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The effects of the use of a color code in graphic presentation and assessment on the reader's immediate recall and delayed retention

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THE EFFECTS OF THE USE OF A COLOR CODE IN GRAPHIC PRESENTATION AND ASSESSMENT ON THE READER'S IMMEDIATE RECALL AND DELAYED RETENTION

A Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

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August 1991

This dissertation is dedicated to those
who have added to the color scheme
of my personal life and professional work.
I have absorbed, blended, and reflected
the light they have shared.

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ABSTRACT

The study investigated the effects of the use of a color code in graphic presentation and assessment of verbal material on the reader's immediate recall and delayed retention. Nine seventh-grade classes, containing a total of 132 students, were randomly assigned to one of four treatment groups: (a) color-coded graphic presentation with a color-coded graphic assessment, (b) color-coded graphic presentation with a black/white graphic assessment, (c) black/white graphic presentation with a color-coded graphic assessment, and (d) black/white graphic presentation with a black/white graphic assessment. The research design was a 2 x 2 x 2 factorial; the independent variables were the graphic presentation type (color-coded or black/white), the graphic assessment type (color-coded or black/white), and the time of testing (immediate recall and delayed retention). The dependent variable was achievement on assessments at immediate recall and delayed retention. A repeated measures analysis of variance was used to test all relevant interactions and main effects.

Based on the analysis, there was a significant three-way interaction among graphic presentation type x graphic assessment type x time of testing. Further

analyses indicated a significant simple two-way interaction between presentation type x assessment type at the immediate recall and the absence of one at delayed retention. Two major implications can be drawn from these findings:

1. At immediate recall, the important factor in enhancing performance appeared to be the match between graphic presentation and assessment types rather than the presence or absence of a color code. However, there was a slight overall advantage for the matched systematic color code in both graphic presentation and assessment.

2. At delayed retention, the important factor in enhancing performance appeared to be the presence of a systematic color code in graphic presentation. The additional presence of a color code in assessment produced a slight advantage.

The knowledge gained from this study supports and extends our understanding of schema theory, graphics, and color. These findings should be noted and their implications assimilated by graphic designers, teachers, and students when preparing and using educational materials.

CHAPTER I

THE PROBLEM

Literacy allows the reader to make sense of the world; since the world is continually changing, so are the requirements for literacy. To meet contemporary technological challenges, educators must move beyond the traditional approaches to reading and writing and view literacy as the skill with which humans manipulate the many media of mass communication. Although reading and writing are still essential, much more is required in the multimedia age. As Venezky, Kaestle, and Sum (1987) describe the frustration of achieving literacy in The Subtle Danger: Reflections on the Literacy Abilities of Young Adults, "The main literacy problem over the long run has not been that people's literacy skills have been slipping, but that literacy demands keep rising" (p. 5).

Literacy use has expanded and intertwined with every social function in American society. Clearly, both an historical analysis and a sociological analysis of literacy indicate the importance of context in determining the purposes, demands, and processes necessary to be literate (Blake, 1990; D'Angelo, 1982; Mikulecky, 1990; Smith, 1983).

A verbal battle is waged by many educational theorists and practitioners who attempt to create a precise definition of literacy as it cuts across context. These conflicts might be assuaged by adopting Smith's (1983) umbrella definition of literacy--"the ability to make use of all available possibilities of written language" (p. viii). This malleable definition accommodates the elusive, metamorphic characteristics of literacy and its divergent tasks.

A theoretical base that provides the scaffold for a broad understanding of literacy is schema theory (Rumelhart & Ortony, 1977). The schemata, or characterizations of objects, events, and situations, allow us to make sense of new encounters with written information by relating to previous experiences. These fundamental schemata upon which all learning is based are proposed to be structured, yet flexible enough to accommodate literacy tasks in any setting.

In the contemporary context, a literate person moves beyond the conventions of print and processes all possibilities of written information. Verbal literacy, the ability to read and write a language, is only one dimension of literacy; visual literacy, the ability to understand and make visual messages (Dondis, 1973), enables a learner to successfully interpret a broader context of the information environment. The prevalence

of graphics in American life today makes it imperative to consider the comprehension of graphics as an integral part of the reading process. A single example indicates the magnitude and diversity of graphics: a stratified sample of 113 daily newspapers from 39 states and the District of Columbia were analyzed for 1 week; a content analysis revealed that maps, photographs, charts, and illustrations represented 27% of the total area of the front pages; also, color was used by 32% of the newspapers regularly, while 59% occasionally used some front-page color (Kenney & Lacy, 1986). The wide use of graphics, however, does not mean they are being effectively designed and integrated into context (Gerber, 1985). On the contrary, educators have neglected to instruct graphic designers, teachers, and students to manipulate and interact with the graphic features or characteristics in ways that enhance literacy.

To support strategies that assist in the comprehension of information as it naturally occurs across many settings (Fingeret, 1990)--to build a reader's schema to facilitate rapid comprehension, immediate recall, and long-term retention--educators must utilize the power of unique, distinguishing graphic features. Among the graphic features that could aid in effective communication, purposeful

learning, and enhanced recall and retention is the use of color (Dondis, 1973; Hartley, 1986; Kostelnick, 1988). Therefore, it is the purpose of this study to determine if the use of a color code in graphic presentation and graphic assessment has a significant effect on reader recall and retention of verbal material.

Statement of the Problem

In response to the frequent presentation of information in graphic form, recent research stresses the need for and importance of well-designed graphics (Gerber, 1985; Kostelnick, 1988; Peterson, 1983). Empirical research needs to be conducted to determine the effects of the manipulation of graphic features on reading (Hartley, 1986), graphical comprehension (Peterson, 1983; Soderston, 1983), and instruction. Certainly, color is one critical feature researchers need to consider.

Research Questions

The following research questions were investigated in this study:

1. Is there a significant interaction among the graphic presentation type (systematically color-coded or black/white), the graphic assessment type (systematically color-coded or black/white), and the

time of testing (immediate recall or delayed retention) of verbal material?

2. Is there a significant interaction between the graphic presentation type (systematically color-coded or black/white) and the graphic assessment type (systematically color-coded or black/white) when immediate recall of verbal material is tested?

3. Is there a significant interaction between the graphic presentation type (systematically color-coded or black/white) and the graphic assessment type (systematically color-coded or black/white) when delayed retention of verbal material is tested?

4. Is there a significant difference in recall of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation?

5. Is there a significant difference in retention of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation?

6. Is there a significant difference in recall of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment?

7. Is there a significant difference in retention of verbal material between those given a systematically

color-coded graphic assessment and those given a black/white graphic assessment?

Limitations of the Study

The following limitations to the study were recognized:

1. Subjects may have perceived that this was an artificial task in a contrived setting, and they may not have invested fully in the task.

2. Extraneous variables not controlled for by the experimental design may have affected recall and retention.

3. Since the population examined was limited in nature, generalization cannot be made to other populations.

Assumptions

The following assumptions were made in this study:

1. The homeroom teacher presented the instructions precisely as stated.

2. The subjects understood the verbal directions provided on the audiotape.

3. The subjects worked conscientiously at the task.

4. Use of prior knowledge was adequately minimized by using a unique graphic summarizing a little-known Norse myth.

Definition of Terms

For the purpose of this study, the following research terms were used:

Color Code

A color code is a systematic method of structuring perceptual and associative information for the purpose of facilitating learning, retention, and recall (Lamberski, 1982).

Content Literacy

As defined by Indrisano and Paratore (1987), content literacy is the result of using not only words and their meanings, but also forming individualized schemata that reflect the relationship of the concepts to one another and the world.

Cue

A cue is a verbal or visual strategy by which the perceiver's attention is focused upon perceptual information (Lamberski, 1982).

Graphic Assessment

The graphic assessment is a graphic presented to the reader for the purpose of evaluating recall or retention.

Graphic Features

According to Hartley (1986), "This term refers to typographic detailing and includes features such as

underlining, italics, boldface, capital letters and color" (p. 325).

Graphic Presentation

The graphic presentation is a graphic containing new information that is presented to the reader.

Graphics

Graphics are pictorial alternatives to prose. Macdonald-Ross (1978) used the term graphics in reference to "graphs, charts, diagrams, notations, maps, and other representations specifically adapted for presenting scientific, technical, social, commercial, and textual information" (p. 50).

Literacy

As defined by Smith (1983), literacy is "the ability to make use of all available possibilities of written language" (p. viii).

Pattern Literacy

This term refers to the knowledge and use of text structure that acts as the reader's map (Indrisano & Paratore, 1987).

Recall

This term refers to the ability to call back or remember information immediately after reading.

Retention

This term refers to the ability to call back or remember information after the passage of time.

Schemata

Schemata represent our generalized knowledge about a sequence of concepts underlying objects, situations, actions, and events. Readers integrate new information in the text with previous experiences already stored in their knowledge systems (Rumelhart & Ortony, 1977).

Text

This term applies to the communication using traditional print and graphics. Often, educators have limited their scope of the term text to mean only traditional print. Singer and Donlan (1981) expanded this view to mean any visual communication, including graphics.

Verbal Material

Oral language and written discourse are considered verbal material.

Importance of the Study

Consumers of knowledge must be able to efficiently read and utilize graphics. Additionally, the manipulation of graphic features has a direct application to computerized instruction and processing (Cunningham & Braden, 1990). Through the manipulation of graphic features, specifically the use of color, it may be possible to more efficiently access and enhance the construction of schemata. The knowledge gained from this study concerning schema theory, graphics, and

color will add to the understanding of how color coding affects the reader's recall and retention, will emphasize the importance of effective graphic design, and will add to the understanding of the reading process and, thereby, promote literacy.

CHAPTER II

REVIEW OF LITERATURE

Contemporary profiles have shown that there are approximately 1 billion people who are illiterate in the world today (Bhola, 1989). Shocking as this statistic may seem, the researchers have not cursed illiteracy. They have asserted that the problem is literacy (Kirsch & Jungeblut, 1986). As our literacy demands grow, a literate person must be able to conceptualize, generalize, draw inferences, and see relationships while engaging in the complex mental process that is used when a reader encounters a variety of materials that satisfy many needs and purposes.

In today's burgeoning technological society, Resnick and Resnick (1977) used the term mass literacy in reference to the growing literacy demands in the United States and France, even as literacy abilities have continued to increase. They warned that "while we may be able to borrow important ideas and practices from earlier periods, there is no simple past to which we can return" (p. 371). It quickly becomes apparent that the elusive nature of literacy requires a lifelong pursuit.

Literacy or language proficiency is not the mere possession of words that can be structured through

chaining. It is a more complex development that allows the learner's understanding to move beyond the aggregation of primitive elements into a network of related concepts. Schema theory explains the interrelated meshwork that forms the unarticulated, personal theory of human experience. The underlying assumption of schema theory is that the text itself holds no meaning, but it interacts with the previous knowledge of the reader in retrieving and reconstructing meaning. The interpretation or slotting of new information is influenced by the reader's background, personal history, knowledge, and beliefs. In essence, new information in the text is correlated with experiences already stored in the knowledge system. Scripts, or stored experiences, do not represent isolated concepts but a network of interrelated constructs. This scripting is easily adapted to graphics, allowing variables or slots of the schemata to represent various features of graphics and patterns created with distinctive characteristics (Rumelhart, 1980).

History of Schema Theory

During the first half of this century, American social science was rooted in the behavioral theory of psychology; theorists in psychology and education regarded the human organism as driven by sensory

inputs. Skinner (1953) contended that each stimulus received by the organism evoked a response, and a perception or pattern of behaviors was created by the chaining of simple response units. Experimentation, however, taught researchers and practitioners that chaining involved a bottom-up model of processing that could account for only the perception of simple objects and the solving of trivial problems (Anderson, 1977). The emphasis in social science is no longer strictly on behavior; cognitive psychology currently influences theory and practice by recognizing learning as an active, constructive process that is cumulative in nature, influenced by prior knowledge, represented and organized in memory, and subjected to process-oriented analysis (Shuell, 1986).

