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ABSTRACT

The designer of instructional materials makes many decisions that are probably based on evidence that is unreliable. More reliable evidence, based on perceptual and media research, has not been available to him in his own language. In this project a search of perceptual literature since 1960, and a search of media studies at the ERIC Clearinghouse for Educational Media and Technology at Stanford University are carried out, and the information collated analyzed to derive tenable principles and generalizations that can be used by practitioners who design instructional messages. A crucial objective of the project was to disseminate these principles to the designers of instructional materials. (GO)

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FINAL REPORT
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PERCEPTUAL PRINCIPLES FOR THE DESIGN OF INSTRUCTIONAL MATERIALS

Malcolm L. Fleming
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Audio-Visual Center
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JANUARY, 1970

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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As an essential part of this project, the report was critically examined by four authorities representing the primary contributing discipline, psychology (especially perceptual research), and the primary professional user group, instructional technology (audio-visual, television, programed instruction, textbook, etc.). This much-revised version of the report owes much of its substance, organization, and relevance to the excellent contributions of the following four consultants:

Dr. Ralph Norman Haber, Professor and Chairman
Department of Psychology
University of Rochester
Rochester, New York

Dr. Jerrold E. Kemp, Coordinator
AV Production Services, Audio-Visual Center
San Jose State College
San Jose, California

Dr. Susan M. Markle, Head
Programed Instruction, Office of Instructional Resources
University of Illinois
Chicago, Illinois

Dr. Robert W. Wagner, Director
Department of Photography
Ohio State University
Columbus, Ohio

A number of the faculty of the Division of Educational Media, School of Education, Indiana University critiqued various chapters and versions and made valuable suggestions. Graduate students in two classes, Advanced Production and Message Design, were very helpful in appraising the rough draft from a potential user's viewpoint.

Instrumental to the implementation of this project were the staff and facilities of the Stanford Libraries, the Stanford Center for Research and Development in Teaching, and the ERIC Clearinghouse on Educational Media and Technology at Stanford University.

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M.L.F.

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SUMMARY

Title of Project: Initial Title--An Analysis of Recent Behavioral Science and Media Research Literature and the Derivation of Principles for Designers of Instructional Materials

Revised Title--Perceptual Principles for the Design of Instructional Materials

Problem: It is contended that specifications for instructional materials (behavioral objectives, media, etc.) leave many judgments to the designer of the instructional materials, that the designer makes decisions largely without reliable evidence, that such evidence from perceptual and media research has not been available to him in his own language.

This is seen to be an increasingly acute problem at a time when the development of innovative and experimental materials is so frequently the output or culmination of local, regional, and national efforts toward change in education.

Objectives: (1) To search the recent behavioral science research literature (primarily perception) and media research literature that bears on the process of designing instructional messages, (2) to analyze selected parts of that literature and to derive tenable principles and generalizations that can be used by practitioners who design instructional messages, (3) to disseminate to the appropriate practitioner audiences the products of step 2.

Procedures and Results: The perception literature since 1960 was searched, primarily in secondary sources. Also, media studies were searched at the ERIC Clearinghouse for Educational Media and Technology at Stanford University. These sources were screened for those most relevant to message design problems and processes. From the selected sources over 60 perceptual principles were selected. These principles, together with numerous examples of their possible application to instructional design, constitute the final report. A draft of the report was submitted to four consultants, perception researcher and message designers, for critical review, and the final report reflects their evaluations.

Topics in the report include attention; perception of objects, pictures, words; perceptual processing and capacity; perceptual distinguishing and organizing; perception of size, depth, space, time, motion; perception and cognition.

Implications: It is expected that the principles derived from research literature and disseminated to the designers of instructional materials should influence practice such that the designer will be a more knowledgeable participant on a development team and will be able to make more design decisions with reference to research evidence. The consequences extend to the numerous learners who will encounter the new materials.

INTRODUCTION

Purpose and Orientation of Report

The prospective readers for this report are those who design instructional materials or teach others to do so. The materials* could range from textbooks to slides, filmstrips and audio recordings; to film, television, and videotape; to the range of programmed materials. It is assumed that, though readers may have technical proficiency in one or more media, they would value more information about how prospective learner audiences are likely to perceive their instructional messages.

This report distinguishes between the role of designer and the role of producer or maker of materials. Though both roles may reside in one man, they more likely will be divided between two or more. The design role consists of making a plan or pattern, which may include rough sketches of pictorial components and rough drafts or outlines of verbal components. A design is seen as decidedly more than a specification (example: 5 min. 16mm color sound film on cell division for 10th graders), and a design is decidedly less than a finished product. It functions as a "blueprint" but may take a variety of forms: script, storyboard, layout, synopsis, mock up, prototype. The instructional design process requires knowledge of the learner, including his perceptual processes, and knowledge of media, including their potentialities and their costs.

