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ABSTRACT

Research in visual communication suggests that relatively complex graphics stimulate viewer interest, while relatively simple graphics facilitate learning. A study was conducted to determine whether the graphics in two science publications ("Scientific American" and "Sciences 81") would be tailored to the ways in which their audiences use information. Presumably, "Scientific American" is geared toward a more instrumental-use audience of working scientists and science educators, while "Science 81" is geared toward a more consummatory-use audience of science "hobbyists." All graphics accompanying an article or department in the five most recent issues of each journal were coded according to three variables. Two variables, visual type and use of color, were used as indicators of graphic complexity. Another variable, perceived function, was used as an indicator of instrumental versus consummatory use of information. Results indicated that the streamlined graphics used in "Scientific American" (primarily black and white or one-color diagrams and graphs) helped to offset the complexity of the written material. In this way, they helped the instrumental-use reader to understand basic relationships between concepts. The visually "exciting" graphics used in "Science 81" (primarily full-color photographs) helped to perceptually motivate the consummatory-use readers--to capture their attention and stimulate interest in the accompanying written material. (HOD)

VISUAL COMPLEXITY AND THE FUNCTION OF GRAPHICS IN SCIENTIFIC AMERICAN AND SCIENCE 81

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PURPOSE

Jack Reniree, a science writer for the National Science Foundation, has said that people attend to science information for one of two reasons: out of curiosity or because it affects them in some way. Grunig (1980) has called this consummatory versus instrumental use of information:

> At times persons read science information simply because it interests them; at other times, they may read it because they can use it. But why a person reads a particular article depends upon whether the situation described in the article involves him or her.

According to this hypothesis, level of involvement--the extent to which a person sees a connection between himself and the content of an article--determines whether he will use the information for consummatory or instrumental purposes.

The information consumer, with a low level of involvement, sees little connection between himself and the material presented in a particular science article. The information is not relevant to his life situation. Because he is indifferent to the content of the article, creativity and presentation play an important role in attracting his attention.

On the other hand, a person who is highly involved with a particular science topic needs little inducement to read an article which is relevant to his situation. Presentation of the material is less important, because he will make an effort to seek out and interpret the information he needs.

Earlier work by Funkhouser (1969) offers support for Grunig's hypothesis. He found measurable differences in the complexity of writing in science articles from various publications, ranging from <u>Reader's Digest</u> to the <u>Journal of the American Chemical Society</u>.

Sentence length, percent of words not on the Dale list of common words, Dale-Chall readability, percent science words, and percent activity words in each publication showed significant correlation to the percent of readers who were college graduates. He concluded that the lower the education level of the audience, the more that textual variables tended in a direction which would encourage reader interest and enjoyment.

It was the aim of this research to see if there are also differences in the visual complexity of graphics used in different science publications. According to the Grunig hypothesis, it was expected that Science 81--which presumably caters to a more consummatory-use audience--would make greater use of graphics that might serve to stimulate viewer interest. It was expected that Scientific American--which presumably caters to a more instrumental-use audience--would tend to use graphics that stimulate learning and understanding.

CONCEPTUALIZATION

Smith (1960) stated that creative art accompanying written material may serve three major functions: 1) to perceptually motivate--by attracting the reader's attention and interest, 2) to perceptually reinforce--by making the verbally described situations more meaningful, and 3) to symbolically enhance--by deepening the meaning of the verbal material and promoting creative thinking.

Although Smith was concerned with artwork, per se, these functions seem equally applicable to other types of graphic illustration that may accompany a text--including photographs, diagrams, and graphs. The motivation function would be most important for the consummatory-use audience, while the reinforcement and symbolic enhancement functions would be more important for the instrumental-use audience.

Visual communication researchers have focussed on the role of stimulus complexity in generating interest and attention to pictures. This line of research is theoretically indebted to Claude Shannon's information theory and his concept of entropy (Shannon and Weaver, 1949). Although in formal application, entropy is a mathematical expression of the randomness of message components, in a broader sense it can be interpreted as the relative complexity of visual stimuli.

To make sense of a picture, the brain must process the visual information encoded in it. Attneave (1959) stressed that an individual's ability to discriminate between (and, therefore, to learn from) increasingly complex stimuli is limited by the information-processing ability of his brain.

Berlyne (1957) and Berlyne et al. (1963) hypothesized that complex or novel stimuli arouse psychological conflict. According to this hypothesis, stimulus-generated conflict can: 1) stimulate investigatory behavior--i.e. interest and attention and 2) serve as both punishment and reward. He suggested that an appropriate level of stimulus complexity can serve to maintain a balance between punishment and reward that is pleasurable to the viewer.

The complexity of a picture is directly related to its density of visual elements. Attneave (1951, 1954) found that visual information is concentrated at points of change in the gradient of a contour--such as vertices, corners, and curves. Such points are carriers of meaning; therefore, a detailed picture can be thought of as information-rich, while a picture composed of relatively few structural elements is relatively information-poor.