Although Kant (1787/1963) first described knowledge or experience as categories in the productive imagination of sensory perception, most contemporary scholars credit Bartlett (1932) with the concept because he coined the term schemata. During the mid-1970s, a plethora of experts confirmed the convergence of similar systems representing knowledge and information processing in research on artificial intelligence, cognitive psychology, and linguistics, although the terms and views varied. Minsky (1975) proposed a theory of knowledge represented by component

frames; Winograd (1975) and Charniak (1975) also described artificial intelligence in terms of frames; Bobrow and Norman (1975), Rumelhart and Ortony (1977), and Schmidt (1975) used the term schema; Schank and Abelson (1975) used the terms script and plan to refer to the different schemata.

Although it is the most prominent theory used to describe the networking of knowledge in memory, many aspects of schema theory have not been easily quantified; therefore, it has been the subject of controversy. Although Pearson (1984) published a review of research that supported schema theory, subsequent studies of widely differentiated functions of reading have still not gained the support of all cognitive psychologists (Woolfolk, 1990). Many reading experts (e.g., Kitao, 1986) continue to study and support the voluminous, yet fragmented, research that posits schema theory as the most plausible guide for instruction, but they recognize the lack of consensus (Gillet & Temple, 1990; May, 1990).

Kamil (1984) insisted that the study of schema theory is fraught with pitfalls that have led to fragmented research. Perhaps it would be advisable for verbal theorists to borrow from motor skill learning advanced research that supports schema theory. Although a study of rule formation in a rapid-timing

task (Doody & Zelaznik, 1988) did not strongly support schema theory, the researchers suggested that nonlinear rule conditions developed as a function of practice represent a new avenue for the serious schema researcher. Schmidt (1975) expressed embarrassment that theorists in motor skill learning once adopted the schematic work in verbal learning and applied it without serious research effort. Recently, however, meta-analysis of research on the distribution of practice within the field of motor learning (Lee & Genovese, 1988) indicated there is a vast research base from which researchers in verbal learning could borrow.

Although the terms relating to schemata are not synonymous, the authors of schema theories and research across a variety of disciplines have agreed upon the basic features and general applications of the theory of knowledge (Sheridan, 1978). Due to the wide acknowledgment of other verbal learning theorists, this study will review Rumelhart's theory of schema (Rumelhart, 1980, 1984; Rumelhart & Norman, 1978; Rumelhart & Ortony, 1977).

Basic Features of Schema Theory

Schema theory provides a framework for thinking about knowledge. Each schema, or building block, is a data structure for a pool of generic concepts. Within each schema, there is a network of interrelations that

holds true among the constituent concepts and embedded information about how that knowledge can be used. Consequently, multiple schemata present prototypes with the following characteristics:

1. Schemata have variables that specify the range of objects and details that make it possible to formulate educated guesses about values when rules are not available. They function as generic guidelines.

2. Schemata can embed, one within another, to form recursive structures and subschemata (Rumelhart, 1980). There are two obvious advantages of embedding: (a) a situation or object can be comprehended by tapping a higher-level schema that has inherent internal multiplicity of constituents, and (b) the variables can be economized.

3. Schemata represent knowledge at all levels of abstraction, ranging from perceptual elements to cogent summaries cf connected sequences. To comprehend abstract concepts, a learner must see the broader context or even construct the larger framework.

4. Schemata represent knowledge rather than definitions. They are not merely the linguistic entries of a lexicographer, but they contain the essential meanings or characteristics that associate knowledge with concepts in a flexible, tolerant format (Rumelhart, 1980).

Analogies for Schemata

Four analogies emerge to help in understanding the features of schemata: schemata are like plays, theories, procedures, and parsers. Like all analogous descriptions, the comparisons tend to be overgeneralizations but, in fact, are useful in developing general understanding.

Schemata Can Be Compared to Plays

The script of the play can be thought of as the knowledge structures of a schema, while the characters, played by the various actors who attend to the written script, can be associated with the variables within the schema. For example, the play Quilters (Newman & Damashek, 1986) is produced with a cast of seven actresses who portray a mother and six daughters; within the "blocks" of the play, the actresses transform into different characters for each scene. The action during block five depicts Mama, Papa, and one of the daughters arriving at the dry goods store to purchase quilt material for a hope chest. Papa, a Baptist minister, unpredictably purchases a bolt of red calico material. The purchase of the material accounts for both a literal and figurative change. The material changes hands, and the idealization or schema of a Baptist minister is altered in the observer's mind.

Schemata Are Like Theories

Schemata are like individual theories that function to construct the interpretation of information. These unarticulated theories are generic in structure to accommodate and assimilate informal and private observations, yet they are specific enough to establish parameters.

Theories serve useful purposes as they are tested in direct observation and extended to vicarious experiences: (a) They allow for the identification of commonalities or universals of experience, (b) they allow for prediction and control of phenomena, and (c) they serve an heuristic purpose allowing for discovery. In essence, analogous to theory testing using the scientific method, isolated experiences can grow and expand into a powerful framework through three phases: (a) the formulation of a hypothesis based on a generalized theory, (b) the deduction of empirical consequence, and (c) the testing of the hypothesis. The result of this process is the acceptance or rejection of the hypothesis. If the process is based on weak measures, the acceptance or rejection may be inappropriate, yet justifiable, in the mind of the contemporary researcher.

Borg and Gall (1983) stated:

> Centuries ago, scientific inquiry was considered a branch of philosophy called natural philosophy.

> Science then was ultimately bound up with issues concerning the nature of knowledge (epistemology), reality (metaphysics), and reasoning (logic). Philosophers of science still worry about such matters, but contemporary researchers in education, especially applied researchers, tend not to dwell on the philosophic assumptions underlying their methods of inquiry. (p. 26)

The same is true for the individual learner.

The following comparison to an existing theory demonstrates the broad similarities between personal schema theory and scientific theory. The theory of evolution proposed by Charles Darwin (Gould, 1977) states that all existing species, genera, and orders of animals and plants are derived from a few simple forms of life by modification of characteristics in successive generations by mutation, hybridization, and selection. The theory exists and more specific hypotheses are proposed and tested. A researcher may test this theory through study and judge that all fauna and flora support the theory, or the researcher may study Biblical references that support the concept of change for all but human existence, or the researcher may totally reject the theory, based entirely on fundamental religious convictions.

Schemata Are Like Procedures

The human processing of information is dependent upon the ability to form an efficient structure for the process. These procedures are easily demonstrable within the design of computer programming. A

collection of programming commands with a common purpose is called a procedure; the collection of subprocedures in a particular lesson is called a file or program. In order to program a lesson, the correct sequence and logical progression of separate programming statements must be written. Like schemata, these written procedures used in computer programming do not allow for an infinite procedural breakdown.

Schemata Are Like Parsers

Parsers are devices that determine whether a sequence of words forms a grammatically acceptable sentence. The constituent parts of the sentence must follow previously determined patterns. Consider the following nonsense sentence: The story was carefully. Application of a parser would indicate that the word carefully is used incorrectly. Subject-verb identification indicates that was is the verb. Since it is the only word in the sentence that can function as a verb, it is not functioning as a helping verb; used as a linking verb, it may be preceded by a noun and followed by an adjective. Since the -ly ending indicates carefully is an adverb, the formula or pattern N-LV-A (noun-linking verb-adjective) has not been utilized. The more sophisticated the sentence pattern, the closer the parallel to schematic processing.

According to Rumelhart (1980), "Whereas schemata have variables, so plays have roles, theories have parameters, and procedures have arguments" (p. 40) with embedded characteristics. All of the analogies presented also emphasized that schemata have different levels of abstraction and work actively to form an individual's knowledge base; schemata represent knowledge rather than definitions.

Functions of Schemata

The major functions of schemata include perceiving, understanding, remembering, learning, and problem solving (Rumelhart, 1980). Perception merely entails the recognition and acceptance of sensory input. This basic function is enhanced by understanding when a construction or appropriate schema can be placed upon the information received. The third function, learning, is more goal-oriented and enables the learner to make sense of what comes to mind.

If, in response to sensory events, the learning task is merely the instantiation of new information into long-term memory, new situations substitute for variables in the schema. This encoding of new information or later reconstruction of the experience is called accretion. Learning may, however, move beyond the building of a data base when there is no existing scaffold to accommodate the new information.

The result may either be the modification of an old schema or the formulation of a new one.

Schemata serve as a vehicle for searching memory for previously encountered patterns and forms; this is referred to as pattern literacy (Indrisano & Paratore, 1987). A classic study in pattern recognition by Simon and Chase (1973) indicated that masters of the game of chess quickly recognized about 50,000 different arrangements of chess pieces. The patterns, however, had to be part of the master's repertoire. Iran-Nejad (1980) offered an analogy comparing pattern literacy to a cluster of lights; different patterns (meanings) can be created by different combinations of individual lights that are capable of participating in more than one pattern. To further explain this analogy, when a new schema follows the format of a previously established one, it is called patterned generation, and the schema is said to be tuned during schema evolution. However, existing structures may not always be analogous, and patterned induction or original creation may occur. No single mental act of learning exists (Rumelhart & Norman, 1978); by broad interpretation, learning in the form of accretion, tuning, or reconstruction occurs whenever the learner modifies the knowledge base.

According to schema theorists, although most learning is the result of pattern development, concept development is a necessary component for whole literacy. Concept literacy is the ability to reason that is tied to a particular schema and related to other bodies of knowledge (Indrisano & Paratore, 1987). Conceptual constraints are an embedded script within the schema; therefore, understanding and problem solving are almost the same task (Rumelhart & Ortony, 1977). Unfortunately, outside the area of mathematics (Gallini, 1989), little verbal learning research has focused on strategies for improving and using schemata to enhance learning and problem solving.

If educators are to help students develop pattern and concept literacy, a framework for the comprehension of graphics and print, they must, in Ausubel's (1963) terms, aid students in finding the appropriate "ideational scaffolding." Purves (1979) suggested that schema is a kind of mental outline that takes place when something is perceived by the individual.

Textual Features

Textual schemata range from the level of the proposition, be it word or line, to the schema for extended discourse which forms a type of mental outline. Research on learning from text has suggested that to help the reader access text schema, the text

should be organized according to the conventional text structures. The text structures should be clearly signaled (Armbruster, 1986), for the quality of the text structurally and rhetorically has great impact on the comprehension process (Steele, 1985). Kintsch and vanDijk (1978) used the term macrostructure to refer to the overall structure of the text. The microstructure, or individual ideas controlled by the schemata, create the propositions necessary for understanding the macrostructure.

There is controversy over the importance of text-based structure and reader's knowledge in comprehension. Meyer (1975) concluded that text-based structures were encoded along with content, and recall was controlled by the specific structure. Shavelson (1972) found that the content structures of the passage altered the reader's knowledge structures. Experiments conducted by Anderson (1977) demonstrated that college students from two different disciplines interpreted sufficiently ambiguous materials on the basis of their professional discipline. Each reader perceived only one interpretation of a text, based on the individual's framework and to the exclusion of all other interpretations. Individual interpretation may be dependent upon the reader's familiarity with the text. The results of an investigation of the recall of

familiar and unfamiliar text (Taylor, 1979) indicated that both good and poor readers depend upon schema-based strategies to read and recall text whenever possible. In a study by Singer and Donlan (1982), high school students learned to apply a problem-solving schema to a complex short story, combined schema general questions to fit complex stories, and used a strategy for generating story-specific questions. Although the results were not clear, similar studies also emphasized the importance of the organization of the text (Jonassen, 1982).

There are many sources of criteria to provide guidance in writing and evaluating structured text. Burbank and Pett (1988) outlined the criteria for designing instructional text in five major categories: (a) general design (structural appeal and personal appeal); (b) instructional design (attention, memory, concept learning, and attitude change); (c) visual design (media considerations, pictures, graphs and diagrams, words-projected, words-printed, and color); (d) text design (content and writing style); and (e) audio design (functions, structure, and recording).