The intent of this report is to translate the findings and generalizations from perceptual research into guidelines applicable to the practical problems of designing instructional materials. Coverage is limited to the perception literature for three primary reasons. First, the perception literature has been largely avoided by other writers relating behavioral science to instructional materials design. Writers such as Briggs, Gagné, Lumsdaine, and Schramm have dealt almost exclusively with the learning literature. Second, the learner, in his reception of instruction, perceives before he learns; and in the view of this report, his perceptions set limits on what he learns. Third, producers of instructional materials, as the writer has observed them,

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*The focus on the materials of instruction must not be taken by the reader as signifying any intent to add further polemics to the debates: teacher vs. medium, medium vs. medium, technology vs. humanity, new wave vs. tried-and-true. Rather, instructional materials are simply taken for granted as an essential component of the instructional process. Materials are selectively emphasized in this report because they are the part of the instructional process in which the writer has had experience--experience in materials design and production, experience in materials research.

find perceptual principles of more immediate relevance than learning principles for the problems of materials design. However, the designers of programmed materials are an exception, for their rationale is largely based on learning principles from S-R Psychology.

Finding guidelines from the behavioral sciences was known from the outset to be no panacea. The research community, even that part studying learning, has hardly begun to deal meaningfully with the complex of interactions that characterize instruction. However, because of the increased tempo of materials development in education, government and industry, a progress report from researcher to practitioner seemed timely.

The research community and the practice community are isolated by barriers of language, interest, status, competency. Integration may not be desirable, but communication is imperative. Middlemen sufficiently tolerated by both communities to serve as communicators are few in number. The rival demands for rigor on the one hand and relevance on the other are all but irreconcilable.

The writer's decision to attempt this report was based on two convictions: first, there were sufficient research findings to report, and second, there was a readiness in both communities for the reporting.

Evidence for the first is in the body of this report for the reader to assess. Evidence for the second can be observed most clearly at those relatively new task-oriented arenas where researcher and practitioner have been brought (pushed?) together, such as the R & D entities in education and industry, the Regional Educational Laboratories, the ERIC Clearinghouses. This writer tends to credit the programmed instruction movement for much of the readiness. Where instructional development proceeds under the demanding quality-control conditions associated with programming, from initial objectives to final evaluation, the team involved becomes aware that the insights of all participants, researcher and practitioner, are demanded and put to the test. Neither sophisticated theories of behavior nor creative syntheses of materials are adequate. This report is an attempt to mediate between the two.

Procedure Employed

The procedure used in the construction of this report consisted of two basic steps: the identification of suitable generalizations from perceptual research, and the translation of these into a language and format more pertinent to the problems of practitioners. Most of the generalizations from research were found, understandably, in secondary sources, i.e., sources that analyzed, compared, criticized, and made encompassing statements about the several studies of each aspect of perception. These sources were recent (the main sources being copyrighted between 1964 and 1968) and were sufficiently diverse in intent and theoretical position to assure a desirable degree of eclecticism.

Initial judgments as to whether or not the generalizations were tenable on the basis of the evidence have essentially been delegated to the secondary sources. Initial judgments as to whether and how the generalizations were suitable for application to materials design situations have been this writer's.

Placing the guidelines somewhere along a specific-to-general continuum appeared early as a central dilemma. Specific prescriptions could be very useful but in a very limited number of situations, while general guidelines would be less definitive in any one situation but of general utility in a larger number of situations. Partly because of the existence of a relatively detailed, though older, source (Saul), the more general approach was chosen. Then, too, no conceivable degree of specificity would eliminate the need for a sizeable input of inventiveness, if not creativity, on the part of the designer of instructional materials. It is intended that these guidelines might inform the inventiveness of designers, but they will not replace it.

Limitations

A word of caution is necessary about the sources credited herein with certain ideas. Typically, the source cited is a secondary source and thus is frequently not the original or primary source of the idea, but, instead, is the reporter or interpreter of it. Because page numbers are given for the secondary sources, the interested reader can, through the referencing within the secondary source, locate the primary source.

Additionally, the present writer's reinterpretations are still further removed from the hard data of primary sources. Frequently, a paragraph credited to one source contains bits from others, all phrased in the present writer's style and for his purposes.

Nevertheless, both the perceptual principles and the design applications have been critically reviewed by a perception researcher and several message designers, and thus can be represented as reasonably tenable and relevant.

Clearly the greatest slippage in the procedure came at the stage of translating research generalizations into guidelines, and the further extension of these to examples of practical uses. Obviously, these extensions are so far from solid research data that they must in the strict sense be considered educated hunches or hypotheses. Every application suggested or inspired by this report must be tested and validated with reference to the constraints of each kind of situation: the types of message materials, learners, and objectives. Because of the embryonic state of research and development in instruction, no other acceptable course of action seems to be available to the materials designer. Quite possibly, the designer may learn more from the field evaluations of his materials than from this report, but the report may at least provide a conceptual framework within which he can better examine, interpret, and remember the results of each design experience.

Summary

1. This report is intended for those who design instructional materials--from textbooks to television to programmed instruction.

