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ABSTRACT

A study tested the data-ink ratio theory, which holds that a reader's recall of quantitative data displayed in a graph containing a substantial amount of non-data-ink will be significantly less than recall from a graph containing little non-data-ink, as it might apply to graphics used in mass circulation newspapers. The experiment employed a between subjects, posttest only control group design. The stimuli were ten simple, horizontal bar graphs taken from the "Snapshot" section of "USA Today." All had familiar labels and no value was more than three digits long. The control stimuli were created to serve the role of identical graphs with much of the non-data-ink erased. The 120 observers were students in two sophomore level classes taught at the School of Journalism at Indiana University. The questions, which were constructed to measure the observer's accuracy in making comparisons between the data groups and accuracy in recalling the exact numbers associated with each data group, probed information such as number of bars displayed in the graph, labels associated with certain graphs, numerical value given to graphs, and relative length of bars in graphs. Observers were given 15 seconds to examine the data contained in the graphs. Statistical analysis of results showed that control groups and treatment groups made a nearly identical number of errors. Further examination of the results indicated that no single graph produced a significant difference between the control and treatment conditions. (One table of data is included and 10 pairs of graphs and 21 notes are attached.) (ARH)

The Data-Ink Ratio and Accuracy of Information Derived From Newspaper Graphs: An Experimental Test of the Theory

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The Data-Ink Ratio and Accuracy of Information Derived From Newspaper Graphs: An Experimental Test of the Theory

Even the casual reader cannot have failed to notice the increasing use of statistical graphs and charts for the display of quantitative data in U.S. newspapers during the last dozen years or so. Increasing attention to design and layout has contributed to the greater use of graphs and charts, not only to break up the "gray," but also to concisely display a large amount of data in a form that both attracts reader attention and more clearly reveals trends and patterns. With the recent availability of personal computers offering graphical packages that in large measure eliminate the need for skilled artists, charts and graphs of increasingly sophisticated dimensions are at the disposal of nearly every daily newspaper.

Although such graphs and charts undoubtedly can improve the communication of information, mass communication researchers have criticized newspaper's use of graphs as unsophisticated and, all too often, misleading. They produce examples from newspapers that support their criticisms and call for an increased awareness of the abilities and limitations of such statistical renderings.[1] But few offer empirical evidence to support their contentions.

This is not to say, however, that graphs have not been the subject of inquiry by scholars in other fields. Empirical studies of graphs have been conducted frequently since the 1920s, but the research has been done primarily by psychologists and statisticians. They have rarely examined the specific types of graphs used in the mass media or considered the purposes to which the mass media assign them. While their findings provide valued insight into the perceptual limitations of newspaper readers and clues to some of the basic functions of graphic conventions, broad theoretical positions are rarely made and so they offer little practical help to graphic designers who need solid support for their editorial decisions concerning charts and graphs in newspapers. Theories of graphic representation have been proposed by scholars using semiotic analysis techniques, however, and these seem much more relevant to the more immediate questions concerning the use of charts and graphs in newspapers.

This paper discusses an experiment designed to empirically test a semiotic theory of the efficiency of graphs at displaying information. Specifically, it tests the data-ink ratio theory, developed by Edward R. Tufte, using statistical graphs appearing in a mass circulation newspaper. Although this experiment examines only a small part of the overall, semiotic based graphic theory, it will hopefully create further interest among mass communication scholars in the testing and application of these theories and thereby contribute to our understanding of the mass media.

Review of the Literature

Kolata, in a Science magazine article on data display stated that there is currently a "revolution in graphic methods" being carried out by statisticians who are developing a variety of new ways of analyzing and presenting data.[2] The roots of this current "revolution" are sunk deep into the past, however. As Shakespeare noted (Henry VI, Act IV), "Our forefathers had not book but the score and tally."[3] Both the score and the tally represented an advance to the concept of abstract number from the more literally iconic predecessors. In 1637 Descartes' Cartesian coordinate system marked a major milestone in the progress of graphical representation of data. The system dominated notions about what graphs were and what they were for — the depiction of the mathematical functions governing the behavior of objects in space and time — and it took more than 150 years before anyone realized that graphs could be used for anything else.[4]

Such a breakthrough did come about in 1786 with the publication of William Playfair's The Commercial and Political Atlas, in which spatial dimensions were used to represent nonspatial, quantitative, empirical data. Though it now seems natural to represent the rising and falling of import levels over time as a rising and falling line, it does not seem to have been done before that time, and so Playfair's first graphs are a rather astonishing accomplishment. His graphics were successful because they took advantage of the capabilities of human perceptual, memory and conceptual abilities.[5]

Kosslyn suggests that the results of psychological experimentation can provide a guide in the design and use of statistical graphics through an increased understanding of the psychological underpinnings upon which our perception of graphic material rests. He notes that this research tends to be highly focused on particular cognitive issues and is therefore too narrow for use in general evaluations of graph design, but argues that the findings support a basic theory of visual processing priorities and limitations that must be considered if one is to improve the informational properties of statistical graphs and charts.[6]

The contemporary "canonical theory" of human information processing divides cognitive processing into three different phases, each with its own capacity limitations. If these limitations are exceeded, information processing can be disrupted.[7] In the first phase or memory store, the light reflected from the graph strikes the retina of the eye and is converted into a pattern of impulses to the brain where they are processed to detect patterns of line, shapes, colors and textures. This processing is "pre-semantic" and leads only to a visual sketch. Physical variations in lines and marks are not always registered accurately and perceptions are sometimes systematically distorted. The capacity of this store appears to be unlimited, but the information is stored there only a second or so at most.

These visual sketches or "perceptual units" must be stored in the short term memory for further processing to take place. The "Gestalt psychology school" in the 1920s discovered a number of laws that describe how marks are organized into forms in the short term memory, and these must be respected if different parts of the graph are to work together.[8] With rehearsal, the perceptual units can be kept in the short-term memory store for a seemingly indefinite time. The capacity of the store, however, is severely restricted to approximately seven "chunks" of information.[9] This limited capacity has considerable importance for graphs that require the reader to remember line patterns or colors and the referent they are associated in chloropleths or "patch maps," as well as other graph forms.

Ultimately, the input must access relevant information stored in the long term memory, a store virtually unlimited in capacity and duration, which constitutes one's "world knowledge," including how charts and graphs convey information. Comprehension of the information and proper storage of that information in the long term memory network depends upon accessing the relevant stored information. Incorrect inferences drawn from the stored information about the input can result in a graph presenting "lies."[10]

The nature of this information processing system presents a number of cautions that must be considered in designing visual displays. Each memory store places constraints on the processing of information in graphically presented data. To avoid unrealistic demands upon the mind's processing capacity, a theoretical framework which respects the strengths and weaknesses of the system would be invaluable to newspaper graphic designers. Semiotic analysis provides us with such a framework.

Perhaps the most influential thoughts on theories of graphical display were presented by Bertin, who provided the basic constructs of a theory in his 1967 book, Semiologie Graphique, which was translated into English in 1981.[11] In the book, he discusses the limitations imposed by the information processing system and proposes several structures which might lend an empirical scientific grounding for the design of graphs. He develops extensive taxonomies of graphic variables and sets forth several innovative constructs concerning these variables and the possible roles they may fulfill. He provides little of his own empirical evidence to support his theories, however. Rather, most of the experimental investigation into graphs has been taken up by statisticians who have produced several promising findings.

Cleveland and McGill have begun examining "graphical perception," the visual decoding of graphic information by attempting to identify a set of "elementary perceptual tasks" that are carried out when people extract quantitative information from graphs. They conducted a series of experiments to test the identification of several basic graphic tasks and to establish a hierarchical ordering of these tasks according to how accurately people perform them. While accuracy of quantitative extraction is not the only aspect of a graph important to an overarching theory, it is a fundamental one.[12]

Tufte, working alone lines of inquiry similar to Bertin's, proposed a number of ideas about how graphs function. Of particular interest to this paper are his thoughts on the limited capacity of short term memory and the necessity, therefore, of considering processing priorities. If a display is to be understood, it should not require the reader to hold more than the capacity limit of the store in mind at once. This leads Tufte to conclude that graphs should "draw the viewer's attention to the sense and substance of the data, not to something else."[13] From this, he proposes a theory of "data-ink ratio."