The features of text identified by Hartley (1986) that are the most appropriate to this research can be identified as typographic detailing or cuing: underlining, italics, boldface, capital letters, color,

and multiple cuing. Although good typography can aid different reading strategies and poor typography can hinder them, Hartley (1986) asserted that in the past few researchers have given much thought to typographic design; such matters have usually been left up to editors and typists. The term visual rhetoric (Bonsiepe, 1965) has referred to the ability of the writer to use visual communication to achieve the purpose of the document through the choice of typeface (e.g., Geneva, Monaco, Venice), graphic cues (e.g., bullets, icons, asterisks), textual arrangement (e.g., lines, flow charts, comprehension maps), data display (e.g., bar charts, pie charts, line graphs), shape and size of page, and color.

In reference to technical writing, Kostelnick (1988, p. 77) created a 12-cell matrix of visual rhetoric that described the visual elements that comprise a document. (See Figure 1.) Kostelnick's schema of visual communication can be encoded into three modes: (a) alphanumeric/symbolic, represented in text by linguistic units like numbers, letters, and symbols; (b) graphic, portrayed through marks, lines, tone, and colors which encode shapes, images, and abstract forms; and (c) spatial, denoted by the distribution of the alphanumeric/symbols and graphics across the text. The 12 cells are created when the

Figure 1. A 12-cell schema of visual communication: Four levels and three coding modes.

	Alphanumeric/ Symbolic	Spatial	Graphic
Intra	1 micro-level textual form: style, size, weight, and posture of letters, numbers, and symbols	2 local spacing between characters and textual particles: CPI, picas, kerning	3 marks: punctuation, underscoring; iconicity of letters and words
Inter	4 serial and segmenting devices: headings, letters, numbers; typestyle variations showing textual structure	5 vertical/horizontal arrangement of text: line endings, indentation; lists, matrices, trees, flow diagrams	6 cueing devices: bullets, icons; syntactic devices: line work and arrows on tables, charts, diagrams
Extra	7 decoding devices: legends, captions, labels, numerical description of data	8 configuration of schematic and pictorial sign systems; plotting of data on X-Y axes, circles, other forms; depth of pictorial images	9 schematic: lines, tones, colors, and textures on data displays; pictorial: resolution of details on images, abstract to realistic
Supra	10 macro-level serial and segmenting devices: section titles, numbers; page headers, pagination	11 cohesion of entire document over several planes: page breaks, size; location of extra-textuals within text	12 coding marks unifying pages or sections of text: line work, color, icons, logos, tabs

Note: From "A systematic approach to visual language in business communication" by C. Kostelnick, 1988. Journal of Business Communication, 25.

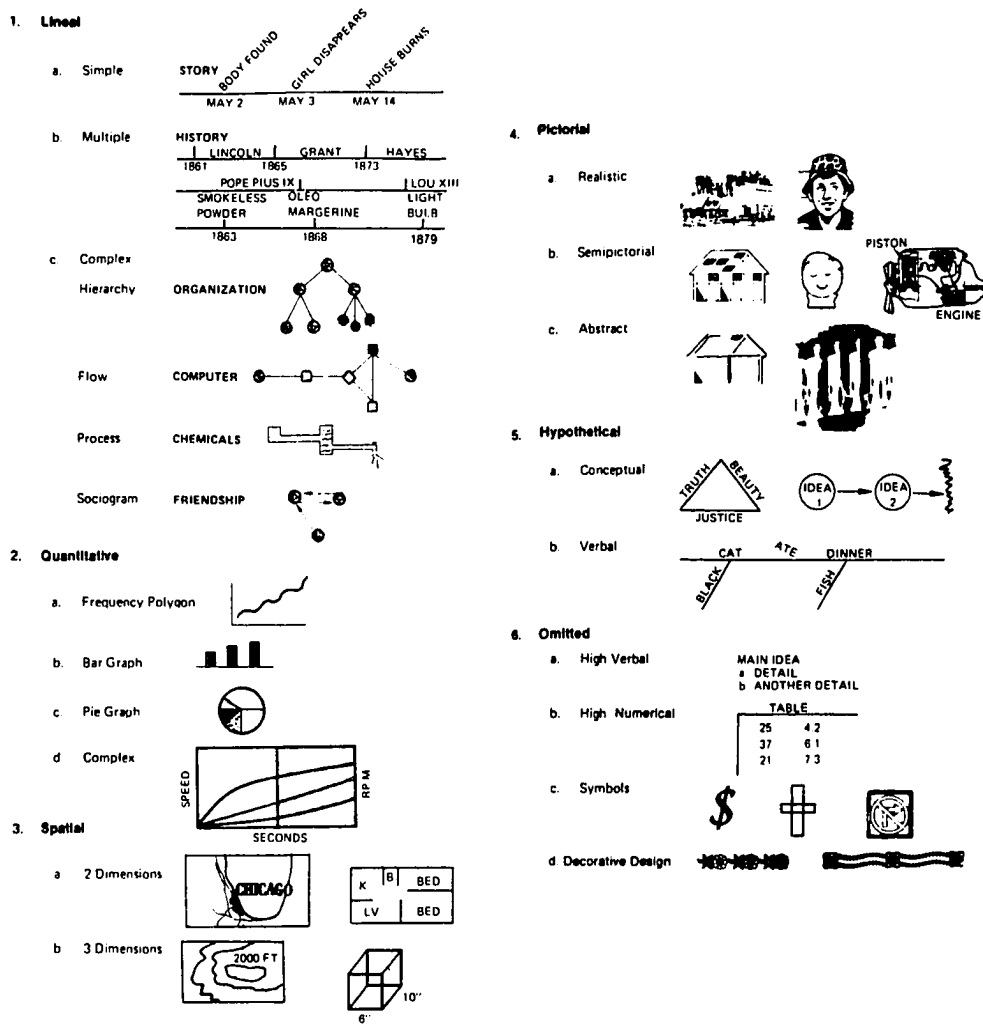
three coding modes are integrated on the four distinct levels: (a) intratextual, which controls the local form, size, posture, and embellishment of textual elements; (b) intertextual, which is coded primarily in the spatial mode, generating visual clues that enhance retrieval; (c) extratextual, which represents spatial and graphic information; and (d) supratextual, which represents the global arrangement and variation of graphics and text within the coherent document. The individual choices at all four levels may not seem novel, but the combined features within the document compose a unique system of visual language dependent upon the context. Kostelnick insisted that the characteristics of text must be able to be used as a basis of communication among designers, technicians, and typists. His framework was supported by reviews of research provided by theorists and practitioners on the intertextual level (Hartley, 1986), the extratextual level (Macdonald-Ross, 1978), and the supratextual level (Welford, 1984).

As in all areas of schema research, the investigation of textual schemata is fragmented. Much research is needed before the general, vague recommendations can evolve into precise, objective guidelines for writing content area textbooks. "But research on content-area text must not stop with the

investigation of text variables. In order to have impact on the practical matter of designing textbooks, researchers must take into account the interaction of text, reader, and criterion task" (Armbruster, 1986, p. 264). Contemporary research has suggested that in the multimedia age these characteristics must also be defined and described clearly enough that they can be used effectively by teachers and students who are both consumers and producers.

Definition, description, and evaluation of these features become increasingly complex when applied to graphics because of the wide variety of graphic forms. Although not exact, the term graphics is still the best word to describe pictorial alternatives to prose. The term is sometimes interpreted narrowly to include only diagrams, graphs, mathematical curves, and charts. A broad interpretation of the term would include anything of a visual nature. The most detailed definition of graphics was provided by Fry (1981), who defined and broadened the term to include five major categories: (1) lineal, (2) quantitative, (3) spatial, (4) pictorial, (5) hypothetical, and (6) intentionally omitted representations. (See Figure 2.) Fry pragmatically described the convenience of graphs and made suggestions for drawing and valuing graphs as a means of improving literacy.

Figure 2. Illustration of the taxonomy of graphs.



Note. From "Graphical Literacy" by E. Fry, 1981. Journal of Reading, 24.

Graphics as pictorial means of simplifying complex ideas are short cuts to comprehension. By manipulating the features of graphics, the use of schemata for comprehension, recall, and retention can be enhanced.

Color Research

Color is the most emotional part of the visual process (Curtiss, 1987). Although color is one of the most significant and perhaps interesting features of text, it is also among the least understood and poorly researched; therefore, investigations into the possible manipulation of color to enhance learning are worthwhile.

Early research showed that color was overrated (Lumsdaine, 1963). A review of the contemporary literature, however, showed that color is used in text for multiple reasons: (a) motivation, (b) aesthetics, (c) understanding, and (d) recall. Suggestions from designers for the use of color in text are based primarily on the first two reasons. The paucity of research about the use of color to aid comprehension and recall was the basis for this study.

There is an overwhelming amount of literature on color, but the research specific to color and learning is contradictory and confusing, while there are few specific coded applications to graphics. Several researchers (Berry, 1975; Chute, 1979; Lamberski, 1980,

1982; Lamberski & Dwyer, 1983) have asserted that, upon first perusal, the general findings relating to color seemed clear; repeatedly, early studies indicated that color in instructional materials did not seem to increase learning. However, they concluded that theorists and practitioners had failed to recognize: (a) the interrelatedness of color as a variable to other components within the learning system, and (b) the flaws in research designs and unbiased experimental materials that prohibited meaningful interpretation of results. The surveyed research presented contradictory evidence for the value of color in active materials (Gropper, 1976) comprised of self-paced materials like posters, comic books, textbooks, programmed instruction, and photographs. The review of literature included the following three studies concerning the manipulation of color in graphics (Dooley & Harkins, 1970; Lamberski, 1982; Scarpino, 1972).

Dooley and Harkins (1970) compared the learning and attention effects of color when color was used as a code and as decoration on bar charts. Three bar charts were displayed on each of three classroom charts: (a) black/white presentation; (b) red, green, and blue presentation; and (c) colored borders around black/white presentation. Results showed that,

regardless of how color was used, it attracted student attention. Although the learning scores were somewhat higher for the red-, green-, and blue-colored charts, the results were not significant. In conclusion, the principal effect of color in this study was motivational, for a black/white code was equally effective as an information transmitter.

Similarly, in a study carried out by Scarpino (1972), control groups were shown black/white charts and overhead projections, while experimental groups were presented colored charts and overhead projections. According to this study, color strategies did not appear to facilitate achievement more than noncolor strategies. This was true for achievement with respect to understanding concepts and problem solving in areas of physical science where color was not a vital part of the physical phenomena and where color was an inherent part of the physical phenomena, such as in the measurement of light and heat. However, Scarpino pointed out that the results could have been due to the increased instructional time received by the noncolor strategy groups who received black and white materials.

Only one of the three studies effectively utilized color as a code in the design of active materials. After reviewing empirical studies, however, Lamberski (1982) attempted to correct the previous errors made in

designing the research and in creating unbiased experimental materials. Based on that analysis, he sought to test the effects of verbal and visual coding strategies on instructional and test materials. Using color and black/white, self-paced learning booklets with simple line drawings, word labels, and prose text, Lamberski measured four cognitive knowledge tasks. Although the use of color in evaluation materials did not affect achievement, color-coded, self-paced instructional materials were superior to the black/white presentation materials on both immediate and delayed posttests.

The results of Lamberski's continuing studies were synthesized into a review of the research on the use of color in the teaching-learning process. Dwyer and Lamberski (1982-83) reported that the learner must engage in extensive coding during information processing. A color-coding process may enable the receiver to retain critical information and to disregard redundant or irrelevant information. An effective, systematic color code assists the reader in organizing and categorizing stimuli into meaningful patterns. According to their review, it remains unclear how color coding affects memory, but Dwyer and Lamberski suggested that the presentation of color in a printed stimulus must assist the information processing

by providing structure. The color code, therefore, must be adequately structured prior to transmission to provide the reader with an efficient set of rules or color strategy.