2. It's intent is to bring perceptual research findings to bear on the problems of designing instructional materials.

3. However, the reader is not to expect detailed and specific rules. Instead, these are rather general guidelines plus numerous examples of possible ways to apply them.

4. Because research continues to discover more about the perceptual process, and because the perceptions of individual human beings are complex and multiply determined, the responsible designer is urged to test these guidelines and adapt them as feedback from his audiences indicates.

5. Ideally, these guidelines should inform the inventiveness of designers, but they are not intended to replace it.

CHAPTER 1

MAN AS PERCEIVER: A GENERAL OVERVIEW

The study of perception deals with the ways in which man senses or becomes immediately aware of his environment. Perception is a complex process by which man receives or extracts information from his environment. It is considered to be a stage in cognition along with others such as: sensation, imagery, learning, retention, recall, concept formation, problem solving, thinking. Being one of the earliest stages in cognition, perception has an important influence on the others. Reciprocally, the other cognitive processes markedly influence perception.

Although the study of perception includes a variety of senses such as touch, taste, smell, sense of balance, and muscle sense, the following will dwell almost entirely on vision and audition, the two senses of greatest interest to the instructional message designer.

Importance of Perception

There are several reasons for the designer to know and apply perceptual principles.

A. In general, the better an object or person, event or relationship is perceived the better it can be remembered. (Berelson and Steiner: 181)

B. It is important in instruction to avoid misperception. (Hochberg: 2) If a student misperceives the intent or content of a paragraph or film sequence, he may also misunderstand it or may learn something false or irrelevant.

C. Where it is desirable in instruction to replace the real world with some substitute or surrogate such as a photo or drawing, it is important to know something about how to represent that reality adequately for perceptual purposes. (Hochberg: 2)

Several Basic Perceptual Principles

While it is frequently impossible to predict reliably what an individual will perceive in a given situation, it is possible to consider some of the major ways in which his perceptions will vary and some of the conditions under which they will so vary. Knowing some of the regularities of man's perceiving, the message designer can arrange conditions of stimulation that are consistent with the perceiver's general tendencies. This is another way of asserting the basic assumption of this report: the more a communicator knows about his audience the more effective he is apt to be.

What follows in this chapter is a rather sketchy portrait of man as perceiver. It is simply an outline drawing intended to reveal several gross general aspects. Subsequent chapters will add some of the fascinating details as well as expose some of the remaining puzzles.

1. First, man's perception is relative rather than absolute, aotbe.* (Hochberg: 2-10, Helson: 126)**

When estimating size, brightness, loudness, he is not a scientific instrument. A piece of paper perceived as "white" in sunlight will also be perceived as "white" in moonlight, for although its absolute brightness is vastly different, it reflects the same percent of the available light. That is, its relative brightness, which is the same, is what is perceived. Size judgments are relative to the perceived distance between object and observer. The perceived loudness of a chord in a music track will be relative to the just-preceding level of sound.

Man cannot estimate reliably the number of pounds an unfamiliar object weighs, but he can very well judge the relative weights of a number of objects. One object will tend to become a standard and the others rated as lighter, much heavier, about the same as the standard.

1a. Perceived levels of stimulation are relative to immediate past experience which serves as an anchor or reference point in judging subsequent stimulation. (Helson: 175-178)

A familiar example is the perceived scene-to-scene brightness of a film or the brightness of successive slides. The first few scenes or slides, whether light or dark, set a reference point for judging succeeding scenes or slides as relatively light or dark. Thus the absolute brightness of the series, within limits, becomes less important than the scene-to-scene or slide-to-slide uniformity.

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*Aotbe means all others things being equal. It means that the preceding statement holds under controlled research conditions but may well vary in applied situations, i.e., other factors may reduce or nullify its effect. Though "aotbe" holds for every numbered guideline in this report, it will appear only at the first of each chapter as a reminder to the reader.

**All numbered guidelines have been reproduced so as to stand out from the body of the report. This is done to call attention to their importance. However, none of the guidelines are direct quotations, despite the fact that the format used has signified such in other publications.

1b. Where immediate past experience is at a high level new stimulation may be underestimated, where immediate past experience is at a low level new stimulation may be overestimated. (Forgus: 158, Helson: 124)

This is another way of saying that the initial impact of a change of stimulation level is greater than shortly thereafter. We squint when the lights go on after a projection, we shiver on first entering the swimming pool, the first bite of dinner or dessert tastes best.

This phenomenon is well known in the communication realm. The dramatic pause heightens the effect of the first words to follow, a large white space may add punch to a small figure in the corner of an advertisement.

The very principle of perceptual relativity can be used by the designer to control or increase the predictability of his audience's perceptions. For example, the reader of a book or viewer of TV perceives relative to the part of the book or program he has just finished. Because the designer knows a great deal about these immediate past perceptions he can design the next page or scene accordingly. The writer of self-instructional programs is even better informed, for he knows in detail the sequence of prior perceptions as reflected in prior responses. Hence, he can more reliably predict the readiness of the learner to correctly perceive the next frame.