The data-ink ratio theory holds that a large share of the ink on a graphic should present "data-information." "Data-ink is the non-erasable core of a graphic, the non-redundant ink arranged in response to variation in the numbers represented," he states.[14] The formulaic expression of the data-ink ratio then is:

$$\text{Data-ink ratio} = \frac{\text{data-ink}}{\text{total ink used to print the graphic}}$$

= proportion of a graphic's ink devoted to the non-redundant display of data-information

= 1.0 - proportion of a graphic that can be erased without lose of data-information.[15]

Tufte presents several intuitively attractive examples of how maximizing the data-ink ratio improves comprehension of the data, but cites no empirical evidence of support for the theory. While it seems to make sense that decreasing distractions would increase the cognitive processing of the data, the data-ink ratio theory has yet to be put to an experimental test.

Purpose

This paper proposes to experimentally test the data-ink ratio theory as it might apply to graphics used in mass circulation newspapers. Though the experimental test conducted here cannot directly address the overall construct of the basic theory, it is hoped that this test of the theory may provide a beginning for the empirical support of the data-ink theory as it applies to newspapers.

Very little quantitative research has been published by mass communication researchers on the use of graphs in newspapers. A search of the major journals and abstracts found only one dissertation on the subject. In 1963, Parker wrote a Ph.D. on the comprehension of trend information displayed in various types of graphs typically found in newspapers. The research was primarily a contribution to the discussion of superiority of bar and line graphs over pie and other volume type graphs, but is directly related to the hierarchical ordering being attempted by Cleveland and McGill. The research did not, however, attempt a test of theory directly.

This is not to say that there have not been several informative papers on graphic display directed at mass media designers. Wainer has written an excellent book chapter directed specifically at newspapers that notes several common pitfalls and makes a number of suggestions, often based on psychological findings, that would both improve the communicative ability and decrease the distortions in many mass media graph forms. But again, very few of his suggestions rest on empirical tests employing actual newspaper material.[16]

This paper proposes to test the data-ink ratio theory using graphs taken from a mass circulation newspaper to see whether such a theory has relevance to mass media designers. The hypothesis underlying the test is:

> A reader's accuracy of recall of quantitative data displayed in a newspaper graph containing a substantial amount of non-data-ink will be significantly less than will be the accuracy of recall from the same graph containing the same quantitative information with most of the non-data-ink erased.

Increasingly, newspapers are using a considerable amount of non-data ink within the framework of graphs, ostensibly to attract reader attention. Often this ink is in the form of drawings in the background, background color screens, figures that replace simple bars or other items that may attract reader attention. While this research does not address itself to the ability of non-data-ink to attract attention to a graph, it does attempt to determine whether the use of such attention-getting devises decreases the reader's ability to accurately process the information presented in the graph. Should the hypothesis be supported, designers of graphs might very well pause to consider whether the non-data-ink used to attract attention is worth the cost of decreased reader accuracy.

Method

The experiment employed a between subjects, posttest only control group design. The stimuli were ten simple, horizontal bar graphs taken from the "Snapshot" section of USA Today.[17] The section appears in every issue at the bottom left-hand corner of each section front. These graphs tend to be very high in non-data-ink, often including drawings in the background and/or figures rather than conventional bars as the indicators of amounts. Ten different graphs were used to minimize any improvement in performance due to the specific information in the graph that might be especially salient to a subject and to minimize any influence the specific configuration a graph form might have.

The graphs were reproduced in black and white so as not to introduce the unwanted variable of color. The reproductions were made at a 29 percent increase in size to decrease any possible illegibility due to small letter size that may have appeared in the original size. The subject matter of these graphs were all of a light feature nature. None of them contained any reference to emotion-laden topics such as crime, disasters, death or any subject that might evoke a strong emotional response. The graphs contained from five bars to ten bars. All had familiar labels and no value was more than three digits long.[18] These ten graphs formed the experimental treatment stimuli.

The control stimuli were created to serve the role of identical graphs with much of the non-data-ink erased. No physical method of erasing the non-data-ink from the original graphs could be determined, so the graphs were reconstructed using newly set type and layout. Every effort was made to reproduce the data and supporting text as identically as possible with available equipment. Three of the original graphs used figures to closely approximate simple bars and so conventional bars were substituted for these figures in the control stimuli. All lines of text, whether headlines within the graph, caption material, labels or source lines were typeset to identical length and type size. There was, however, some slight difference in the letter formations themselves due to the fact that the USA Today type face is exclusive to that publication. The researcher determined that the type face available to him was of close enough resemblance that it would not dramatically affect the outcome of the experiment.[19] With the minor exceptions of the type face difference and the use of bars instead of figures, the control stimuli are identical to the treatment stimuli both in size, text clarity and data content, except for the erasure of the non-data-ink formed by background screens and various drawings.

The ten treatment forms and the ten control forms (all measuring 4 1/2" by 3 1/4") were pasted onto the optical center of an 8 1/2" by 11" piece of white typing paper in the vertical orientation. This yielded 20 different stimuli forms. Each of these forms was then photocopied enough times that each observer ould examine one graph during the administration of the stimuli in the experimental situation. A #10 envelope was stapled to the back of each graph which contained a 5 1/2" by 7" sheet of paper with the test questions printed on it.

Observers. The 120 observers were students in two sophomore level classes taught at the School of Journalism at University in the Spring semester of 1987. One class consisted of 94 students, primarily journalism majors, taking an introductory course in photojournalism. The other class consisted of 26 students, exclusively non-journalism majors, taking an introductory course in mass communications. No students were enrolled in both classes.

Procedure. Two pretests of the stimuli and procedure were conducted to determine the proper exposure time and adequacy of the posttest

ns. Each pretest was conducted using 20 observers in c.sses that

the journalism class as a prerequisite, hence, no observer in the

was tested again in the final experimental application. The first pretest used a 30-second exposure time to the stimuli and resulted in a ceiling effect in which no difference was demonstrated between errors on the control and treatment conditions. Additionally, one of the posttest questions was found to be confusing.

The second pretest employed a 15-second exposure time and reworded questions. The 15-second exposure time to the stimuli resulted in a measurable difference in number of incorrect responses between the two groups. It is reasoned that 30 seconds, which seemed to be the amount of time people took to read one of the graphs when told that they would be asked questions about it, is longer than most readers actually spend with a similar graph in a newspaper-reading context. The 15 second period seemed more reasonable as an approximation of the time "normally" spent reading such a graph in a newspaper, however, no empirical evidence could be found to support this notion. The second pretest also indicated that the rewording of the problematic question was successful.

The questions were constructed to measure the observer's accuracy in making comparisons between the data groups and accuracy in rec .ling the exact numbers associated with each data group. The same type of information was asked for from each observer, though the wording of each question was specific to that particular graph to decrease any ambiguity due to more abstract question formulations.[20] In the abstract form, the questions were:

1. How many bars were displayed in the graph?
2. What was the label associated with the longest bar in the graph?
3. What numerical value was given to that longest bar?
4. What was the label associated with the shortest bar in the graph?
5. What numerical value was given to that shortest bar?
6. Was the longest bar twice as long or longer than the shortest bar?

The first question was scored correct only if the count was exact. The numerical value questions were scored correct if the answer was within

10 percent of the correct value. The final comparison question was to be answered yes or no and was scored correct only if the correct answer was circled.

At the beginning of each class, instructions were read to the observers from a prepared script. Observers were informed that they were taking part in experimental research, that they would not be identified in the final report and that they would not experience any physical discomfort. The stimuli were then placed face-down on the desks in front of them according to a random distribution. The observers were told not to look at the printed side until a signal was given. Further instructions informed then that the paper in front of them had a graph printed on it like they might expect to find in a typical daily newspaper. At the signal they were to turn the paper over, examine the graph as they would had it actually been in a newspaper and then, at the second signal, turn the paper face down again. After the papers had been turned over, the observers were asked to remove the paper from the envelope, answer the questions as accurately and completely as possible, and then return the sheet to the envelope. Observers were not limited in the time needed to answer. Monitors, three in each class, then collected the stimuli.