Finally, although many contradictions appear in the sources Burbank and Pett (1988) cited, after reviewing a broad range of empirical studies on the physiological factors, psychological factors, and learning factors associated with color, the authors tendered the following suggestions for the use of color:

> (a) consider the context in which a color will be viewed--what colors are to be seen simultaneously or sequentially; (b) use the spectral extremes, red and blue, to attract attention; (c) when acuity is important, employ the colors in the middle of the spectrum; (d) for optimum legibility, maintain a high brightness contrast between an image and its background; (e) photographing colored objects demands the use of an appropriate film and judicious lighting to assure good color rendition; (f) saturated cool or warm colors are appropriate for small children; (g) consider the meaning of colors as they relate to audience; (h) to attract attention, use extremes of value or chroma; (i) to achieve harmony, use familiar color schemes, organize carefully, and employ colors with similar attributes; (j) research shows that color creates interest and that people prefer color to black and white; (k) easily named colors aid memory more than colors that have complex names; (l) use color to provide structure, to emphasize relevant cues, to differentiate central from peripheral information, and to make distinctions between elements of a visual. (p. 11)

After a thorough investigation of the design of text, Hartley (1986) stressed consistency if only one

or two colors are to be used. He warned that the designer should resist the overuse of color simply because it is technically possible to use. Similarly, the use of too few colors when text denotes multiple functions may also be problematic.

After analyzing research on the use of color in information systems, Marcus (1986) made the following practical suggestions concerning the use of color:

> (a) use only three to seven colors; (b) use blues for backgrounds and large areas, but not for thin lines and small shapes; (c) avoid placing contrasting colors together, such as red with green, because this can cause afterimages and illusions of shadows; (d) remember that colored areas of greatly different sizes, although created with the same color, may not appear to be the same color; (e) be wary of using colors that are close to each other in value to differentiate information, because changes in ambient lighting can change the perception of hue, brightness, and saturation; and (f) use brighter colors for older viewers. (1986, pp. 7, 12, 14)

Although the study of color has been a popular area of investigation, research seems to have contributed little to the possible role of color in cognitive learning. The failure of researchers to recognize the importance of the interrelatedness of color as a feature in the learning system, flaws in research designs, and biased experimental materials has resulted in an inconclusive, contradictory research base. Thoughtful research is essential to determine the role color plays in learning from text.

Summary

Since a literate person moves beyond the conventions of print to process all possibilities of written information, and the literacy tasks vary according to concept domain, the relationships among constituent concepts, and the format of the text, literacy development becomes the responsibility of all teachers and students in every classroom. In disregard of the obvious demands, publishers, teachers, and students are not instructed to recognize patterns of relationships and organize ideas into appropriate conceptual and textual frameworks. The prevalence of graphics in our media-oriented world makes it imperative to consider graphics a special form of text and graphical comprehension an integral part of the reading process. Graphic designers must learn to manipulate the features of graphics to enhance schematic processing. A solid knowledge of the effects of color on learning would help both designers and readers to utilize all possibilities in reading the information environment.

CHAPTER III

METHODOLOGY

Readers increasingly use graphics to gain information, yet a review of the literature showed that little is known concerning the use of color graphics. Empirical research is necessary to help designers, educators, and readers effectively write and read graphics. The main purpose of this study, therefore, was to determine the effects of the use of a systematic color code in graphic presentation and assessment on the reader's recall and retention of a graphic summarizing a myth.

Null Hypotheses

The following null hypotheses were formulated on the research questions presented in chapter 1:

1. There will be no significant interaction among the graphic presentation type (systematically color-coded or black/white), the graphic assessment type (systematically color-coded or black/white), and the time of testing (immediate recall or delayed retention) of verbal material.

2. There will be no significant interaction between the graphic presentation type (systematically color-coded or black/white) and the graphic assessment

type (systematically color-coded or black/white) when immediate recall of verbal material is tested.

3. There will be no significant interaction between the graphic presentation type (systematically color-coded and black/white) and the graphic assessment type (systematically color-coded or black/white) when delayed retention of verbal material is tested.

4. There will be no significant difference in recall of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation.

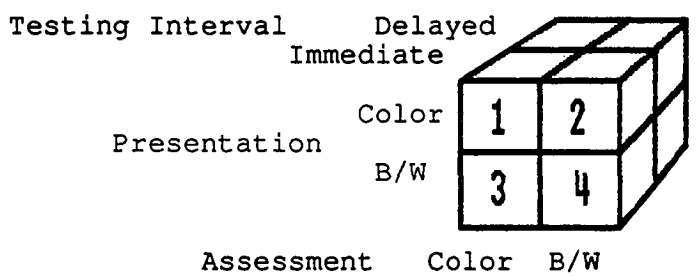
5. There will be no significant difference in retention of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation.

6. There will be no significant difference in recall of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment.

7. There will be no significant difference in retention of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment.

Research Design

The research design was a 2 x 2 x 2 factorial with repeated measures on the final factor. The independent variables to be manipulated were the type of graphic presentation (color-coded or black/white), the type of graphic assessment (color-coded or black/white), and time of testing (immediate recall and 2-week delayed retention). The dependent variable was recall/retention. The dependent measure was the achievement on the assessment graphic. The achievement score was the number of characters, events, and explanations that were recalled and retained. To accommodate three independent variables, with two levels each, the following 2 x 2 x 2 (presentation x assessment x time of testing) factorial design was used:



Each randomly assigned subject appeared in only one of the four treatment groups (1, 2, 3, and 4) for both recall and retention.

Presentation and assessment were the between-subjects factors, and recall/retention was a within-subjects factor. The three-way factorial design allowed the researcher to test hypotheses about three independent variables, their two-way interactions, and their three-way interaction.

Subjects

The study was determined to be exempt from review by the Human Subjects Review Board, and permission was granted by the local school administration to use the entire seventh-grade class from a Midwest junior high school with 495 students in Grades 7-9 for this study. The selection of a junior high population helped to ensure that the students had not received instruction in the use of schema-based graphic designs or the use of color to direct attention in text or as an aid to recall. A review of the curriculum guide for the junior high school indicated the students had not had prior instruction in graphic forms other than those traditionally used in study skills (maps, charts, graphs), and the instruction concerning the use of color was limited to aesthetic uses in the arts. Each of the nine seventh-grade homerooms, containing a total of 197 students, was randomly assigned to one of four treatment groups (adjusted n = 33). From the

treatment group comprised of three homerooms, subjects were selected according to a table of random numbers and reassigned other homerooms, thus equalizing the number of subjects in the four treatment groups. Treatment Group 1 received a color-coded presentation and was tested with a color-coded assessment. Treatment Group 2 received a color-coded presentation and was tested with a black/white assessment. Treatment Group 3 received a black/white presentation and was tested with a color-coded assessment. Treatment Group 4 received a black/white presentation and was tested with a black/white assessment. Although 197 seventh-grade students were assigned to the treatment groups, 33 students were absent during one of the two testing sessions, and 4 students were withdrawn from the school during the interim between the first and second assessments; consequently, 160 subjects participated in the study. All 160 subjects were tested so that students would not feel they had been singled out for the study. Later, the assessments of subjects from the learning disabilities contained classrooms (LDCC), subjects with color discrimination problems, subjects with prior knowledge of the myth used in the presentation and assessment materials, and subjects reported by their teachers as not trying were

dropped from the study. Two subjects were randomly eliminated from the color-coded presentation/ color-coded assessment treatment group, so all treatments had the same number of subjects (n = 33). After these exclusions, the 132 remaining students comprised the subjects of this study.

Procedures

Treatment Groups

Each homeroom class was randomly assigned to one of four treatment groups:

1. Color-coded presentation, color-coded assessment
2. Color-coded presentation, black/white assessment
3. Black/white presentation, color-coded assessment
4. Black/white presentation, black/white assessment.

During their homeroom session, all students received directions and listened to the myth via audiotape (see Appendix A), studied the graphic presentation, and demonstrated both recall and 2-week delayed retention on the graphic assessment. In this way, the researcher helped to control for contamination, since all students were actively engaged

in the study at the same time. Also, the use of homeroom time helped eliminate the possibility that students would associate the tasks with the content of the regular classroom; this could have been potentially problematic in courses like social studies and art, where students may have had some experiences with graphics and color.

Materials

The packets distributed to each subject were comprised of an envelope containing a graphic assessment, either color-coded or black/white, with an affixed presentation graphic of an old Norse myth, either color-coded or black/white, turned face down on top of the envelope. The graphic design was the same on all presentations and assessments (see Appendix B); the form of the graphic was a unique design created by the researcher to prevent the subjects from having prior experience with the graphic. To further ensure that the experimental materials were unbiased, the content was comprised of brief summary statements (characters, action, and what the myth explains) taken from a little-known Norse myth. As further assurance that the subjects had no prior experience with the graphic, they were asked two questions concerning their familiarity with the graphic and the content of the

myth. The subjects who had prior knowledge of the myth were eliminated from the study, and no subjects reported they were familiar with the graphic. The systematic color code was explained to all subjects who received color presentations and was selected to create a pattern in the reader's mind: red was used to code those components of the myth that represented mortal actions; blue was used to code those portions of the myth representing the actions and plans of the immortals; and yellow was used to code the references to nature in the myth.

Responsibilities of Administration

On the first day of the experiment, following the homeroom announcements, each subject received a packet containing a presentation and an assessment. Teachers were given detailed instructions and were responsible for monitoring the experimental procedures (see Appendix C) as subjects listened to the audiotape of the directions and myth, studied the graphic presentation for 7 minutes, and recorded their versions of the summary statements onto the assessment during a 10-minute response period. Two weeks later, homeroom teachers asked subjects to complete a second assessment to demonstrate retention.

Analysis

All assessments were scored by two raters to ensure accuracy (see Appendix D). The range of scores was 0 to 84. One point was given for each correct word or acceptable synonym. One point was given for each box or area (referring to the areas containing phrases at the far right) where all of the words were written in order and spelled correctly. One point was also given for each word or phrase that was placed in the correct box or area.

A repeated measures analysis of variance with appropriate tests of simple interactions and main effects was used to test the seven hypotheses. The specified level of significance was .05, meaning that successive replications of this investigation should provide mean significant differences on 95% of the comparisons performed. The same significance level was used for all study comparisons.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this research was to study the effects of the use of a systematic color code in graphic presentation and assessment on the reader's immediate recall and delayed retention of verbal material. A review of the related literature led to the seven following research hypotheses:

Hypothesis 1. There will be a significant interaction among the graphic presentation type (systematically color-coded or black/white), the graphic assessment type (systematically color-coded or black/white), and the time of testing (immediate recall or delayed retention) of verbal material.

Hypothesis 2. There will be a significant interaction between the graphic presentation type (systematically color-coded or black/white) and the graphic assessment type (systematically color-coded or black/white) when immediate recall of verbal material is tested.

Hypothesis 3. There will be a significant interaction between the graphic presentation type (sytematically color-coded or black/white) and the graphic assessment type (systematically color-coded or

black/white) when delayed retention of verbal material is tested.

Hypothesis 4. There will be a significant difference in recall of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation.

Hypothesis 5. There will be a significant difference in retention of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation.

Hypothesis 6. There will be a significant difference in recall of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment.

Hypothesis 7. There will be a significant difference in retention of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment.

To test the hypotheses, a 2 x 2 x 2 (presentation type x assessment type x time of testing) factorial design was used with repeated measures on the final factor. The analysis employed a repeated measures analysis of variance. The measure of performance used

was the number of elements correctly identified on the graphic assessment.

Analysis of the Three-way Interaction

It was hypothesized that there would be a significant interaction among the three factors of graphic presentation type (systematically color-coded or black/white), graphic assessment type (systematically color-coded or black/white), and the time of testing (immediate recall and delayed retention) of assessing verbal information. The data that entered into that test appear in Table 1.

A survey of the data disclosed important findings. A comparison of the means and standard deviations for the four treatment groups derived from assessments made at two times revealed that the subjects who were given the color-coded presentation and color-coded assessment produced the highest scores on both the test of immediate recall and the test of delayed retention. Their mean score on the test of immediate recall was 60.70 (SD = 14.09), and their mean score on the test of delayed retention was 25.36 (SD = 16.35). In striking contrast were the mean scores of those subjects who were given a black/white presentation and color-coded assessment. This group produced the poorest achievement on both tests; their

Table 1

Mean Performance at Recall and Retention for Each Treatment Group

Group	Time of Testing			
	Recall		Retention	
	M	SD	M	SD
Color presentation				
Color assessment	60.70	(14.09)	25.36	(16.35)
Black/white assessment	50.30	(18.76)	23.79	(20.74)
Black/white presentation				
Color assessment	46.21	(13.43)	13.97	(10.88)
Black/white assessment	53.76	(17.72)	19.00	(15.29)

Note. n = 33 for each group.

mean score on the test of immediate recall was 46.21(SD = 13.43), and their mean score on the test of delayed retention was 13.97 (SD = 10.88).