There are many other relativities in perception--how one feels, what one is seeking, what other people think, etc. For example, there is some evidence that the size of a highly valued object may be overestimated. (Forgus: 252) The notion of perceptual relativity is pervasive and will be encountered again in what follows.

However, the designer should not leave this section with the view that it implies either that our perceptions are unreliable or that they are so changeable as to be unpredictable. The fact is that, in spite of a very large number of studies that demonstrate the relativity of perception, our senses, aided by our past experience, prove in practice to be highly adaptable and serviceable to our needs.

2. Man is a very selective perceiver. He attends to only a few of the sights, sounds, smells, etc. available to him in his environment at any one time. (Berelson and Steiner: 100)

It follows that the designer who can predict what his audience will selectively perceive in a message will be the most successful. He will know what aspects of his message will need to be accentuated to gain attention and which will need to be removed or de-emphasized to prevent distraction. Perceptual selectivity is of two types, and the designer will deal differently with each.

> 2a. Selective perception is in part dynamic, i.e., it depends on what the individual has learned about his environment, what he at any moment wants or feels an interest in, what his general perceptual tendencies are. (Berelson and Steiner: 100)

The poet's perception of cloud formations differs from the meterologist's, the postman's perception of a watchdog is very different from that of the youthful owner or of a veterinarian. Each selects the attributes of cloud or dog that he is familiar with, that he sees as relevant to his interest and need.

This directing the gaze, inclining the ear, extending the finger tips involves choice--a choice to attend to some aspects of the environment and not to attend to others. This has been called "selective exposure." The designer's audience may selectively expose itself to other messages, such as a fellow student's conversation, instead of to the available instruction. Outside the classroom the competition is still keener between available messages looking for an audience, especially messages from those with ideas, goods, and services to sell. There will be more about the designer's struggle for the attention of his audience in the next chapter.

After a perceiver has chosen to expose himself to a message, he may only become aware of a small portion of it, at least at any one time. This is "selective awareness." Of the many words on this page which are imaged on the viewer's retina, only a very few are in awareness at any time. Concurrently, other senses are receiving stimulation: the weight and feel of the book, the temperature of the room, the distant radio. Awareness thus involves selection both within and between senses. The designer's message may even be in competition with itself. There may be more information in his message than the audience can attend to and process in the available time or interest span. That is, our perceptual processes have limited capacities.

> 2b. Selective perception is in part physical, i.e., each input channel has load limits, and the total information processing capacity from all inputs is limited. The stimulus potential, i.e., the quantity and diversity of available information in the environment is great, but the perceiver can attend to only a limited amount at a time. (Forgus: 132)

It can thus be said that man does not so much decide to be selective as that he is physically incapable of doing otherwise, i.e., of attending to more than a minute fraction of the information available to him at any one moment. It is a common experience of people who walk the same street each day that they still find, sometimes to their surprise, objects and details of objects which they never noticed before. The severe limitation in the amount of information man can process at one time is usually not serious so long as there is time to examine more aspects of the situation. Over time many sights and sounds along that street become familiar and require only a passing glance, i.e., minimum information processing.

The lessons for the designer are double edged, he must not exceed the perceptual capacities of his audience, but neither can be allow those capacities to be so unemployed that a more stimulating message will be selected.

The problem of channel capacity is very complex and still being intensively investigated. The capacity problem is particularly acute in fixed-paced (designer-paced) messages such as television, film, and audio recordings. Books and programmed materials permit the learner to keep input well within channel and processing capacities. Capacity problems will be given more attention in Chapter 5.

3. Man's perceptions are organized. That is, we do not perceive chaotic arrays of different brightnesses, colors, temperatures, noises, except perhaps at a discotheque. Rather, we perceive relationships, groupings, objects, events, words, people. (Forgus: 112, 131)

Without organized perceptions we could scarcely cope with the environment. Organized perceptions provide the stability, order, pattern, predictability necessary to normal functioning.

3a. The organization of a stimulus markedly influences the speed and accuracy of perception. (Forgus: 112, 120)

The designer needs to know how different kinds of stimulus organization affect the perceptions of his audience. For this purpose the Gestalt "laws" of perceptual organization, though quite general, will provide some clues. Two of these laws follow, some of the others will be considered in later chapters.

3b. The first and perhaps the simplest organization is that of "figure and ground." Within a fraction of a second our visual system organizes the visual field into one or more figures which appear to stand out against a background or ground. (Forgus: 15) Similarly, sounds are divided into figure and ground--concert music, for example, being figure and sound of the air conditioner being ground.

Good figures attract the perceiver's attention, hence the designer will want the important elements in his messages to be perceived as figures, whether they be visual or auditory, pictorial or verbal. (Figure 1) Some of the characteristics of good figures will be considered in Chapter 4.