Results Each of the 120 answer sheets were scored as to accuracy of response. A difference of means test (t-test) was made to determine whether there was a significant difference in the number of errors made by the control group and the treatment group.

A comparison between all the control forms and all the treatment forms shows that the number of errors made by both groups was nearly identical. The control group made a total of 157 errors (43 percent) and the treatment group made 168 errors (46.6 percent). The test produced a t value of -.74, and an associated probability of p .46, which is not significant at any reasonable level. Therefore the null hypothesis could not be rejected. (see Table 1.)

Further examination of the results indicates that no single graph produced significant difference between the control and treatment conditions at the p .001 level. While there was one graph that did show a significant difference at the p .005 level, it must be viewed as an aberration rather than a supportive finding. (see Table 1.)

Table 1 about here

An additional test was conducted to examine whether any single test question showed a significant difference between control and treatment, but again, all tests were non-significant.

Discussion

In the experiment, the observers were given 15 seconds to examine the data contained in the graphs. Any shorter period would seem an unrealistic amount of time to simulate actual newspaper-reading behavior. Judging by the pretest, a longer period of time probably would not have shown a difference in the percentage of errors between the two graph conditions, although it may have decreased the error rate.

The researcher cannot discount the possibility that the 15-second observation period was long enough to mask any difference in recall accuracy, but it may be that the experimental design suffered instead from a testing effect wherein the advance knowledge that the stimuli were graphs forewarned the observers and increased their attention to detail.

While these data do not permit the researcher to conclude that the ratio of data-ink to non-data-ink has no effect on accuracy judgments based on graphically displayed data, it does call the data-ink ratio theory into question somewhat. And though these data cannot establish any type of threshold level at which non-data-ink does influence data recall accuracy, it would seem that current use levels may fall below such a level, if one does exist. Perhaps future research can establish such a level. Certainly Tankard's suggestion that the Mackworth head camera be used to more precisely determine the time a person spends with graphs seems well worth exploring.[21]

General Discussion

Though the results of the experiment conducted for this research failed to support the stated hypothesis, there is no doubt something for newspaper graph designers to consider in the emerging theory of quantitative data display. Many of the building blocks of such a theory have been found by experimentation and theory building in cognitive psychology, and these blocks are now being assembled by other psychologists, statisticians and semioticians. It seems obvious that many, if not most, members of the society come in contact with visually displayed quantitative data, whether in graphs or tables, most often in their daily newspapers. If the job of newspapers is to present information to the reader as accurately and as concisely as possible, then graphs are indeed an excellent means of accomplishing the task. Accuracy is dependent on a smooth flow of information from the printed page to the human memory system. By increasing our understanding of how graphs can run afoul of the system's bottlenecks, we can increase our ability to communicate clearly.

Table 1.

Graph(s)	Number of cases	Mean of errors	t value*	associated probability*
all control	60	2.62	-.74	.46
all treatment	60	2.8		
#1 control	6	2.5	-.90	.38
#1 treatment	6	3.16		
#2 control	6	3.0	.54	.60
#2 treatment	6	2.83		
#3 control	6	3.83	.78	.45
#3 treatment	6	3.17		
#4 control	6	1.5	.24	.82
#4 treatment	6	1.33		
#5 control	6	3.5	-.54	.60
#5 treatment	6	3.67		
#6 control	6	3.17	1.98	.076
#6 treatment	6	1.83		
#7 control	6	3.83	.52	.62
#7 treatment	6	3.33		
#8 control	6	2.17	-.73	.48
#8 treatment	6	2.67		
#9 control	6	1.33	-3.61	.005
#9 treatment	6	3.5		
#10 control	6	1.33	-2.15	.059
#10 treatment	6	2.5		

T value and two-tail probability from pooled variance estimate

NOTES

1 See Howard Wainer, "Making Newspaper Graphics Fit to Print," in Kolers, Peter A. and Mary A. Wrolsted's, Processing of Visible Language, Vol. 2, New York: Plenum, 1980, pp. 125-142 and James W. Tankard, Jr., "Quantitative Graphics in Newspapers," Journalism Quarterly, Vol. 64, 1987, pp. 406-415 for examples.

2 Gina Kolata, "The Proper Display of Data," Science, Vol. 226, 1984, p. 156. pp. 156-157.

3 as quoted in Howard Wainer & David Thissen, "Graphical Data Analysis," Annual Review of Psychology, Vol. 32, 1981, p. 194. pp. 192-241.

4 Ibid.

5 Ibid.

6 Steven M. Kosslyn, "Graphics and Human Information Processing," Journal of the American Statistical Association, Vol. 80, No. 391, September, 1985, pp. 499-512.

7 see David Marr, Vision: A Computational Investigation Into the Human Representation and Processing of Visual Information, San Francisco: W.H. Freeman, 1982.

8 see Lloyd D. Kaufman, Sight and Mind: An Introduction to Visual Perception, New York: Oxford University Press, 1974.

9 see George A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity For Processing Information," Psychology Review, Vol. 63, 1956, pp. 81-97.

10 see Kathryn T. Spoehr and Stephen W. Lehmkuhle, Visual Information Processing, San Francisco: W.H. Freeman, 1982.

11 Jacques Bertin, Semiology of Graphics: Diagrams, Networks, Maps, translated by William J. Berg, Madison: University of Wisconsin Press, 1983.

12 see William S. Cleveland and Robert McGill, "Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods," Journal of the American Statistical Association, Vol. 79, No. 387, 1984, pp. 531-554.

13 Edward R. Tufte, The Visual Display of Quantitative Information, Cheshire, Conn.: Graphics Press, p. 91.

14 Ibid., p. 93.

15 Ibid., p. 93

16 op.cit., Wainer, 1980, pp. 125-142.

17 the horizontal bar graph, which depends upon an assessment of length, was found co be the most accurate of the commonly used graphs in Cleveland's and McGill's tests. op.cit., p. 544-545.

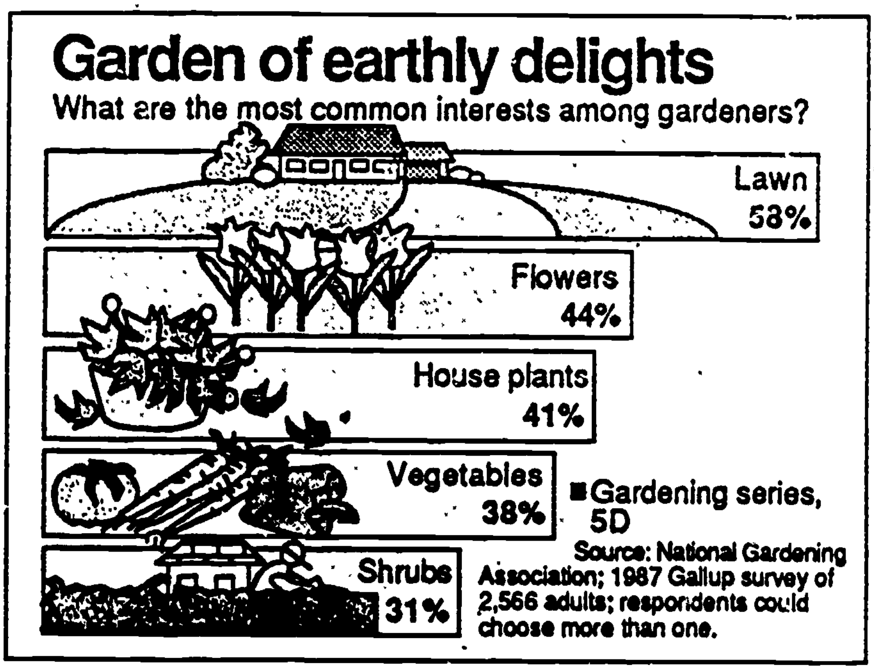
18 see Appendix for reproductions of the stimuli.