Attneave (1959) and Jacobson (1951) pointed out that too much detail in an illustration can act as a barrier to learning, due to the limited capacity of the visual system to process the wealth of information. In light of this, relatively simple illustrations--such as line drawings--are thought to better facilitate learning than more complex visuals--such as photographs.

The continuum of standard printing techniques--ranging from black and white only, to black and white plus one color, to black and white plus two colors, to full color--also embodies increasing stimulus complexity. Katzman and Nyenhuis (1972) found that subjects rated color cartoons and posters significantly more interesting than black and white counterparts. They also found that use of color improved learning of irrelevant, peripheral, or detailed visual material, but did not improve learning of the central material.

Dwyer (1976) gauged the effect of visual complexity and color on learning by exposing subjects to eight different treatments of an illustration of the human heart: 1) a simple black and white line drawing, 2) a simple two-color line drawing, 3) a detailed black and white drawing, 4) a detailed drawing in realistic color, 5) a black and white illustration of a model, 6) a realistic color illustration of a model, 7) a black and white photograph, and 8) a realistic color photograph.

Dwyer found that the color version of the line drawing, the detailed line drawing, and the heart model were most effective in stimulating learning. He suggested that since the color in the simple line drawing provided no additional information, its effectiveness may have been due to increased interest. He concluded that excessive detail in the more realistic illustration hampered learning by interfering with the transmission of the intended information.

In constructing a system for classifying illustrations, Fleming (1967) noted two additional elements often found within the pictorial unit: verbal information--such as labels and numbers, and design elements--such as arrows and color overwashes. Such verbal and design elements are important to schematic illustrations and diagrams.

Gropper (1970) pointed out that diagrams facilitate discrimination among stimuli, generalization across stimuli, and associations between stimuli by using several spatial techniques: stimulus separation, adjacency, grouping, and ordering. The implication is that, by reducing visual complexity, diagrams allow for associational learning.

In general, research supports the notion that more complex visual forms stimulate viewer interest, while less complex forms facilitate learning. Although complex graphics--such as photographs--contain a multitude of information points that can capture a viewer's attention, they are more difficult for the brain to process. Also, it may be difficult for the viewer to determine relationships between the visual elements. Less complex graphics--such as graphs, diagrams, and line drawings explain more because they reduce the visual "noise" of unnecessary detail and emphasize relationships between visual elements.

RESEARCH ASSUMPTIONS AND HYPOTHESES

According to Grunig's hypothesis, there are two major publics for science information: an instrumental-use public and a consummatory-use public. Presumably, Scientific American is geared toward a more instrumental-use audience of working scientists and science educators, while Science 81 is geared toward a more consummatory-use audience of science "hobbyists". We would expect that graphics in each of these publications would be tailored to the way in which their audiences use information.

If Scientific American is, indeed, intended for an instrumental-use audience, we would expect it to make use of graphics that stimulate learning. Presumably, the professionals who read Scientific American can often find information that is useful to their work. Because they actively seek information relevant to their research or teaching, there is little need for high-complexity graphics to capture their attention.

Instead, we would expect to see less complex types of graphics--diagrams and graphs--that reinforce and enhance the verbal material. Such "streamlined" graphics also help to offset the complexity of the verbal material by emphasizing basic relationships between concepts. We would also expect to see less use of color, since color adds little, if anything, to learning.

If Science 81 is, indeed, intended for a consummatory-use audience, we would expect it to make greater use of graphics that stimulate interest and attention. Presumably, the "hobbyists" who read Science 81 have no particular use for the information presented, but read mainly out of curiosity. Because of this, we would expect to see more complex types of graphics--photographs and detailed drawings--that perceptually motivate the reader. We would also expect to see greater use of color.

METHOD

The sample population included the five most recent issues of Scientific American (July-November, 1981) and Science 81 (June-November, 1981). All graphics accompanying an article or department were coded. Graphics were excluded if they appeared: 1) in advertisements, 2) as tables which included no visual elements other than straight lines, or 3) in the table of contents.

The presence of a frame or a caption was the operational definition for a discreet graphic. For cases where several framed graphics were included above a single caption the following criteria were used: 1) The entire captioned group was counted as a single graphic if a time sequence was portrayed or if the individual graphics were closely related in content. 2) Each individual graphic was counted separately if the group did not satisfy the first criterion or if more than one visual type or color scheme was used.

Each graphic was coded according to three variables. Two variables, visual type and use of color, were used as indicators of graphic complexity. Another variable, perceived function, was used as an indicator of instrumental versus consummatory use of information. Each graphic was assigned to only one of the possible categories for each variable.

The operational definitions for the categories for each variable were as follows:

Visual Type

Low Complexity: Graphics usually having verbal and/or design elements (labels, numbers, arrows, etc.)

1) Graph
2) Schematic diagram or map

High Complexity: Graphics having no verbal or design elements

3) Drawing or painting
4) Photograph or computer-generated graphic

Use of Color

Low Complexity

1) Black and White
2) One color

High Complexity

3) Two colors
4) Full color

Perceived Function

Instrumental-Use

1) Explain: Graphic appears to explain some aspect of the verbal material.
2) Present data: Graphic shows numerical data.