Studying Noun Clauses

You have learned that a dependent clause may be used as an *adjective* or as an *adverb*. Dependent clauses may also be used as *nouns*. A dependent clause that is used as a noun is called a **noun clause.**

The second sentence in each of the pairs of sentences below illustrates how noun clauses may be used in a sentence. Study the examples silently. Be prepared to discuss them with your teacher and your fellow students.

Noun Clause as a Subject

1. The committee *reports* were fascinating.
2. *What the committees reported* was fascinating.

Noun Clause as a Predicate Nominative

1. One committee suggestion was a *panel discussion.*
2. One committee suggestion was *that the class hold a panel*

Figure 1. Each paragraph and each italicized word is a "good figure." Both facilitate selection and organization by the perceiver. Titles give a "set" for what follows; the second paragraph gives a set for studying the examples. (From English Your Language, Book 8, by Wolfe and Ryan, Copyright by Allyn and Bacon.)

> 3c. Stimulus figures that are incomplete may be completed by the perceiver. This is called closure, for the perceiver closes or completes what are objectively open or incomplete figures. (Berelson and Steiner: 107)

This is further evidence of the perceiver's need for organized perceptions. In the final analysis any organization is preferable to none.

In a way, this simplifies the designer's task. He can leave figures incomplete, just sketches or outline drawings, and the audience will close or complete them. There is certainly abundant evidence that the barest of figural representations are accurately perceived. Cases in point are the road signs for a turn or winding road, or stick figures for people and their actions. Also, verbal statements can imply, or suggest, or outline rather than state in full.

However, there are risks in the above as a general strategy, especially where the situation is unfamiliar or ambiguous, for the perceiver may then impose his own organization on the situation, "improving," simplifying, reorganizing as desired. The result may be a misperception of the designer's intent.

The designer's choices are simple: (a) Organize the message, or (b) Realize that each perceiver will impose his own organization upon the message. (He may anyway.)

Other principles dealing with the stimulus control of perceptual organization will be treated in subsequent chapters, especially 5 and 6.

> 3d. Perceptual organization is affected not only by the stimulus but by the perceiver's past experiences, present interests and needs. (Berelson and Steiner: 110)

There may be many situations where the designer should permit or encourage a diversity of perceptual organizations. An example would be where inquiry methods of instruction were being employed.

The designer otherwise is responsible to arrange conditions which facilitate the desired perceptual organization. In the case of a lengthy message or a connected series of messages he has some influence over the perceiver's immediate past experiences as well as the perceiver's present interests and needs. Hence, he has some additional means of influencing organization.

> 4. Man perceives what he expects or is "set" to perceive. This influences both what he selects and how he organizes and interprets it. (Forgus: 269)

The influence of set is pervasive in the perceptual process, i.e., it can determine what in the environment is sought, what is selected, how it is organized, how it is categorized or interpreted. (Figure 1) Set operates to reduce the number of alternative interpretations given a stimulus.

A message designer who can control the set of his audience is more likely to achieve his purpose. A set to perceive in a certain way can be induced by instructions given the perceiver and by characteristics of the stimulus. (Forgus: 269) For example, where the first chapter of a book begins with a brief synopsis and ends with a series of questions, one expects the subsequent chapters to be so patterned. A film that begins with a crisis or problem is expected to deal thereafter with the causes or the consequences or the resolution or all three. What is stated in a caption or narration for a filmstrip provides a very strong set for interpreting the accompanying picture. The TV teacher's instructions provide a set as to what to look for and also a set for liking or disliking what follows.

Aspects of two perceptual principles, organization and set, are combined in what has been called "advance organizer." (Ausubel: 148) An advance organizer is a presentation in advance of a unit of instruction which is at a higher level of abstraction and which serves to explain, integrate, and interrelate the material to follow. Such a device appears to both sensitize the learner as to what to perceive, i.e., give him a set, and provide a structure or organization for relating and remembering it.

> 4a. Particularly where sensory data are ambiguous or unfamiliar, there is room and need for expectations and motives to govern interpretation. (Berelson and Steiner: 112)

It is well-known that puzzles and problems are frequently difficult because of our expectations. A common matchstick puzzle, for example, begins with a symmetrical figure composed of four rectangles around a central small square. Three matches are to be moved so that six squares are left. The expectation is that the squares should all be the same small size as the one in the beginning figure, whereas the solution consists of five small squares and one four-times larger. Though normal expectations may be misleading in such unusual situations, they are apt to be accurate in most other situations. Expectations, being built up or learned from extensive experience, are apt to be functional in comparable situations. (Chapter 8 considers the negative effect of set on problem solving and creativity.)

Culturally determined expectations as to how an object or event will be perceived are obviously very important to the designer of messages for people of the particular culture. This applies as well to sub-cultures whether they be in inner-city ghetto or in exclusive suburb.

> 4b. Set can influence the number of alternative interpretations of a message which an audience is likely to make. (Forgus: 269) It thus in effect can influence the amount of information transmitted.