19 Please see Appendix to assess the closeness of the [illegible] type faces used.

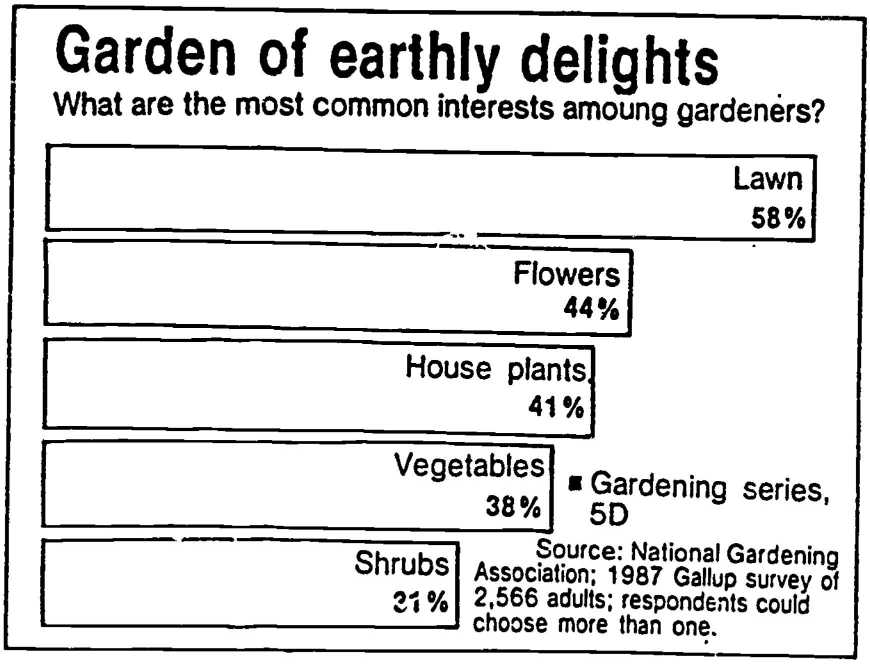
20 see Appendix for the exact question wording for two of the stimuli.

21 op.cit., Tankard, p. 415.

Graph 1 Treatment



Graph 1 Control

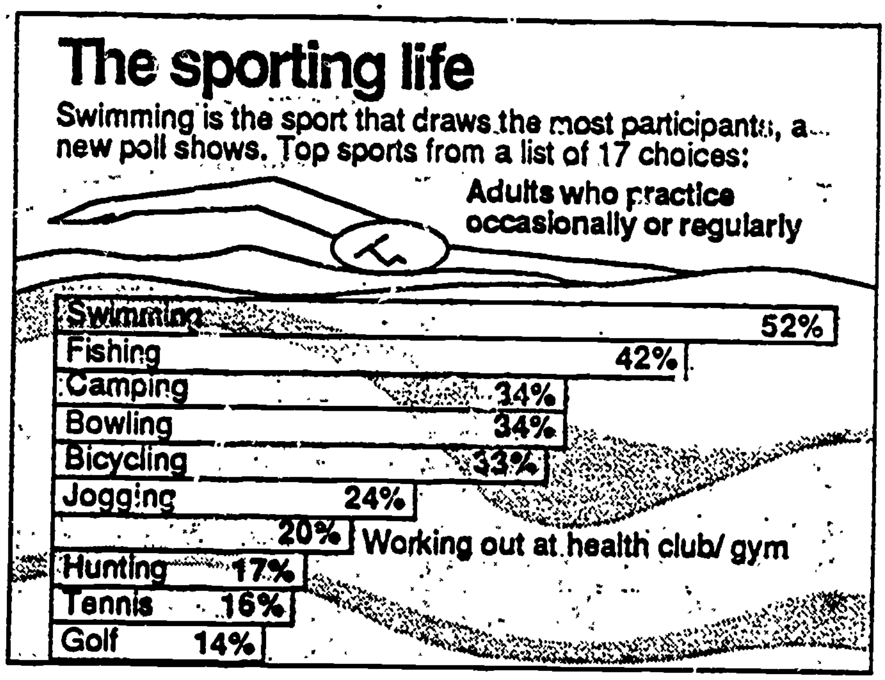


Questions for Graph 1

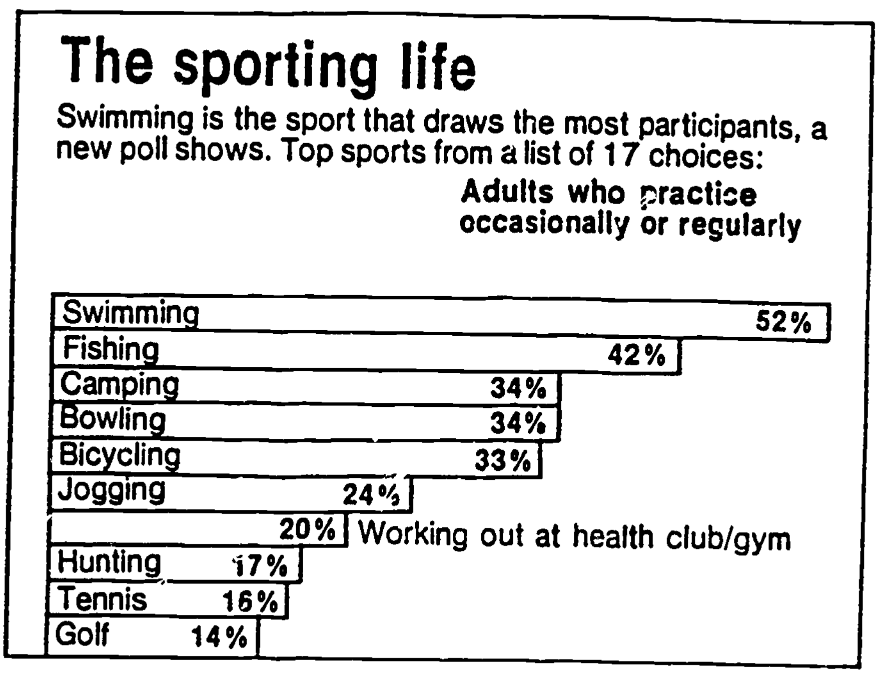
1. How many gardening interests were displayed in the graph?
2. What was the most common interest among gardeners?
3. What was the percentage of that most common interest?
4. What was the least common interest among gardeners in the survey?
5. What was the percentage of that least common interest?
6. Was the most common interest two times larger (or more) than the least common interest?

YES or NO (circle one)