Furthermore, the treatment group with the second highest immediate recall (M = 53.76, SD = 17.72) received a black/white presentation and black/white assessment. If only the recall scores had been considered, it would have appeared that matched

presentation type and assessment type produced the higher mean scores, with consistent color coding as the preferred treatment; also, it would have appeared that the mixed presentation/assessment types produced the lower mean scores, with the introduction of color delayed until assessment as the less preferable treatment. However, when the results of the tests of delayed retention were inspected, the findings suggested that presentation type had more impact than assessment type. Subjects who were given a black/white presentation and black/white assessment earned the second highest mean scores on the test of immediate recall. With a mean score of 53.76 (SD = 17.72), they scored above the subjects who were given a color-coded presentation and a black/white assessment and who earned a higher mean score of 50.30 (SD = 18.76) on the test of immediate recall. The reverse was true for delayed testing. Those subjects who received a color-coded presentation and black/white assessment earned the second highest mean score on the test of retention. With a mean score of 23.79 (SD = 20.74), they ranked above the subjects who were given a black/white presentation and black/white assessment and who earned a mean score of 19.00 (SD = 15.29) on the test of delayed retention. When the test of retention was delayed, the treatment groups that received

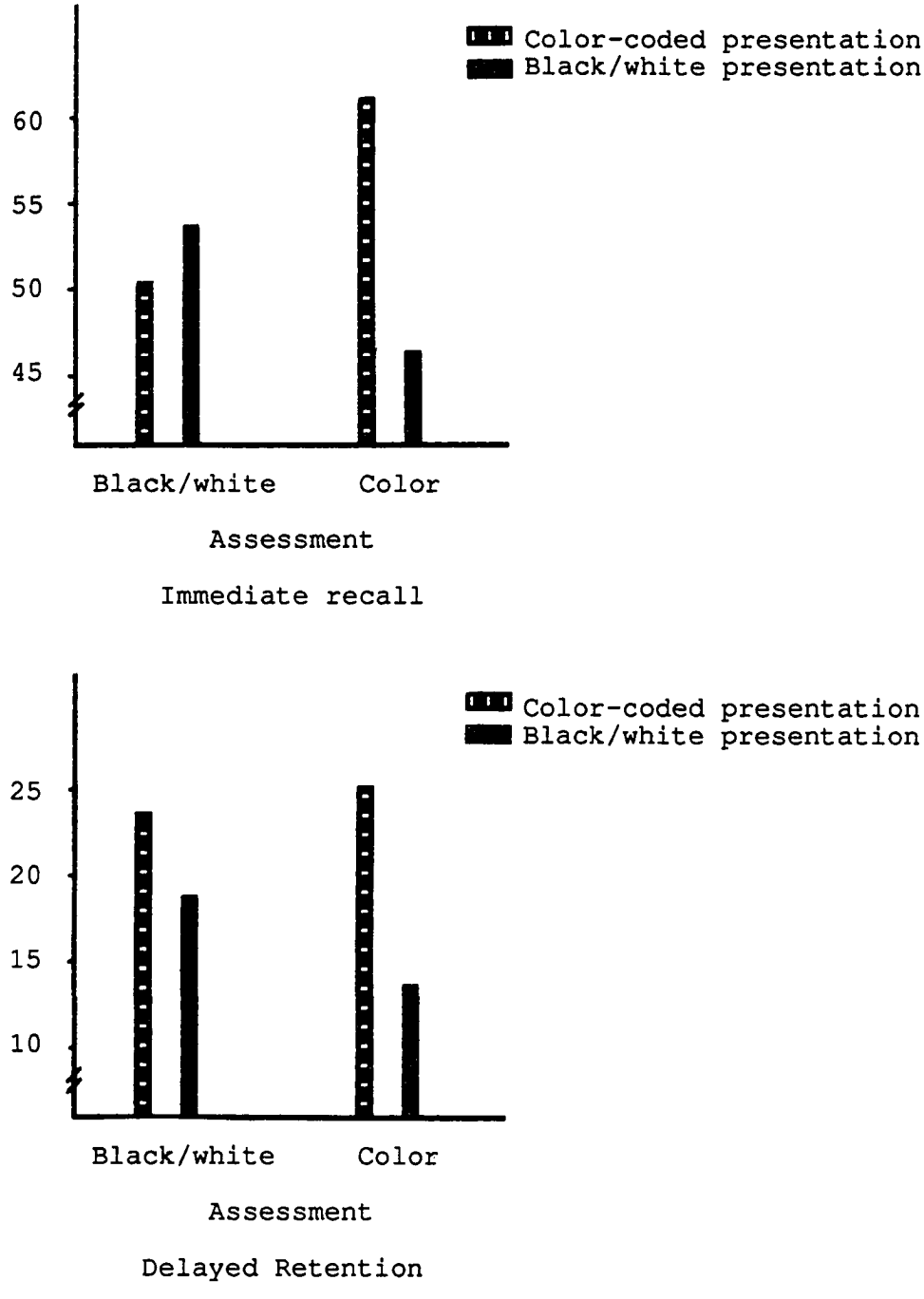
color-coded presentations scored higher than those who received black/white presentations, without regard for the assessment type received.

When analyzed using an analysis of variance for repeated measures, the three-way interaction was significant, $F(1,128) = 5.32$, $p = .02 < .05$. Therefore, in this study there was an interaction, and the null hypothesis that there would be no interaction among graphic presentation type, graphic assessment type, and time of testing (recall and retention) of verbal information was rejected at the .05 level. This interaction is portrayed graphically in Figure 3.

The graphic display of the means and standard deviations for the four treatment groups tested for recall and retention shows that a match in presentation/assessment type increased immediate recall. However, the nature of the presentation alone apparently had a greater impact on delayed retention.

The presence of a significant three-way interaction strongly suggested differing effects of two-way interactions at each level of the independent variable of time of testing. A two-way analysis of variance was then performed in order to test the reliability of the simple two-way interactions at each testing time.

Figure 3. Three-way interaction of presentation x assessment x time of testing.



Analysis of the Simple Two-way Interactions

Recall Performance

Performance scores for each presentation type as a function of assessment type were plotted separately for tests of immediate recall and delayed retention in Figure 3. The results suggested that the source of the three-way interaction was the presence of an interaction between presentation type and assessment type on the test of immediate recall and the absence of one at retention. When analyzed using a general linear models procedure for analysis of variance, the interaction between presentation type and assessment type on the test of immediate recall was significant, $F(1,128) = 10.17$, $p = .01 < .05$. Therefore, the null hypothesis stating that there would be no significant interaction between the graphic presentation type (systematically color-coded and black/white) and the graphic assessment type (systematically color-coded and black/white) when immediate recall of verbal material was tested can be rejected at the .05 level.

The data in Figure 3 also showed that those subjects who received color-coded presentation and black/white assessment earned a mean score of 50.30 ($SD = 18.76$); those subjects who received the color-coded presentation and color-coded assessment earned a higher mean score of 60.70 ($SD = 14.09$).

Subjects given a black/white presentation and black/white assessment earned a mean score of 53.76 (SD = 17.72); the subjects who received a black/white presentation and were tested with a color-coded assessment earned a much lower mean score of 46.21 (SD = 13.43). In summary, the simple two-way interaction of presentation as a function of assessment for the test of recall showed that when presentation type and assessment type matched, subjects demonstrated better recall than when presentation and assessment type differed.

Retention Performance

No significant interaction between graphic presentation type and graphic assessment type was present in the test of delayed retention, $F(1,128) = 1.37$ $p = .24 > .05$. Therefore, the null hypothesis stating that there would be no significant interaction between the graphic presentation type (systematically color-coded or black/white) and graphic assessment type (systematically color-coded or black/white) when delayed retention of verbal material was tested cannot be rejected at the .05 level. During the delayed test of retention, both color-coded presentation groups scored higher than the black/white presentation groups; therefore, the type of presentation was the critical factor rather than the match of assessment type to

presentation type. Subjects who received color-coded presentation and black/white assessment earned a mean score of 23.79 (SD = 20.74), and subjects given the color-coded presentation and tested with a color-coded assessment earned a slightly higher mean score of 25.36 (SD = 16.35). Subjects given a black/white presentation and a black/white assessment earned a mean score of 19.00 (SD = 15.29); the subjects receiving the black/white presentation and tested with a color-coded assessment also earned a lower mean score of 13.97 (SD = 10.88). Absence of an interaction between presentation and assessment type at the time of delayed testing suggested a general advantage for verbal information presented with a systematic color code. Apparently, the three-way interaction was due to the presence of an interaction between graphic presentation type and graphic assessment type only during immediate recall testing, reflecting an advantage for matching presentation type and assessment type on immediate testing, and the absence of an interaction at delayed testing, reflecting a general superiority at retention of information presented with a systematic color code.

Additional Two-way Interactions

Neither of the two-way interactions involved with the variable of time was significant. Using the repeated measures analysis of variance and the

statistics for Wilks' Lambda, the interaction of time and presentation resulted in $F(1,128) = 1.10$, $p = .30 > .05$. The same test applied to the interaction of time and assessment resulted in $F(1,128) = 1.65$, $p = .20 > .05$. The results of the additional analyses showed the interaction of time was significant only in the higher order interaction (see Tables 2 and 3).

If assessment type was not considered, color-coded presentation was more effective than black/white presentation during both the testing of immediate recall (color $M = 55.50$; black/white $M = 49.98$) and the testing of delayed retention (color $M = 24.58$; black/white $M = 16.48$). Consequently, the interaction between graphic assessment type and testing time was not significant, $F(1,128) 1.65$, $p = .20 > .05$. When assessment type, irrespective of presentation type, was considered as a factor of the testing time, color assessment reflected an advantage over black/white only at recall (color $M = 53.46$; black/white $M = 52.03$). The reverse (color $M = 19.67$; black/white $M = 21.39$), although not significant, was true at retention.

Analysis of Simple Main Effects

In order to further investigate the two-way interactions, simple main effects were analyzed. A two-way analysis of variance at each testing interval

Table 2

Mean Performance at Recall and Retention as a Function of Type of Presentation Graphic

	Presentation Type	
	Color	Black/white
Recall	55.50	49.98
Retention	24.58	16.48

Note. n = 66 for each group.

Table 3

Mean Performance at Recall and Retention as a Function of Type of Assessment Graphic

	Assessment Type	
	Color	Black/white
Recall	53.46	52.03
Retention	19.67	21.39

Note. n = 66 for each group.

yielded tests of the simple main effects of graphic presentation type and of graphic assessment type.

Simple Effects at Recall

It was hypothesized that there would be a significant difference in the recall of verbal material between those given a color-coded graphic presentation and those given a black/white graphic presentation. An analysis of variance for immediate recall noted that the two presentations, color-coded and black/white, resulted in $F(1,128) = 3.84$, $p = .05$. Consequently, at recall the main effect of presentation type was not significant, and the null hypothesis stating there would be no significant difference in the recall of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation cannot be rejected at the .05 level. Apparently, the method of presentation is not critically important when a short retention interval is employed.

It was further hypothesized that there would be a significant difference in recall of verbal material between those given a color-coded graphic assessment and those given a black/white graphic assessment. An analysis of variance for immediate recall showed the two assessments, color-coded and black/white, resulted in an $F(1,128) = .26$, $p = .61 > .05$. Consequently, the

variable of assessment type was not significant, and the null hypothesis stating that there would be no difference in the retention of verbal material between those given a color-coded graphic presentation and those given a black/white graphic presentation cannot be rejected at the .05 level. Failure of either factor to yield a significant effect was expected in the presence of significant interactions.

Simple Effects at Retention

It was also hypothesized that there would be a significant difference in retention of verbal material between those given a systematically color-coded graphic presentation and those given a black/white graphic presentation. An analysis of variance for delayed retention was used to analyze the effect of the two presentation types, color-coded and black/white. The result was $F(1,128) = 8.23$, $p = .01 < .05$. Consequently, the variable of presentation type, color-coded and black/white, was significant, and the null hypothesis stating that there would be no difference in the retention of verbal material between those given a color-coded graphic presentation and those given a black/white graphic presentation can be rejected at the .05 level.