It can be very useful to think of the design process as one of controlling the amount and kind of information available, or more particularly, of exercising some control of the number of alternative ways an audience may perceive a message.

The designer can structure the situation highly by his selection and arrangement of message elements, or he can permit or plan for conditions that are less structured and which allow the perceiver a variety of interpretations. Which alternative to pursue is not a trivial matter. The designer would not ordinarily make such decisions independently, but once they are made he has the problem of arranging stimulus conditions favoring the chosen alternative.

The designer asks, "In what different ways will my audience be apt to perceive and interpret this message?" He can armchair guess, or better, he can seek the estimate of a teacher having extensive experience with the audience, or ideally, he can try the message out on a sample of his audience. Based on such estimates, and depending on the instructional objectives, the designer can attempt to modify his message so as to either reduce or increase the overall number of interpretations. In either case, the designer's use of set may determine his success.

For example, simply asking a question, posing a problem, or presenting a puzzle may readily induce a set to direct attention a certain way. Set can also influence how perceived information is processed. For example, a set to do any of the following will induce different perception and processing of information: to make a speech about it, to criticize it, to pass a true-false test over it, or to perform some procedure given in it. Clearly, set enhances or facilitates perception and learning of a particular kind, but at the same time it reduces or limits other kinds that the audience is not set to deal with.

Where materials are to involve the audience in the process of inquiry or of open discussion, it will be very important for the activity to be introduced so as to avoid a restrictive set. Otherwise the students will sense which answers and responses are preferred and will assuredly provide them. So powerful is the effect of set that it is in fact very difficult to control. For example, such effects have been found even in highly controlled research experiments, where they are supposedly inoperative. An experimenter's set to see his hypothesis confirmed has at times resulted in his unwarranted perception of confirming evidence or his failure to perceive disconfirming evidence.

> 5. The perceptions of one individual or group may vary markedly form that of another in the same situation. (Berelson and Steiner: 112-116)

This report is frankly selective in its coverage of the perception literature, and one of the omitted areas is that of individual differences in perception, particularly those attributed to such factors as personality, attitude, and motivation. Also largely omitted is the developmental area, the changes in perception attributable to maturation. In part the omission is due to the writer's judgment that general perceptual tendencies would be more useful to the designer, but also pertinent was the fact that the area of individual differences has not been thoroughly researched* nor has the research done been adequately reviewed, synthesized and summarized.

However, in order to suggest some of the work that has been done, there follow a few brief indications.

5a. There appear to be stable individual differences in perceptual tendencies across a variety of test situations. (Witkin: 1)

These individually consistent response patterns or tendencies have been called cognitive styles and are currently the focus of a number of different research programs. Depending on the tasks and measures employed, the following kinds of labels have been applied: cognitive simplicity-complexity, high-low differentiators, factually set-conceptually set, broad-narrow categorizers, field dependent-independent perceivers.** (Ausubel: 170-172) Such labels appear to reflect individual tendencies in the selection and processing of information, and thus to have perceptual implications.

For designers dealing extensively with pictorial or iconic materials, it will be pertinent to note that consistent differences have been found in children's tendency to perceive the relation between pairs of pictured objects. Three styles have been identified: grouping pictures by a common physical attribute, by functional relations, and by inferences based on several attributes. Individuals have also been shown to differ consistently in their tendency to ascribe "affect labels" (such as happy, angry, lonely) to visual stimuli. (Ausubel: 172-173)

For message designers whose objective is to persuade, the following differences in an audience may be quite pertinent: open-closed mindedness, authoritarian or non-authoritarian, and degree of tolerance for ambiguity.

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*However an increasing amount of research work is being done in the area of perceptual development, particularly at the infant and early childhood level.

**Field dependency-independency is based on the finding of response consistencies across a number of perceptual test situations, which range from distinguishing a visual figure in a complex visual context to estimating verticalness under conditions of either visual or postural tilt. The tendencies toward being dependent on or independent of the visual field in such perceptual situations are the basis for categorizing people as field dependent or independent. Such tendencies are now being investigated in a larger context of behavioral dependence or independence, e.g., with reference to the views and actions of other people. (Witkin and others: 1-16)

Differences in the cognitive styles of audiences may eventually require that alternative forms of a message be designed to optimize its perception by each audience. Technological provision for individualization of instruction would make this possible, once cognitive types have been reliably identified. Meanwhile, the designer's wisest strategy might be to build redundancy (in the sense of depicting the same idea in several ways) into his messages so that most cognitive types will, hopefully, be accommodated. (Figure 2)

> 5b. There is some evidence that a phenomenon called perceptual defense operates to reduce perception of disliked or threatening objects or events. (Neisser: 126-128)

Apparently, people tend to repress awareness of, or at least to delay reporting, threatening words or pictures. (Neisser: 126-128) They also avoid bringing such things from peripheral vision to central foveal vision, i.e., they avoid looking directly at them. (Luborsky and others) Whatever else these findings mean to the designer, they strongly suggest that such perceptual tendencies will not be changed by the more obvious and direct methods of stimulus control which are available to the designer.