Graph 2 Treatment



Graph 2 Control

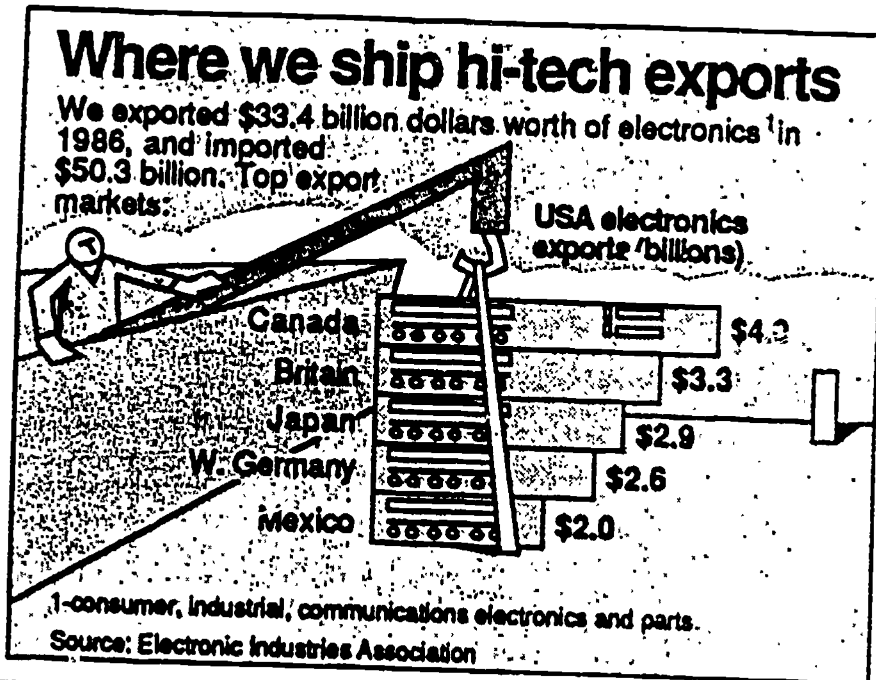


Questions for Graph 2

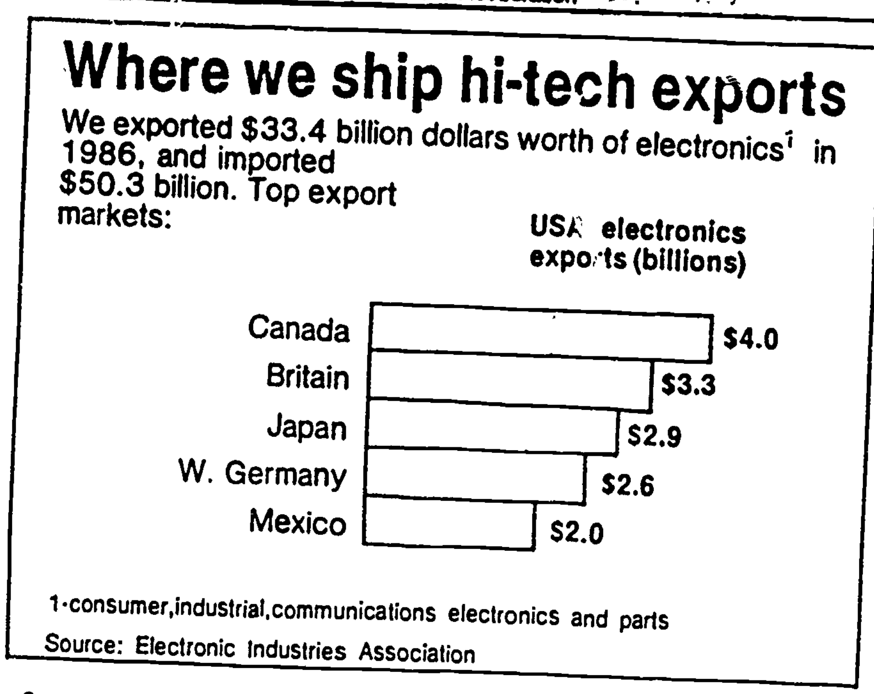
1. How many sports were displayed in the graph?
2. What sport drew the <u>most</u> participants?
3. What percentage named that sport?
4. What sport drew the <u>fewest</u> participants in the survey?
5. What percentage named that sport?
6. Was the <u>most</u> common sport two times larger (or more) than the <u>least</u> common sport?

YES or NO (circle one)

Graph 3 Treatment



Graph 3 Control

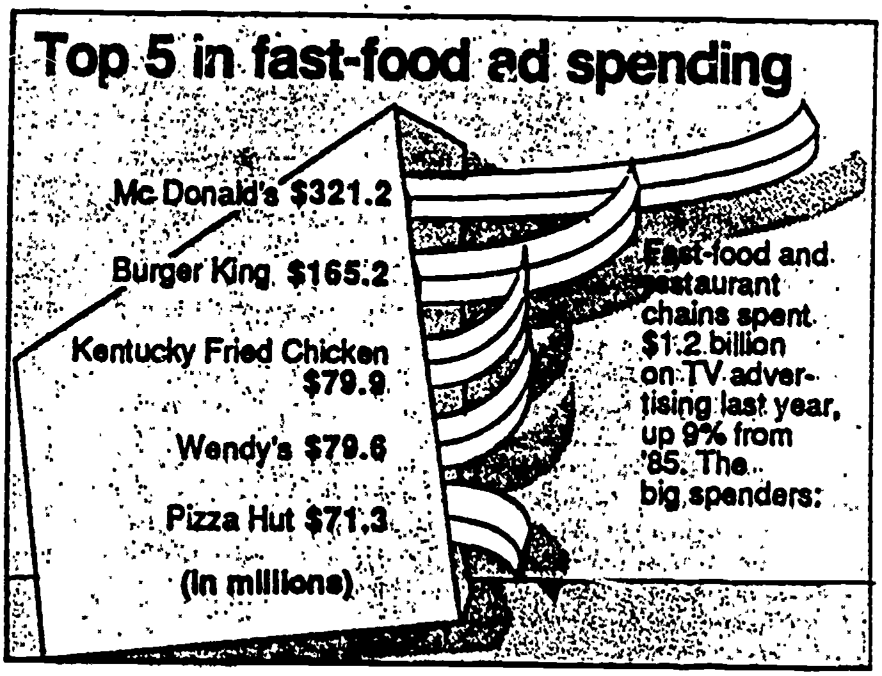


Questions for Graph 3

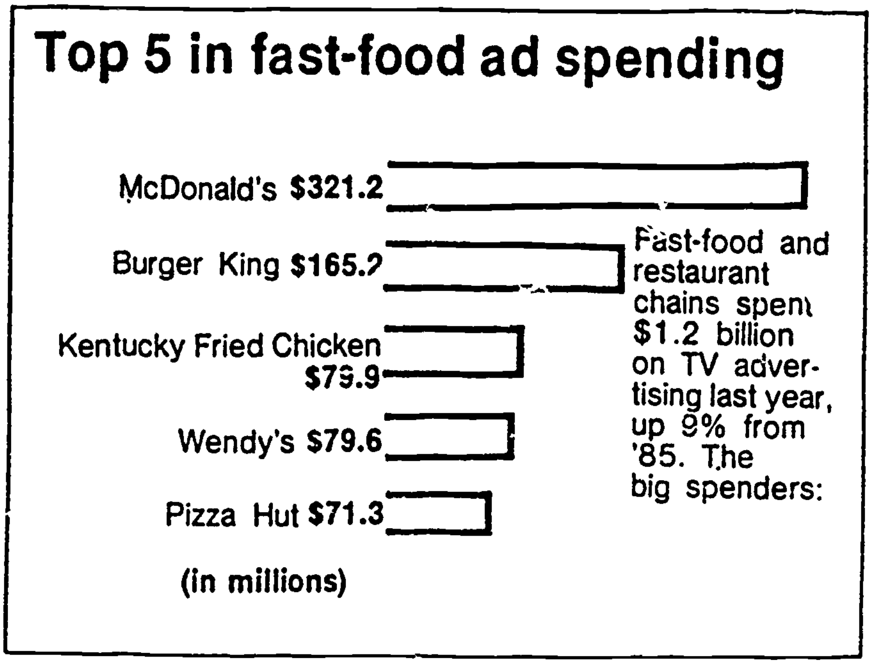
1. How many countries were displayed in the graph?
2. What country received the <u>most</u> U.S. exports?
3. How much did that country receive (in $ billions)?
4. What country received the <u>fewest</u> U.S. exports in the survey?
5. How much did that country receive (in $ billions)?
6. Did the country receiving the <u>most</u> exports get two times more (or greater) than the country receiving the <u>fewest</u>?