Finally, it was hypothesized that there would be no significant difference in retention of verbal

material between those given a color-coded graphic assessment and those given a black/white graphic assessment. An analysis of variance for delayed retention noted that the two assessments, systematically color-coded and black/white, resulted in $F(1,128) = .38$, $p = .54 > .05$. Consequently, the variable of assessment type was not significant, and the null hypothesis stating that there would be no significant difference in retention of verbal material between those given a systematically color-coded graphic assessment and those given a black/white graphic assessment cannot be rejected at the .05 level. Analysis of variance tables are included in Appendix E.

Discussion

A return to schema theory is essential to the discussion of these results. Although schema theory was not formulated to explain graphics, it makes intuitive sense to draw parallels between the building blocks of memory used in verbal learning and those used in graphical comprehension. For example, one result of this investigation was that immediate recall of verbal material was facilitated by a match of the type of graphic presentation and that of the assessment. Rumelhart and Norman (1978) stated that the unpacking of schema in recall is the most efficient if it is top-down. In the top-down analysis, major structural

aspects appear before the details. In this study the graphic format, assumed to be a major structural aspect, could be retained because color acted as an overall organizer. Furthermore, Rumelhart and Ortony (1977) suggested that presenting information in a structured form most closely resembling the structure of the schema which will be required for remembering will maximize the appropriateness of the interpretation and minimize the processing required. Rumelhart and Ortony's use of the term structured form can readily be interpreted to mean graphic form.

Since the color code used in presentation for this study had the greatest effect on performance at delayed retention, this research provided some support for the conclusions of schema theorist Rumelhart (1984) who suggested that the longer the amount of time between the presentation and recall of information, the fewer memorial fragments are available and the greater the reliance on the subject's previously established schemata. His conclusion is based, in part, on the research of Spiro (1977), who discriminated between inferences drawn at the time of comprehension and those drawn at a later time. In Spiro's study, all subjects read stories that they were led to accept as the truth, but some subjects were given a piece of inconsistent information following the reading. When later asked to

recall the story, there was a tendency for those subjects who had been given the inconsistent information to distort the original telling of the story to make it consistent with the later information. Due to their distortions, those subjects were unable to provide the episodic information from the text; instead, they relied on their previously established knowledge of a generic or general schema.

A global look at the findings of this study showed that schema theory does not explain the difference in the effect of the use of color coding at different retention intervals. It appeared that, for immediate testing, either structure provided an adequate system for recall. Over time, however, those subjects who received the systematic color code had an advantage in demonstrating delayed retention. Whereas schema theory explains the findings of this study at the testing of recall, it falls short of explaining the differences found between the testing of recall and the testing of retention.

In this study, there was also some evidence that the description of the color coding that explained the specific use of colors influenced the conceptual knowledge or schemata the subjects were able to apply. The fact that 4 students who had been given color-coded presentations chose to write color names on their

black-white assessment was informative; the fact that 3 of them wrote the color names only beside the words man, nature, and gods was even more revealing, for the oral directions specifically using red, yellow, and blue in describing the coding may have impacted the schema developed by the learner. This suggested that the code was essential, and a random assignment of colors to the graphic may not have produced the same empirical results.

The results of this study suggested that consistency of the color code in graphic presentation and assessment and later the application of color coding in graphic presentation created a cognitive template for the development of individual schemata and thus produced significantly improved retention. These results, like the noteworthy investigations of Lamberski (1982) in investigating the effects of color on immediate recall and delayed retention, pointed to the significance of color-coded presentation materials on both immediate recall and delayed retention. Whereas Lamberski found that the color coding of evaluation materials did not affect achievement, the match of presentation type and assessment type (color-coded and black/white) increased scores of subjects on immediate recall in this study. The effective use of the color code in this study may have

been influenced by its application to a graphic for which the subjects had no prior knowledge, unlike Lamberski's familiar graphic depicting the chambers of the heart.

Replication of this study, with modifications, to attempt further controls, to use color as a cue rather than a code, and to experiment with the other features of graphics could be enlightening. Although the results of this research indicated that a color code applied to graphics improves the reader's retention, as Lamberski suggested, this efficacy may result in part from uncontrolled factors like sustained student attention, the demand to understand the concepts upon which the code was based, or the enhanced associative memory structures or visual schema provided for the reader. Further research should also include the application of simple color cues in graphics, as opposed to the use of a systematic color code, to determine if color not associated with content could be as effective in producing enhanced retention. The manipulation of other features, such as italics, spacing, underscoring, and additional methods of coding without color, also deserves the attention of researchers to bear out the assertion, based on what is known at this time as a result of this study, that the additional expense incurred in the production of color

graphics is justifiable, for it increases reading retention.

CHAPTER V

SUMMARY, RECOMMENDATIONS, AND IMPLICATIONS

The ability to read and write information in graphic forms becomes an essential skill for a literate person as the literacy demands of a technological society continue to expand. Because the requirements of literacy are vastly divergent in a world of changing context, schema-based strategies for reading and writing graphics could provide a flexible approach to the interpretation of information in our environment (Rumelhart & Norman, 1978). Hence, manipulation of the essential characteristics of graphics must be at the command of readers, educators, and designers in their quests of understanding, instruction, and production. Experimentation is needed to identify the critical features of graphics that can be manipulated to enhance learning, for reliable knowledge of graphics applied intelligently will improve communication (Macdonald-Ross, 1978) and understanding.

Color is an important characteristic of text when it is coded for meaning. Furthermore, color appears to be related to the interaction between the reader and the text (Dwyer & Lamberski, 1982-83). To advance our knowledge of the reading of graphics, this study was designed to investigate the effects of a use of a color

code in graphic presentation and assessment on the reader's immediate recall and delayed retention of verbal meaning.

The entire seventh-grade class from a Midwest junior high school with 495 students in Grades 7-9 was used in this study. Each of nine seventh-grade homerooms, containing a total of 197 students, was randomly assigned to one of four treatment groups (adjusted $\underline{n} = 33$).

An analysis of variance for repeated measures was used to test the hypotheses. The independent variables manipulated were the type of graphic presentation (systematically color-coded or black/white), the type of graphic assessment (systematically color-coded or black/white), and time of testing (immediate recall and two-week delayed retention). The dependent variable, recall/retention, was measured by the achievement on the assessment graphic. The achievement score was the number of characters, actions, and explanations that were remembered and recorded. To accommodate three independent variables, with two levels each, a 2 x 2 x 2 (presentation x assessment x time of testing) was used. Presentation type and assessment type were the between-subjects factors, and recall/retention was the within-subjects factor. These data were analyzed using repeated measures analysis of variance.

Summary

Based on the results of the analysis of variance with the level of significance established at the .05 level, there was a significant three-way interaction among graphic presentation and graphic assessment and time of testing. When time was considered, there was an interaction between the color code used in presentation and the color code used in assessment on the immediate recall of verbal information. Since the presence of a significant three-way interaction suggested the presence of different interactive effects at different levels of one independent variable, simple two-way interactions within each level of testing time were analyzed. Analyses indicated that the source of the three-way interaction was the presence of an interaction between graphic presentation type and graphic assessment type at immediate recall, and the absence of a comparable interaction at the retention test. Consequently, there were two major findings of this study:

1. At immediate recall, the important factor in enhancing performance appeared to be the match between graphic presentation and assessment types, rather than the presence or absence of a color code. However, there was a slight overall advantage for having a

matched systematic color code in both graphic presentation and assessment.

2. At delayed retention, the important factor in enhancing performance appeared to be the presence of a systematic color code in graphic presentation. The additional presence of a color code in graphic assessment produced a slight advantage.

Recommendations for Practice

The findings of previous research, viewed in conjunction with the findings of the present investigation, were used to generate the following insights and recommendations. Because the match of presentation and assessment type had an impact on the immediate recall of verbal information presented in graphic form and color-coded graphic presentation proved advantageous in later tests, the use of color in graphics should be considered when developing curriculum, planning instruction, and designing text. The code should be thoughtfully created to enhance and extend schema development.

A precursor to considering the use of color in graphics must be the integration of graphic and visual literacy into the school curriculum. The many definitions and areas of visual literacy have led to its use in a diversity of curricular areas. Robinson (1991) suggested that, although art courses could

provide instruction in visual literacy, visual literacy development also could be a part of language and literacy curricula and fit into language arts, English, and reading courses. Since problem solving, communications, and even computer literacy are also enhanced through visual literacy development, the concepts of visual literacy could be taught in math, social science, and computer courses as well.

This research adds support to schema theory by making a strong parallel to graphic conceptual schema. Therefore, graphic schema strategies that include a color code should be used across the curriculum when planning for instruction. Strategies that enhance the use of schema in performing complex cognitive tasks allow learners to categorize information by concept domains, develop conceptual hierarchies for information that is to be processed, and formulate relationships between concepts (Gallini, 1989). Schema development allows the reader to see patterns in text that tap the existing knowledge structures. Marzano (1988) stated that:

> Graphics can be used to synthesize complex information from diverse sources efficiently, helping students to identify patterns and relationships that are otherwise difficult to apprehend and can help the user to generate information about the structure and relationships among parts that may not have been clear in the original nongraphic information. (p. 86-87)

This study also extends beyond schema theory to indicate color is a key feature in the pattern to be considered when developing curriculum and planning for instruction.

The results of this study show the need for color-coded patterns in graphic presentation and assessment. The code should be carefully designed and fully explained to facilitate learning and retention of verbal material and, thereby, promote literacy. The efficacy of the color code may be determined by the logic used in designing the color pattern which may sustain student attention and interaction along with the content and its associated memory structure. The findings of this study regarding significantly improved retention of subjects presented with color-coded materials should provide the impetus necessary for developing improved graphic design enriched with color.

Graphic design can be enhanced through color to help the learner translate, categorize, and link incoming information for improved learning and retention. It is imperative that designers of educational materials, whether textbook designers or teachers producing their own classroom materials or students designing their own study guides and notes, use color to enhance schema for processing and retaining content. Based on the results of this study,

the purpose of graphic design, to facilitate understanding and immediate recall or long-term retention, must be a central consideration for the designer, and the color code should be determined by that purpose. Designers, teachers, and students must let the purpose of learning drive the design and the design carry the burden of memory for future use of graphically presented verbal information.

Implications for Future Research

To continue this line of research, it is recommended that future study focus on color and graphics:

1. Research should be conducted to investigate how skilled readers use color to remember patterns in schemata. This research should include quantitative, as well as qualitative, ethnographic research and case studies of readers considered to be at an expert level. The results would have implications for the graphic schema strategies we teach to students.

2. Research should include experimentation with both cuing and systematic coding using different colors and varying numbers of colors in graphic background and print to see what impact these variables have on immediate recall and delayed retention.

3. Research should include the use of a color code in other graphic presentations and assessments to

see if similar results are produced using a variety of both new and familiar graphic presentations and assessments.

4. Research should include experimentation with the reading of graphics unaided by a listening component to see if similar results are produced with and without a listening activity.

5. Finally, there should be further research into the other features of graphic presentations and assessments to determine the comparative efficacy of other graphic features in tapping and developing schemata. This research should indicate whether other features in the graphic design are effective in producing increased immediate recall and delayed retention of verbal material presented in graphic form. The results of further research would provide valuable information for readers, teachers, and designers of curricular materials at all levels of the learning spectrum.

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APPENDIX A

Script for Audiotape

Script for Audiotape

Directions:

You will be participating in a study that will help educators to understand better how students remember information. Not only will your participation play an important part in educational research, but the myth you will hear should be fun to recall now and in the future. Do your best to listen carefully to the explanation and to the myth.

Explanation:

A myth is a story of the acts of superhuman beings. Although these stories are improbable to us now, the ancient myths were believed to be true by those who originally told them. The ancient myths of many cultures are highly imaginative explanations to account for the world of nature and for the facts of life as experienced by man in an age when scientific study was practically unknown. When the ancient people could not scientifically explain why they grew old, why the mountains rumbled, or why the seasons changed, they made up stories of all-powerful gods and goddesses they could either thank or blame for the happenings. The explanations they created are artistic, too, for they allow us to see beauty in things we often regard as ugly.