Consummatory-Use

3) Illustrate: Graphic appears to illustrate some aspect of the verbal material or provide an example, but does not explicitly explain.
4) Thematic: Graphic appears to present an overview of the verbal material.
5) Humor: Graphic is a cartoon.
6) Shows person: Graphic shows a person mentioned in the verbal material, but does not illustrate or explain his work.

RESULTS

Tables 1 and 2 indicate that there are marked differences in the complexity of graphics used in Scientific American and Science 81.

TABLE 1: Visual types and visual complexity.

	LOW COMPLEXITY Graph	Diagram	HIGH COMPLEXITY Drawing	Photograph
Scientific American				
Number of Graphics	102	259	14	211
Percent	17.4	44.2	2.4	36.0
Total Percent	61.6		38.4	
Science 81				
Number of graphics	1	29	108	275
Percent	0.2	7.0	26.2	66.6
Total Percent	7.2		92.8	

TABLE 2: Use of color and visual complexity.

	LOW COMPLEXITY Black & White	1 Color	HIGH COMPLEXITY 2 Colors	Full Color
Scientific American				
Number of Graphics	234	265	1	86
Percent	39.9	45.2	0.2	14.7
Total Percent	85.1		14.9	
Science 81				
Number of graphics	77	18	5	313
Percent	18.6	4.4	1.2	75.8
Total Percent	23.0		77.0	

Scientific American makes greater use of low-complexity visuals. Nearly 62 percent of all graphics were graphs or diagrams, and 85 percent were black and white or one color.

Conversely, Science 81 emphasized high-complexity visuals. Nearly 93 percent of all graphics were drawings or photographs, and 77 percent were two color or full color.

To statistically test the apparent difference in visual complexity between the two magazines, contingency tables were constructed. High versus low-complexity visual types (Table 3) and high versus low-complexity use of color (Table 4) were compared for the two magazines. In each case, the chi square value was significant at the 0.00 probability level.

TABLE 3: Chi square results--high versus low-complexity visual types.

	LOW COMPLEXITY Graph + Diagram	HIGH COMPLEXITY Drawing + Photograph
Scientific American	361 (229)	225 (357)
Science 81	30 (162)	383 (251)

Chi square = 300.40
For 1 degree of freedom, probability = 0.00

TABLE 4: Chi square results--high versus low-complexity use of color.

	LOW COMPLEXITY B&W + 1 Color	HIGH COMPLEXITY 2 + Full Color
Scientific American	499 (348)	87 (238)
Science 81	95 (246)	318 (167)

Chi square = 388.13
For 1 degree of freedom, probability = 0.00

Table 5 indicates that there are also marked differences in the perceived function of graphics between the two magazines.

Sixty percent of all graphics in Scientific American explain or present data--functions important for an instrumental-use audience. Conversely, nearly 86 percent of all graphics in Science 81 illustrate, show people, or are thematic or humorous--functions most important for a consummatory-use audience.

TABLE 5: Perceived functions and instrumental versus consummatory use.

	INSTRUMENTAL USE		CONSUMMATORY USE			
	Explain	Present Data	Illustrate	Thematic	Humor	Shows Person
Scientific American						
Number of Graphics	276	78	226	1	0	5
Percent	47.1	13.3	38.6	0.2	0	0.8
Total Percent	60.4		39.6			
Science 81						
Number of Graphics	59	0	248	49	36	21
Percent	14.3	0	60.0	11.9	8.7	5.1
Total Percent	14.3		85.7			

A contingency table was assembled to compare instrumental versus consummatory-use functions for the two magazines (Table 6). Again, the chi square value was significant at the 0.00 probability level.

TABLE 6: Chi square results--instrumental versus consummatory-use functions.

	INSTRUMENTAL USE Explain + Data	CONSUMMATORY USE Illus, Theme, Humor, Person
Scientific American	354 (242)	232 (344)
Science 81	59 (171)	354 (242)

Chi square = 212.59
For 1 degree of freedom, probability = 0.00

CONCLUSIONS

Scientific American and Science 81 have markedly different visual styles. The graphic preferences of each magazine represent polarities on the coninuum of visual complexity. In Scientific American the preferred graphic type is the one-color diagram. In Science 81 the preferred graphic type is the full-color photograph.

This research contends that differences in the visual complexity of graphics in each magazine is related to the way in which their audiences use information.

Scientific American's audience uses information primarily for instrumental purposes. Low-complexity graphics serve to deepen the meaning of verbal material by emphasizing basic relationships between concepts. Because the audience's high level of involvement is sufficient motivation for them to attend to the articles, little attempt is made to stimulate interest with high-complexity graphics.

Science 81's audience uses information primarily for consummatory purposes. High-complexity graphics serve to perceptually motivate readers by stimulating interest. Visually "exciting" graphics help to capture the attention of a low-involvement audience.

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