YES or NO (circle one)

Graph 4 Treatment



Graph 4 Control

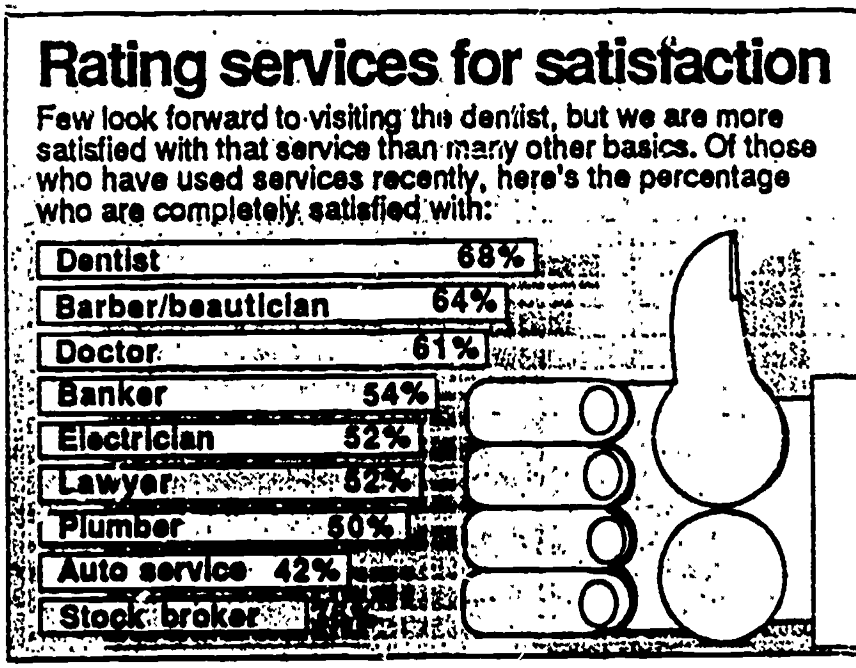


Questions for Graph 4

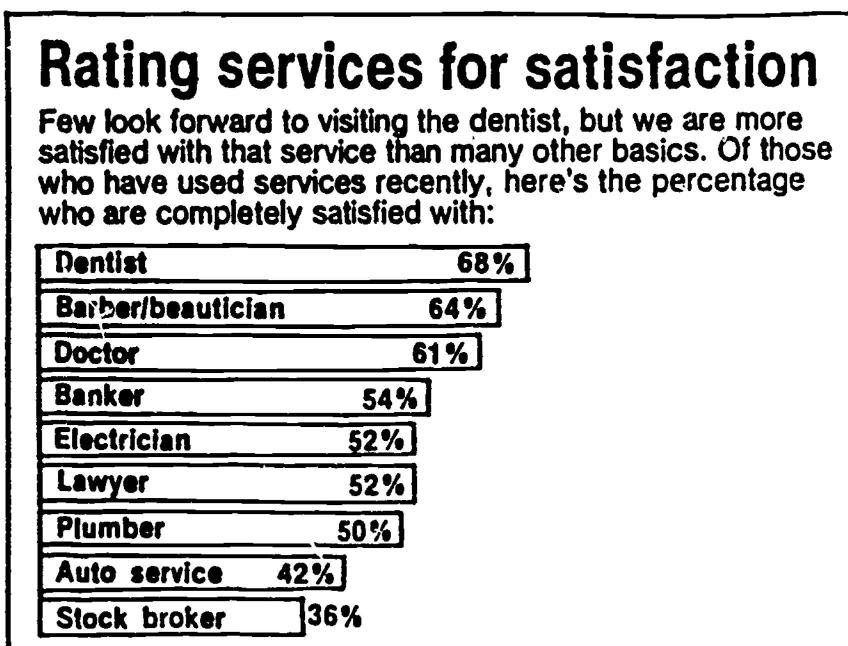
1. How many restaurants were displayed in the graph?
2. What restaurant spent the <u>most</u> on advertising?
3. How much did that restaurant spend?
4. What restaurant spent the <u>least</u> on advertising in the survey?
5. How much did that restaurant spend?
6. Did the restaurant that spent the <u>most</u> spend two times as much (or more) than the one that spent the <u>least</u>?

YES or NO (circle one)

Graph 5 Treatment



Graph 5 Control

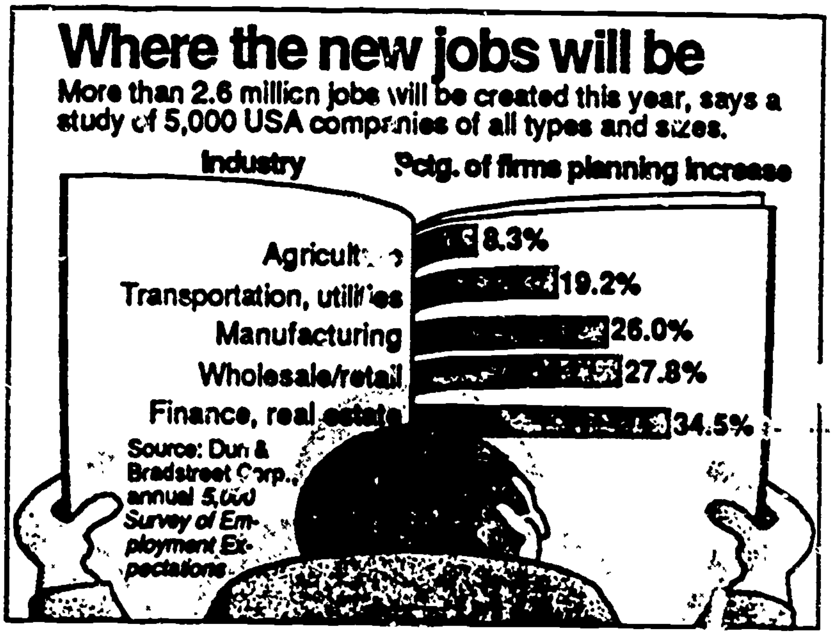


Questions for Graph 5

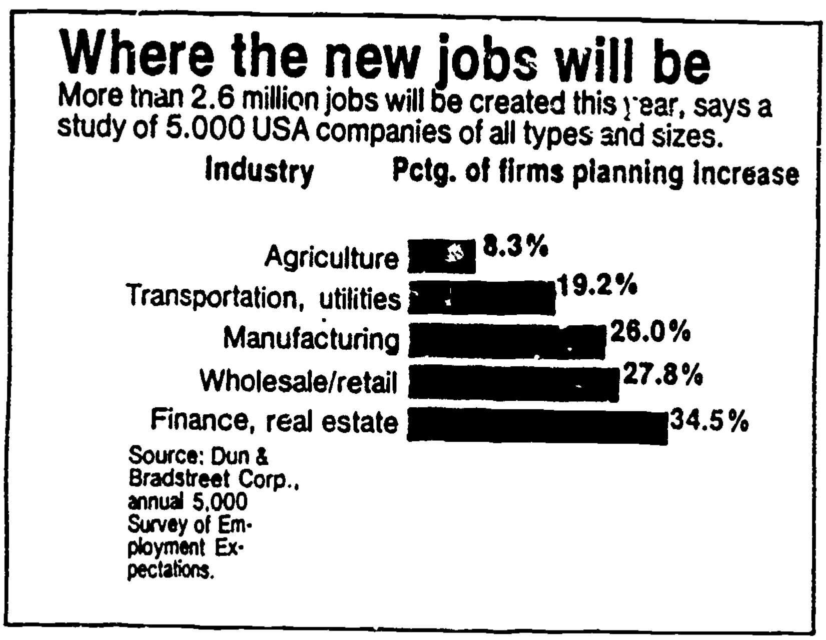
1. How many services were displayed in the graph?
2. What service had the most satisfaction?
3. What percentage named that service?
4. What service had the lowest satisfaction in the survey?
5. What percentage named that service?
6. Was the most satisfying service two times larger (or more) than the least satisfying service?