Not only is a knowledge of mythology the mark of an educated person, but witnessing the wild imagination of the ancient people can be great fun. Since the ancient myths were handed down by word of mouth for a long time before the poets put the stories into writing, this myth will first be presented to you orally. After listening to the myth, you will be challenged to remember key points that will be listed on a brief chart.

Now, enjoy listening to the ancient Norse myth called "The Kidnapping of Idun."

Myth:

The Aesir, the 12 most powerful gods in Norse mythology, were proud of their youthful control over mankind and less powerful gods. The power of the Aesir came, in part, from their eternal youth. The lesser goddess Idun had in her possession the most priceless treasures of the gods--certain apples that restored youth to those who ate them. For this reason, the powerful Aesir were fearful of losing her. On one occasion, when Idun had been carried off by the giant Thjazi, the gods were desperate for her return.

As the powerful Aesir felt the effects of old age, they met in council to discuss the disappearance of Idun and her magic apples. When they discovered Idun

was last seen with Loki, an enemy god of lesser power, they summoned him to their council and threatened him with torture and death. Loki became so frightened by the all-powerful Aesir that he promised to bring Idun back, on one condition. His request to borrow a falcon disguise from them was immediately granted. Once transformed into a falcon, Loki spread his wings and flew off to Thjazi's estate to rescue Idun and her magic apples. Thjazi happened to be at sea fishing when Loki arrived; Idun was home alone. Loki swiftly transformed Idun into a nut and made off with her as fast as he could fly. But just as the falcon flew from Thjazi's estate toward the Aesir's council hall, Thjazi returned. When the giant did not find Idun at his estate, he turned into an eagle and set out to pursue the disguised Loki. Little by little the eagle gained on the falcon.

When the gods saw the falcon drawing near in flight, they burst into celebration, but when they saw the eagle close behind, they quickly gathered a heap of wood shavings outside the walls of the palace. At the very moment the falcon carrying the nut came inside, they kindled the fire. The falcon carrying the nut was unharmed, and Idun and Loki were once again transformed into their human likenesses in safety. The eagle was

unable to come to a stop before it was directly above the bonfire. The eagle's wings burst into flames. This is how the disguised giant Thjazi came under control of the gods. To show Thjazi's family, and indeed to remind all of mankind and the lesser gods that the Aesir were all-powerful, the council of 12 cast Thjazi's eyes into the sky. As Thjazi's eyes were hurled upward, they were transformed into stars that can still be seen in the night sky today.

Directions:

Now, remove the sheet from the top of your envelope and turn it over. During the next 7 minutes, study the chart that summarizes the myth. Please notice the three headings: "characters," "action," and "this myth explains." Follow along as the chart is read aloud to you. (Chart is read.)

Reread the chart several times, and try to remember all of the details listed in the order they are presented. In 7 minutes and again in 2 weeks you will be given a blank chart and asked to record as much of the myth as you remember. The best way to study is to avoid distractions, focus on your chart, and try to visualize your chart in your mind as you study.

(This paragraph read only on the tape for subjects receiving color-coded presentations.) The chart has a

colored background to help you recall the details, for a pattern is created by the color. You will find that all items with blue backgrounds relate to the Aesir; under characters, the Aesir are listed; all actions in blue start with the Aesir; and the explanation in blue says gods. Blue is an appropriate background color for the gods because blue can be associated with royalty. The items that relate to the lesser gods or mankind are listed in red; the listing of characters includes Idun, Loki, and Thjazi. The actions shown in the red backgrounds start with the names Thjazi or Loki. The explanation in red is labeled man. Red is an appropriate color for the lesser gods and mankind because red can be associated with the bloodshed when gods, lesser gods, and mankind clash. Also note that the single action and explanation in yellow both refer to nature, including Thjazi's eyes and the stars. Yellow is an appropriate background color because yellow can be associated with nature, and in this case it is an excellent color for the stars.

Everyone, please review and memorize the details on the chart now.

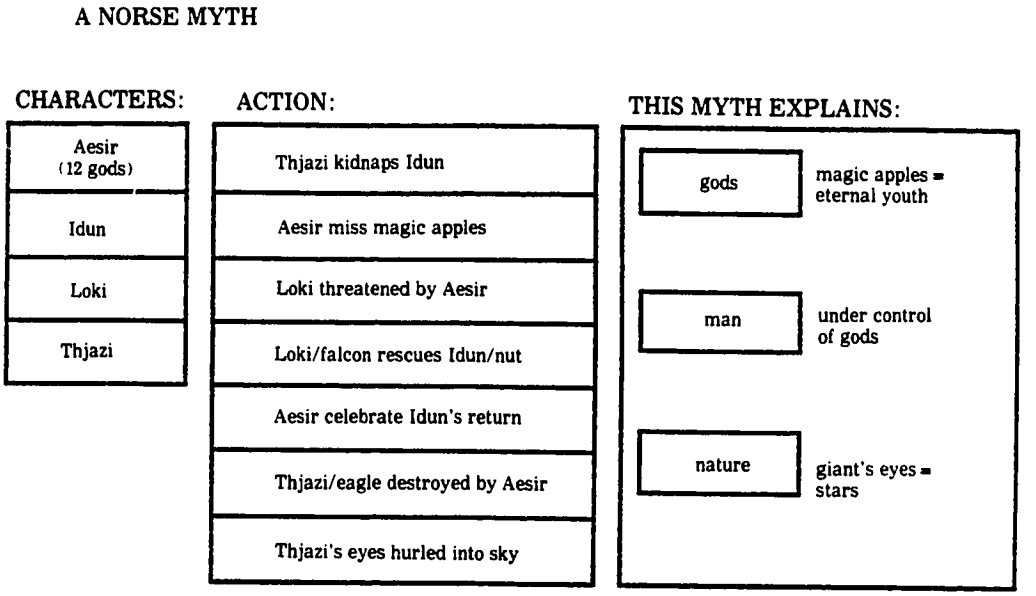
(After 7 minutes have elapsed) Please turn your chart over and place it on the upper right-hand desk corner. It will be collected by your homeroom teacher.

Now remove the blank chart from inside of your envelope. Using a pencil, record the details of the myth on the chart; try to use the exact words in the order they appeared on the original chart. If you cannot remember the precise words or their accurate spellings, just write the general ideas and spellings as you remember them. You have 10 minutes to record your answers.

APPENDIX B

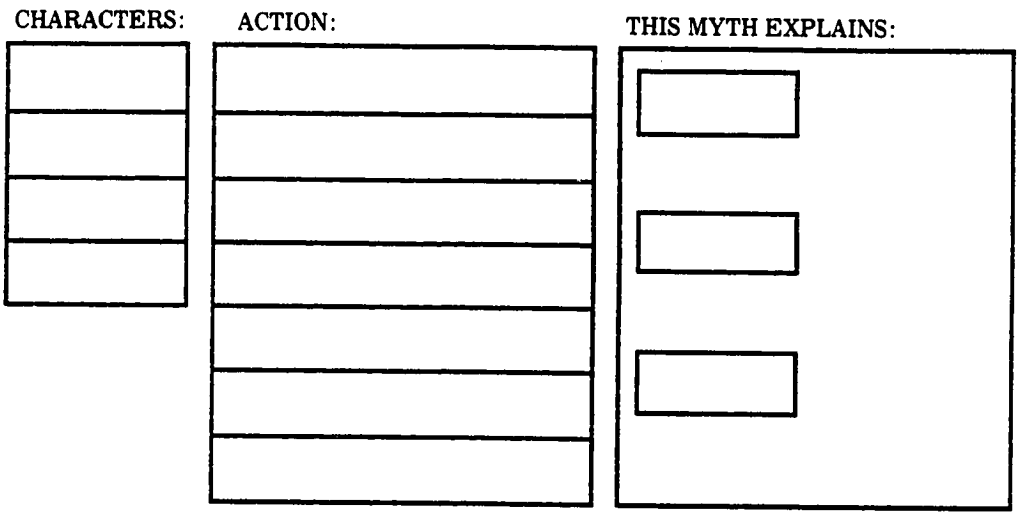
Graphic Presentations and Assessments

Black/white Graphic Presentation



Black/white Assessment #1

A NORSE MYTH



Please answer the questions below:

1. Have you ever seen this chart before? _____

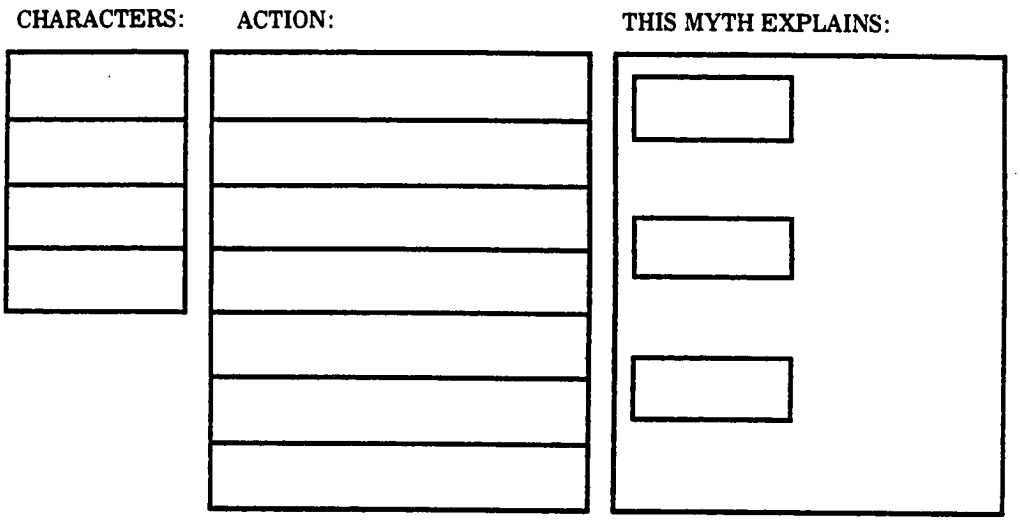
   If yes, what was the source? _____

2. Have you ever heard or read this myth before? _____

   If yes, what was the source? _____

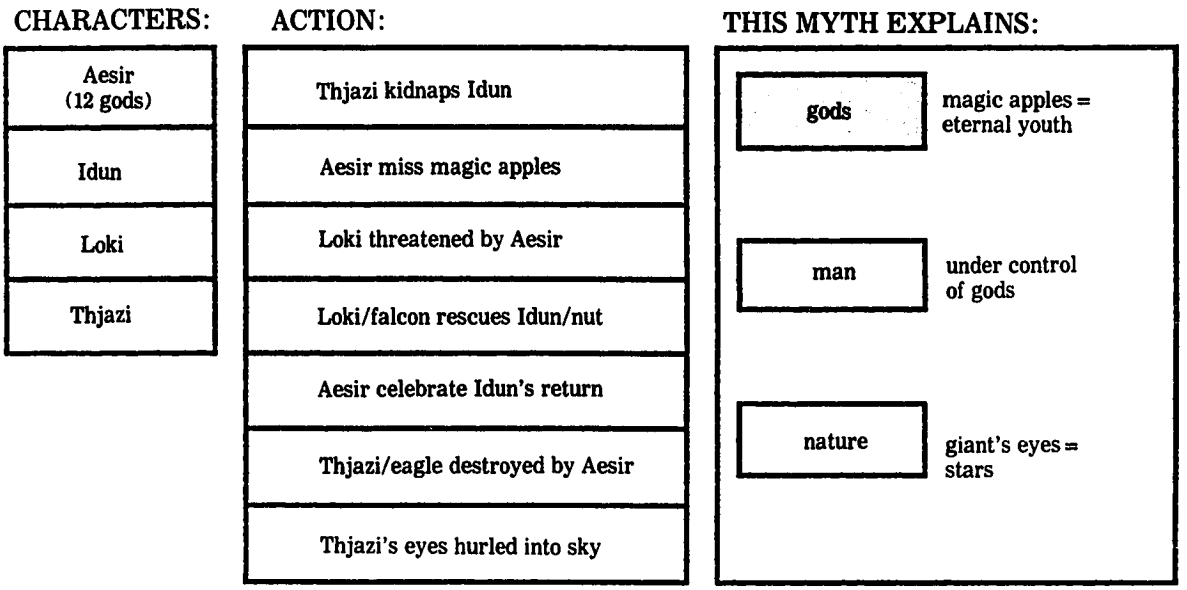
Black/white Assessment #2

A NORSE MYTH



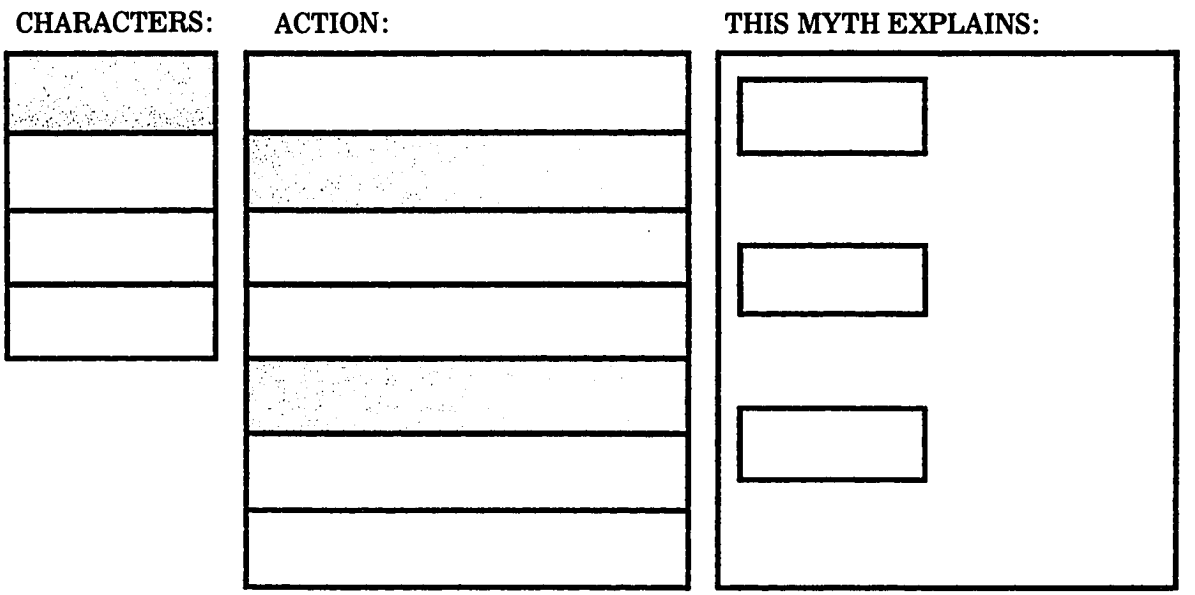
Color-coded Graphic Presentation

A NORSE MYTH



Color-coded Assessment #1

A NORSE MYTH



Please answer the questions below:

1. Have you ever seen this chart before? _____

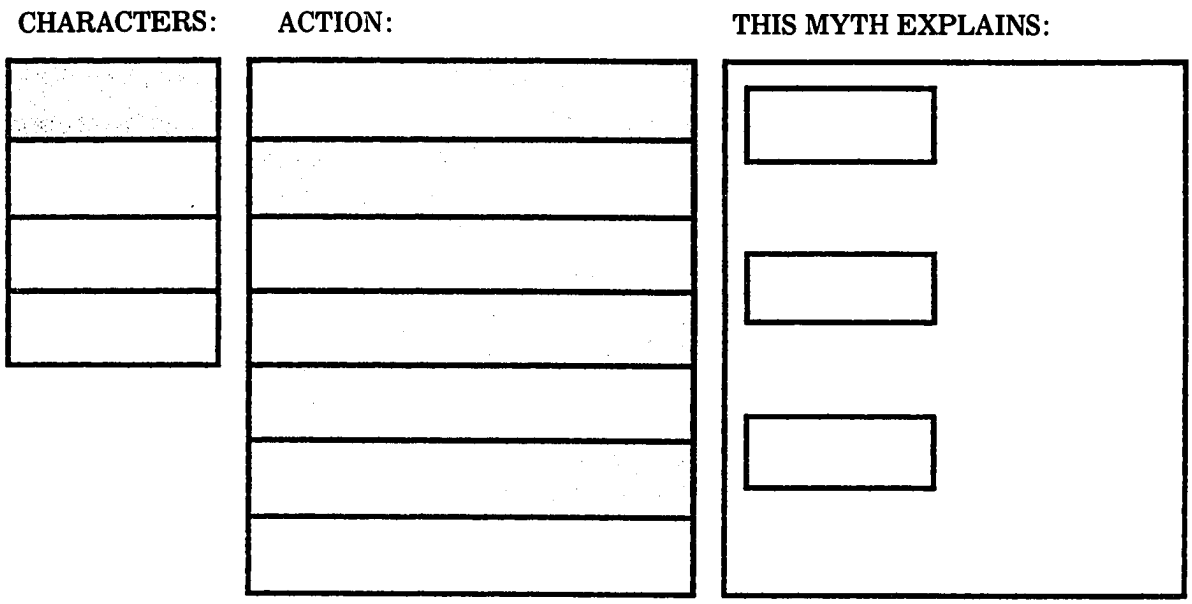
   If yes, what was the source? _____

2. Have you ever heard or read this myth before? _____

   If yes, what was the source? _____

Color-coded Assessment #2

A NORSE MYTH



APPENDIX C

Directions for Homeroom Teachers

Directions for Homeroom Teachers

TO: (Individual homeroom teacher's name)

FROM: Peggy

RE: Directions for Research Project

Day 1: January 29, 1991

First, many thanks for your cooperation.

1. Have the students clear their desks and take out their pencils.

2. Distribute envelopes (and additional pencils as necessary). Have the students set the envelopes aside.

3. Be sure all students have arrived in your homeroom before starting. If a student arrives after you have begun the audiotape, please send the student to me (in the central office).

4. Start the audiotape. DO NOT STOP THE AUDIOTAPE until the students are thanked for their participation (approximately 30 minutes).

5. Please circulate to encourage active participation. The 7-minute study time and 10-minute response time may seem particularly long for some students, but allowing the full time is important.

6. Record the names of students who did not try even with your prodding. Leave this list with the student responses.

7. Pick up the first sheet after the 7-minute study period. (It is clearly stated on the audiotape that the students are to put their sheets in the upper right-hand corner of the desks, and the sheets will be collected by the homeroom teacher.)

8. Collect all envelopes (with answer sheets) and pencils after the audiotape is finished.

9. Try to be very positive with the students as they will be asked to reproduce the chart again in 2 weeks. However, do not encourage discussion about the myth, tape, presentation chart, or assessment chart.

IF YOU HAVE QUESTIONS ANYTIME DURING THE TESTING, I WILL BE IN THE MAIN OFFICE. (Yes, I will be pacing.)

*(All equipment and accompanying materials will be collected at the end of first hour or the beginning of second hour.)

TO: (Individual homeroom teacher's name)

FROM: Peggy

RE: Directions for Research Project

Day 2: February 12, 1991

Again, many thanks for your cooperation. Day 1 certainly went smoothly due to your competent, careful administration of the oral/graphic presentation and graphic assessment. I anticipate continued success!

The directions for today are as follows:

1. When you are sure all homeroom students have arrived, distribute the attached graphic assessments (and pencils as necessary). Have the students leave their papers face down on the desks until the directions have been read.

2. Students who were absent for the initial presentation 2 weeks ago should work on other homework silently as they ordinarily would during homeroom time. Students who participated earlier and who arrive late should be sent to the office.

3. Read these instructions aloud to the students: Two weeks ago you listened to a Norse myth, studied a chart summarizing the myth, and recorded all of the details you could remember on a blank copy of the chart. Today, we are asking you to again recall the details from

the chart without any additional prompts or reminders. Attempt to record the details exactly as they appeared on the first chart; if you are unable to recall the precise spellings and exact wording, write the general ideas you remember. Remember, your careful work and active participation will help educators to better understand how students learn and remember information. You will have 10 minutes to work; you may turn your paper over and begin.

4. Please circulate to encourage active participation. It is more difficult during this session to record the names of students who are not trying, for some students who are frustrated because they do not recall the answers may appear not to be attending. However, please record the names of any students who cause concern, and I will talk to you about them later.

5. Time carefully and allow exactly 10 minutes for student response. Again, this time may seem particularly long for some students, but allowing the full time is important.

6. At the end of 10 minutes, ask the students to put down their pencils. Collect the assessment sheets, and thank them again for their help.

IF YOU HAVE ANY QUESTIONS TODAY DURING THE ASSESSMENT, I WILL BE IN THE MAIN OFFICE.

*(All materials will be collected during the first period.)

APPENDIX D

Instructions for Rating Assessments

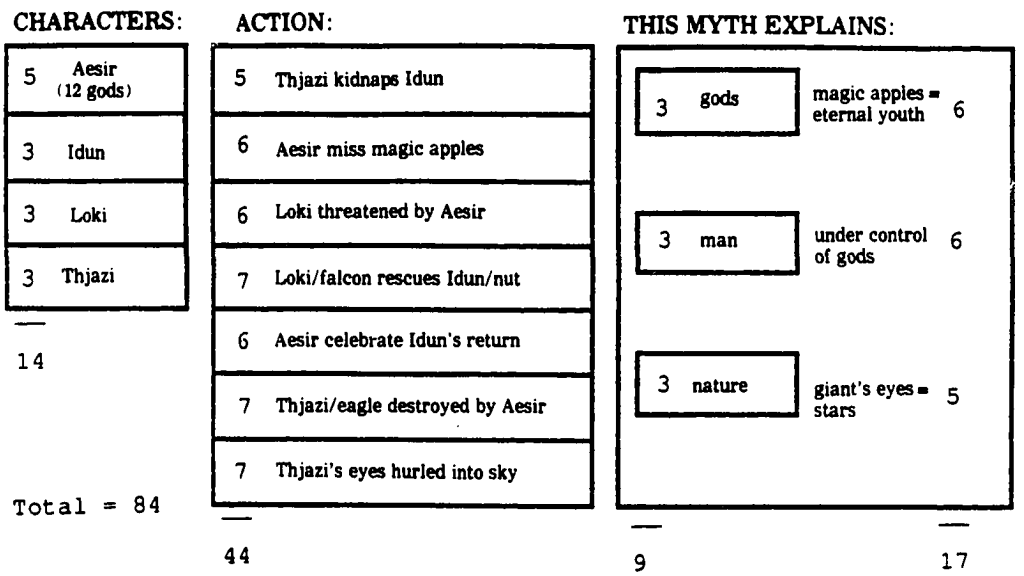
Instructions for Rating Assessments

Instructions for rating:

1. For each correct word or acceptable synonym, score one point. [The only acceptable synonyms appear in the text of the presentation (Aesir = 12 gods = gods, Thjazi = giant = eagle, Loki = falcon, Idun = nut) or are phonetic approximations of the words.]

2. If all items in a box or area (referring to the three phrases on the far right of the graphic) are written in order and spelled correctly, score an additional point for the box or area. This also applies to boxes with only one word and should not include punctuation.

3. If the word or phrase is correctly placed in a box or area, score one additional point for the box or area.



APPENDIX E

Additional Statistical Tables

Additional Statistical Tables

Table 4

Analysis of Variance, Tests of Hypotheses for Between Subjects Effects

Source of variation	df	Sum of squares	Mean square	F	Prob.	Sig.
Presentation	1	3054.56	3054.56	7.20	.01	SIG
Assessment	1	1.52	1.52	.00	1.00	NS
Presentation x Assessment	1	2485.23	2485.23	5.86	.02	SIG

Table 5

Repeated Measures Analysis of Variance, MANOVA Test Criteria and Exact F Statistics

	Value	F	Prob.	Sig.
Time x presentation	.99	1.10	.30	NS
Time x assessment	.99	1.65	.20	NS
Time x presentation x assessment	.96	5.32	.02	SIG