> 5c. Perceptual development tends to proceed from an emphasis on the more concrete attributes or features of objects to the more abstract characteristics of groupings, patterns, and relationships. (Gibson: 71-72)

While this progression from concrete to abstract operations most accurately describes cognitive development from child to adult, it also tends to describe the progression of a learner at any age as he is trained in an unfamiliar subject.

Three stages of cognitive development will be briefly noted. (Ausubel: 198-204, Bruner: 34-40) They should at least alert the message designer to the importance of choosing stimulus conditions or instructional materials which are compatible with the learner's capabilities at each stage.

1. Pre-operational Stage (Preschool period, roughly)--Such a child must learn his abstractions in relation to concrete experiences. These are primary concepts. He learns them from direct manipulation and observation of objects and events.

2. Concrete Operational Stage (Elementary school period, roughly)--Such a child can learn secondary abstractions, those dealing with the abstracted properties of objects and events. Secondary concepts are less likely to be learned directly from example, and more likely to be learned by description and definition. However, his understanding of such concepts is still closely tied to examples.

Levers are classified into one of three groups depending on the relative positions of fulcrum, force, and resistance. Can you think of other examples of these levers?

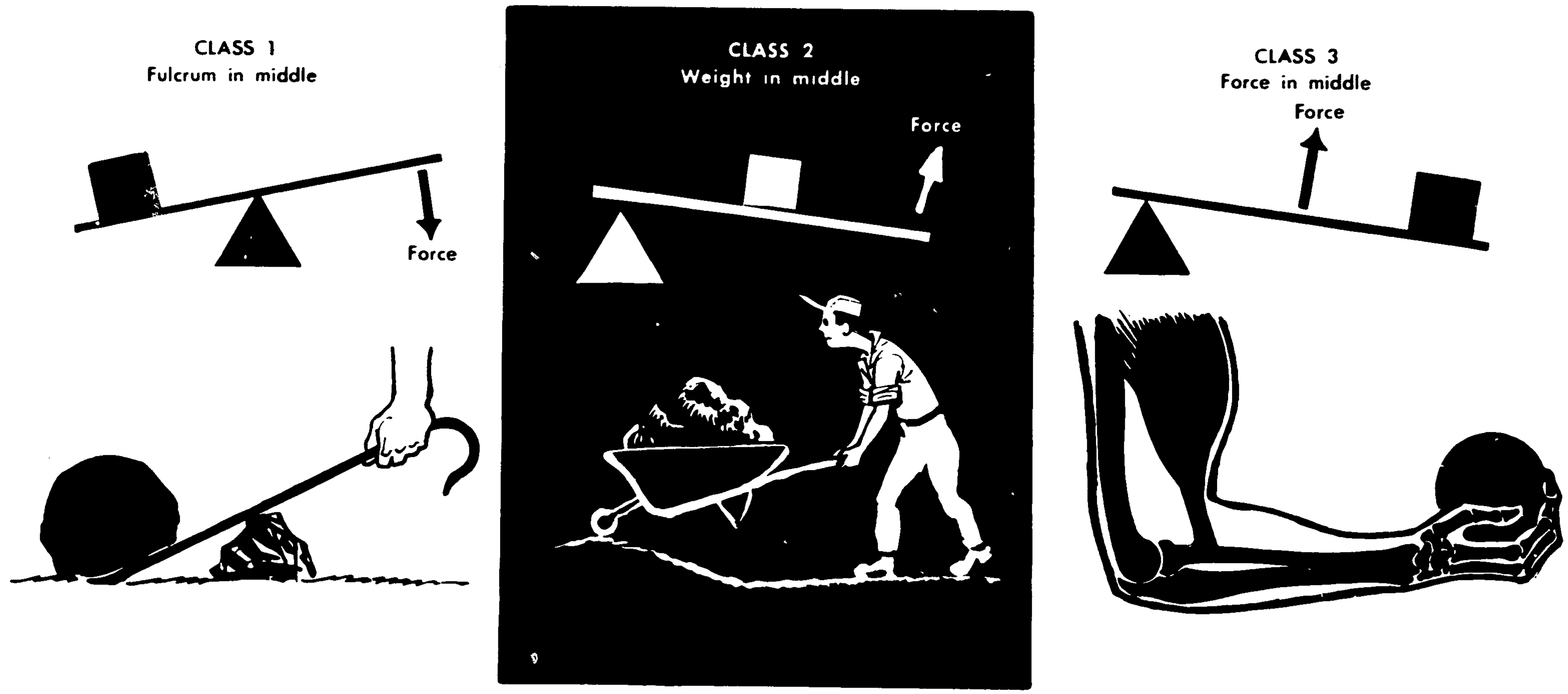

Figure 2. Classes of levers are defined three ways: (1) verbally, (2) abstract figures, (3) concrete examples. This redundancy should facilitate perception by different cognitive types. (From Broadening Worlds of Science, by Jacobson, King, Killie and Konicek, Copyright by American Book Co.)