YES or NO (circle one)

Graph 6 Treatment



Graph 6 Control

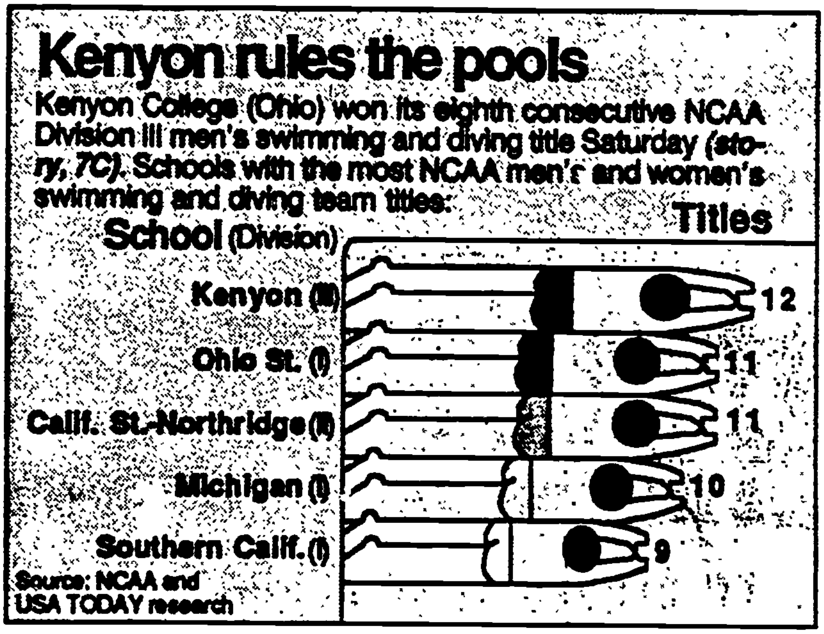


Questions for Graph 6

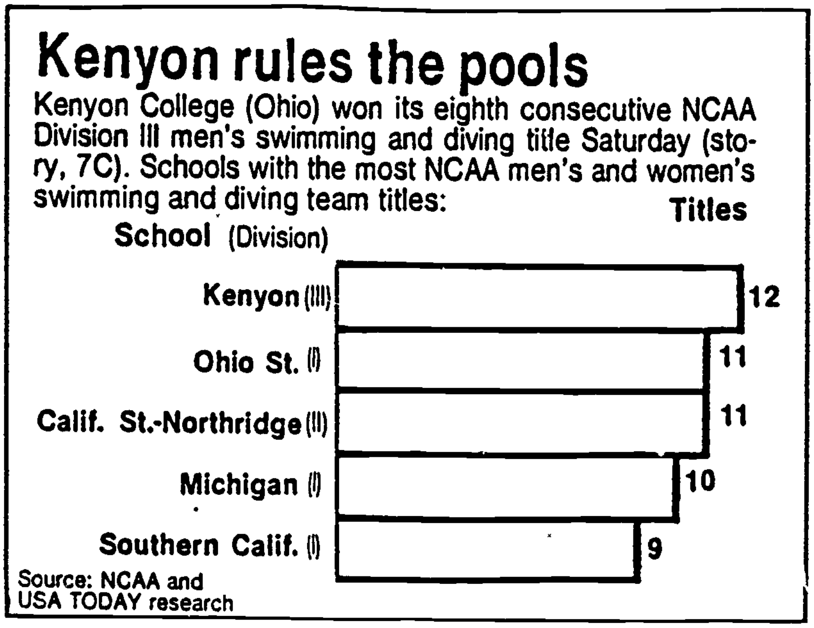
1. How many job areas were displayed in the graph?
2. What area will create the highest increase of new jobs?
3. What was the percentage increase of that highest area?
4. What area will create the lowest increase of new jobs in the survey?
5. What was the percentage increase of that lowest area?
6. Was the highest new job area two times larger (or more) than the lowest job area?

YES or NO (circle one)

Graph 7 Treatment



Graph 7 Control

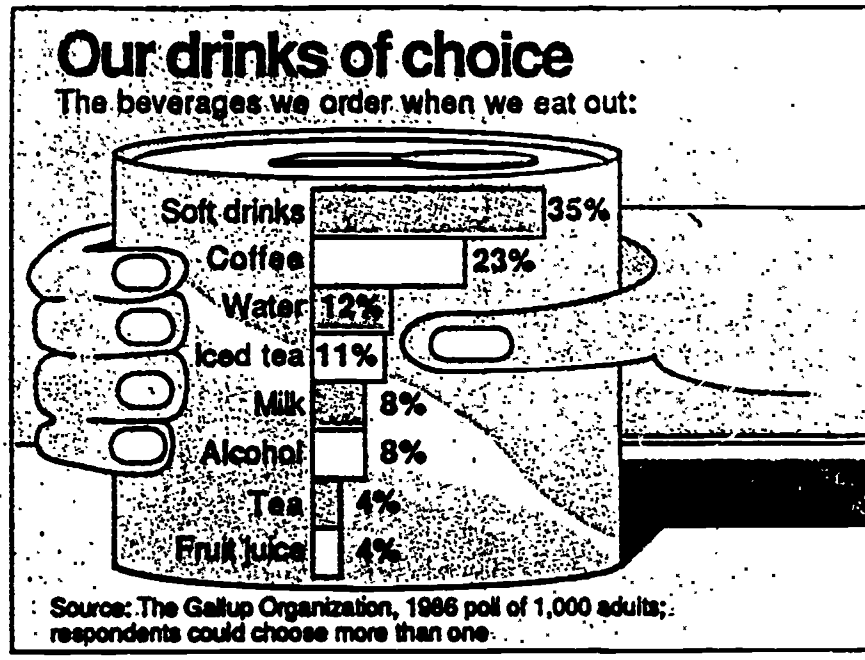


Questions for Graph 7

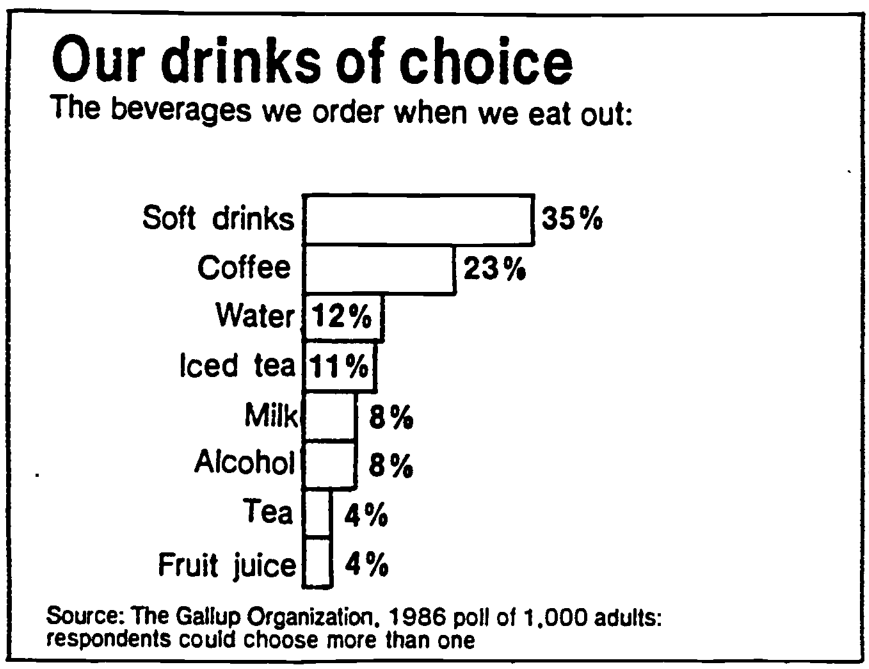
1. How many colleges were displayed in the graph?
2. Which college has won the <u>most</u> titles?
3. How many titles has that college won?
4. Which college has won the <u>fewest</u> titles in the survey?
5. How many titles has that college won?
6. Did the college with the <u>most</u> titles win two times as many (or more) than the college with the <u>least</u>?

