a broader, ongoing, programme of research. That is, it is perhaps easier to convey the newsworthiness or uniqueness of a particular finding if it is cast as a breakthrough or isolated event, rather than if it is contextualized as part of a larger body of research.

When one considers the difference in purpose, as well as in audience, between a scientific report and a journalistic account of science, then perhaps the standards of comprehensiveness held up to now for journalistic accounts of science are indeed difficult for the science reporter to achieve. For this reason, it is important to acknowledge that this paper presents only one way to operationalize the construct of comprehensiveness of science news coverage, and this operationalization presents certain limitations to this study and its findings. That is, the textual variables coded for in this study conceptualize the construct of 'comprehensiveness' of coverage in terms of how the scientist might characterize comprehensiveness. Furthermore, it relies 'on accepted norms of journalistic practice that coverage should be accurate and complete as prescriptive standards for science news against which actual content is assessed... standards which are especially problematic for science journalism... .'[74] Thus, while scientists consider such features as methodological descriptions and statements of limitations as critical for a complete journalistic account of scientific research, what the journalist, editor or even the reader considers a comprehensive account might very well differ from the standards applied in this study, emphasizing the presence of different features from those coded for here. Therefore, it is important to acknowledge that this study investigates only one of many possible 'alterative or variable representations of science.'[75] Future research may wish to investigate trends in the comprehensiveness of science coverage from these other perspectives, to see if there

have been any changes through time.

It is also important to acknowledge that this study examines only science news as it applies to news of research in medicine, technology and the physical sciences, and perhaps thus presents a somewhat narrow view of science news. Though this approach is typical of many content analytic studies of science news, it 'overlooks other areas of media coverage that could be relevant when developing a comprehensive and integrated model of mass-mediated science.'[76] For example, this study did not include journalistic accounts of research in social science (outside of psychology), even though news of such research is becoming more routine in daily newspapers.[77] In addition, news stories of unorthodox or pseudoscience were not analysed even though such stories have the potential to be 'a rich source of public discourse about science.'[76] Because there is no question that science is recognized by the public as a legitimate way of knowing, the diversity that exists in science coverage is directly pertinent to 'understanding public conceptions of human inquiry.'[76] The fact that this analysis does not necessarily reflect that diversity may perhaps limit what we can learn about such coverage, as well as its implications for public understanding of science, from this study.

Obviously it is hard to generalize about trends in all newspaper coverage of science based on this limited sample of articles from only three newspapers. And while admittedly it is difficult to assert with certainty that the trends uncovered in this study can be generalized to coverage in all newspapers, the results do suggest that while there has been an increase in the amount of science coverage, there has not been a concomitant change in the completeness and comprehensiveness of this coverage, at least in terms of how it is operationalized in this study, during the three decades analysed. Indeed, one might assume that if these three 'prestige' newspapers, ones with weekly science sections and/or specialized science writers, do not exhibit an improvement in the comprehensiveness of science coverage then smaller newspapers would also tend to display this trend. Still, it would be interesting to investigate if additional analysis on an expanded sample of both prestige and smaller newspapers, and the articles therein, uncover the same results as this study. In addition, the sampling frame employed ended with the period 1986–1990, and thus the results may not be generalizable to current science news coverage. Studies on science news articles from the 1990s would provide more insight into current science news practices.

Finally, research into the effects of specific article features on readers may have important implications for journalistic coverage of science. That is, while many studies stress the importance of including such pertinent information as discussions of methodology and qualifying statements, few have looked at how the inclusion of such components affect individuals' understanding of the information and issues involved, as well as their perceptions of the scientific process. Research into science news may need not only to analyse the content of these journalistic accounts, but also to look at the potential effects of these features on readers in order to uncover what makes a truly accurate, complete and effective science news story.

Conclusion

News coverage of science has become increasingly important, as it can influence both the public's knowledge and attitudes towards science. There is no question that science continues to make local and national headlines, with newspapers carrying reports on the latest developments in medical research, to news on the environment, to the latest in computer technology. While the public has shown a growing interest in science and science policy,[66] many individuals lack a functional knowledge of these issues. Indeed Miller

asserts that any measures that can be taken to raise the level of scientific literacy and to foster informed and intelligent participation in science policy issues will improve the quality not only of our science and technology, but also of our political life.[2] It is here, then, that the press could play an important role. That is, according to Nelkin:

> For most people, the reality of science is what they read in the press. They understand science less through direct experience or past education than through the filter of journalistic language and imagery. The media are their only contact with what is going on in rapidly changing scientific and technical fields, as well as a major source of information about the implications of these changes for their lives. Good reporting can enhance the public's ability to evaluate science policy issues and the individual's ability to make rational personal choices; poor reporting can mislead and disempower a public that is increasingly affected by science and technology and by decisions determined by technical expertise.[78]

However, it has been asserted that the tendency to deliver scientific research as 'important snippets of news,'[79] omitting many important details in these accounts, results in both a trivialization and misunderstanding of specific research results, as well as of science in general. While it remains to be seen if this is actually the case, it appears that, at least over the last three decades in these three major daily newspapers, science news reporting has not taken the necessary steps to improve the comprehensiveness of these accounts.

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