YES or NO (circle one)

Graph 8 Treatment



Graph 8 Control

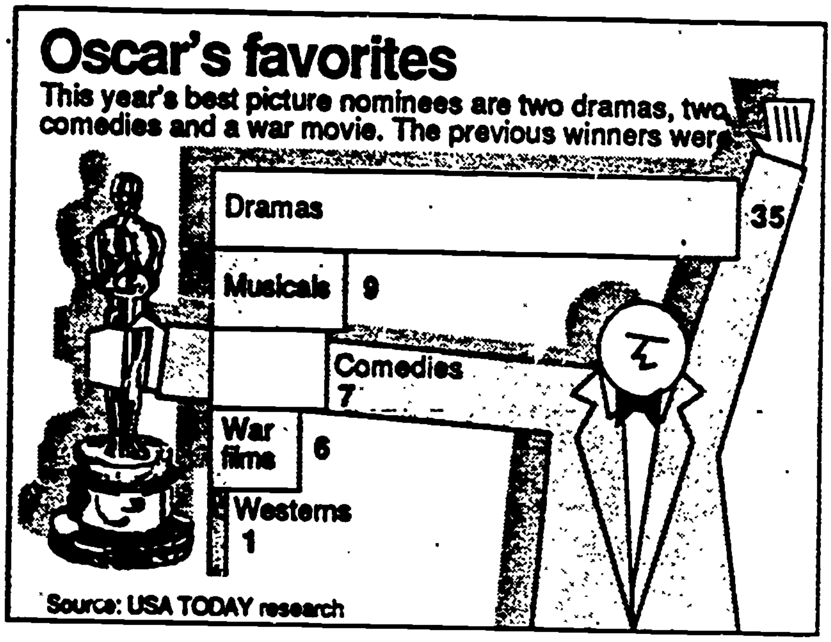


Questions for Graph 8

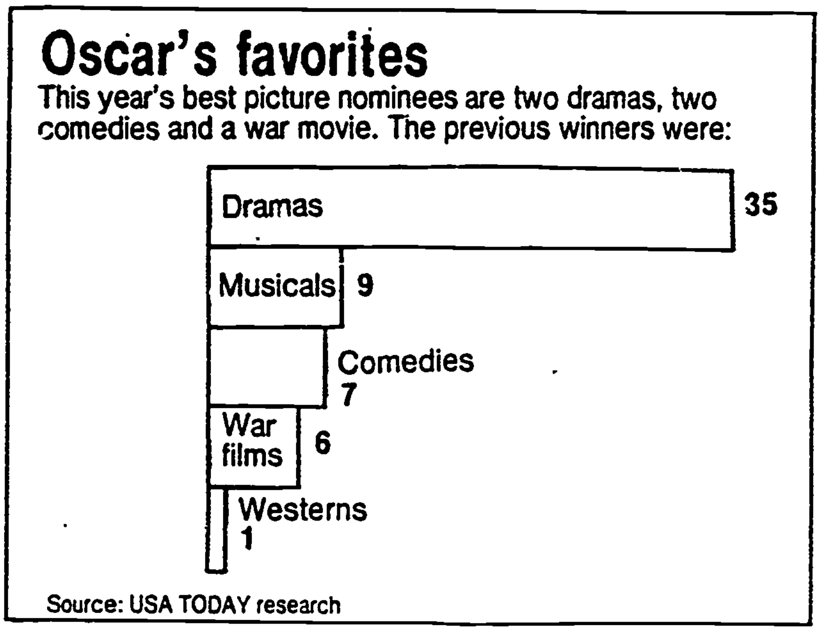
1. How many beverages were displayed in the graph?
2. What was the <u>most</u> common beverage?
3. What was the percentage of that <u>most</u> common beverage?
4. What was the <u>least</u> common beverage in the survey?
5. What was the percentage of that <u>least</u> common beverage?
6. Was the <u>most</u> common beverage two times larger (or more) than the <u>least</u> common beverage?

YES or NO (circle one)

Graph 9 Treatment



Graph 9 Control

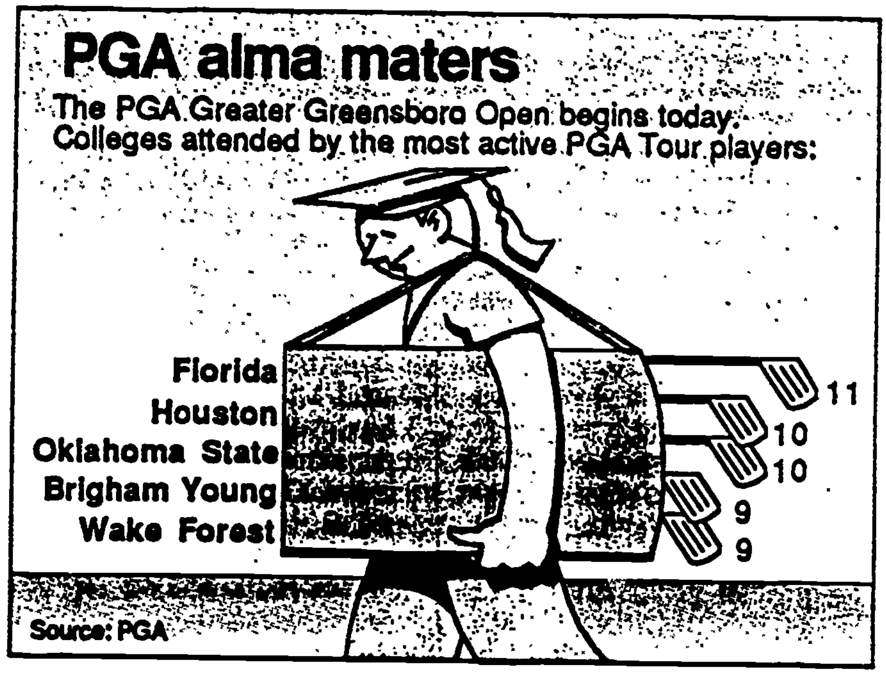


Questions for Graph 9

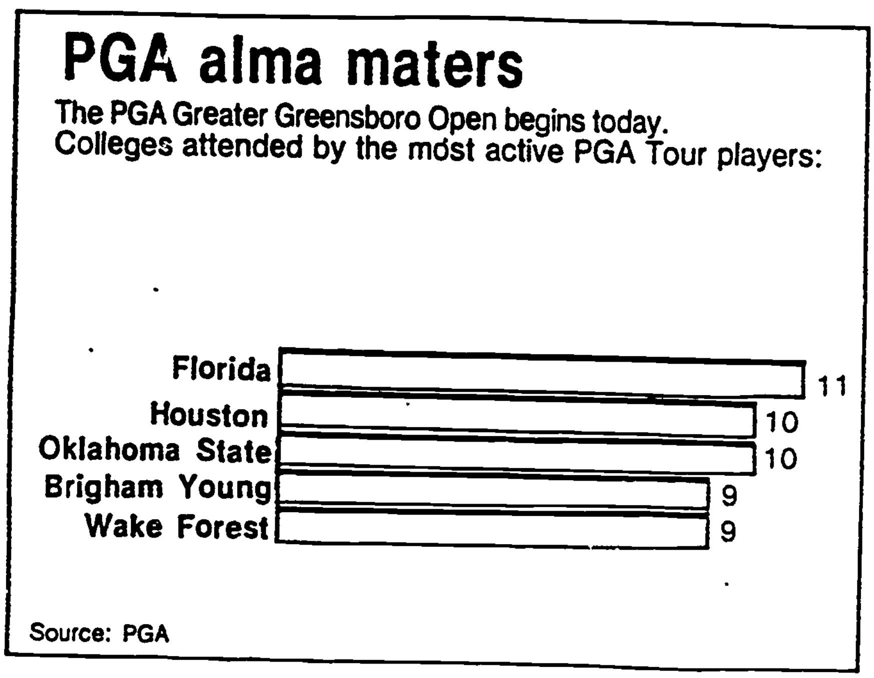
1. How many types of movies were displayed in the graph?
2. What type of movie drew the most Oscars?
3. How many Oscars has that type received?
4. What type of movie drew the fewest Oscars?
5. How many Oscars has that type received?
6. Did the movie type with the most Oscars win two times as many (or more) than the type with the least?

YES or NO (circle one).

Graph 10 Treatment



Graph 10 Control



Questions for Graph 10

1. How many colleges were displayed in the graph?
2. What college had the most PGA alumni?
3. How many alumni did that college have?
4. What college had the fewest PGA alumni in the survey?
5. How many alumni did that college have?
6. Did the college with the most PGA alumni have two times as many (or more) than the college with the fewest?

YES or NO (circle one)