3. Abstract Logical Stage (Junior high and after)--Such an adolescent or adult comes to form abstract concepts independently of immediate prior or concurrent concrete experiences. He can manipulate and relate secondary abstractions, usually in verbal form. He can consider hypothetical conditions and relations. (Ausubel: 198-204, Bruner: 34-40)

It should be possible for the message designer to arrange stimulus conditions generally consistent with a progression of cognitive operations from concrete to abstract. Both pictorial and verbal stimuli can be made more or less concrete or abstract. As a general rule, any reduction in the number of attributes or features which characterize an object or event or idea can be seen as an abstraction, the degree of abstraction depending on the extent of attribute removal. A photograph of people in limbo (without background or setting) is an abstraction, as is the shortening of literal time in a motion picture. More obviously, the elimination of color, modeling and shading, and interior detail are aspects of abstraction in drawing or painting figures.

Words vary widely in abstractness. For example, the words Fido, dog, carnivore, mammal, animal are increasingly abstract and inclusive, each group having fewer attributes in common.

There will be more about the perceptual and learning consequences of pictorial and verbal, concrete and abstract stimuli in subsequent chapters, particularly 4 and 6.

Summary

For starters, we have noted that man's perceptions are relative, selective, and organized. Each of these characteristics provides some general guidelines for the designer. Some examples of how they might apply have been given, others follow. The reader is urged to think of other applications from his own experience.

1. Man's perception is relative rather than absolute.

   A. Provide anchors or reference points to which perception can be related.

      (1) The size of an unknown object should be compared to a known one. The height of the Empire State Building can, for example, be expressed as equal to the height of 215 men.

      (2) The lengths of different lines, as in a bar graph or time line, can compare relative lengths of time, relative costs, relative populations, etc.

   B. Pace the message relatively.

      (1) An interesting message will be perceived as relatively short.

(2) Divide difficult concepts into small relatively easy steps.

2. Man's perception is selective.

A. Limit the range of aspects presented.

(1) A map used to teach physical features needn't include political features.

(2) A complex process can be dealt with a step at a time.

B. Use pointers.

(1) Words can direct the audience to select the relevant aspects of a television demonstration.

(2) Arrows on a complex display help control selection.

3. Man's perception is organized.

A. Make apparent the organization of messages.

(1) Simply numbering the steps in a series of events gives organization to perception and memory.

(2) Verbal cues give order: before-after, greater-lesser, either-or, superset-subset, another, next, in contrast.

B. Choose organizations consistent with concepts or subject matter.

(1) A circular figure may be consistent with the representation of cyclic events such as the seasons, life cycles, business cycles.

(2) A question-raising message can be seen as consistent with the inquiry processes of science.

In addition to the general tendencies for perception to be relative, selective, and organized, perception is variable, i.e., man perceives what he expects or is set to see and what his individual cognitive style and his maturity and experience make more likely for him to perceive. The latter two influences, cognitive style and maturity, are dealt with very briefly in this report for reasons noted in this chapter. It was observed mainly that as the learner develops and matures his perceptual tendencies change from the concrete attributes of objects and their relations to the more abstract characteristics and higher-order relationships. Consistent with such audience differences, the designer must adapt the concrete-to-abstract level of his messages, whether verbal or pictorial.

The principle of perceptual set provides the designer with a powerful tool, for as an introductory part of his messages he can induce a set, i.e., sensitize his audience, to expect and to give attention to certain aspects of the material to follow. The consequences have repeatedly been shown to be selective facilitation of perception and learning. For example, instructions to check a paragraph for spelling will yield a report of spelling errors but probably a poor understanding of the substance of the material.

The principle of set should be carefully used. For example, where the designer makes clear the behavioral objectives, i.e., the kind of final performance or evidence of learning expected, the learner can study wisely with a set for that final true-false test, or essay test, or oral exam, or take-home problem. Contrariwise, where the learner is provided a misleading set or no set, his success or failure may be more dependent on his ability to guess the correct type of exam than on his grasp of the subject matter.

CHAPTER 2

ATTENTION AND PREATTENTION

One of the message designer's first problems is to gain the attention of his audience, and thereafter he has the continuing problem of holding that attention. Though a certain amount of audience attention can be expected in a classroom, it is far from uniform. Further, a generalized attending is often insufficient, for attention must be directed narrowly and precisely to the critical aspects of the subject matter.

In this chapter several principles of attention will be noted, and ways for the designer to make use of them will be explored.

The most apparent indices of attention are the movements of the eyes and head which aim the eyes and ears toward chosen sources of interest and information. We are well aware that looking somebody in the eyes is a way of communicating such things as: I want to talk to you, I'm listening to what you're saying, etc. Teachers use students' eye movements to judge what they are attending to, the perception researcher does the same.

Thus, a general consideration of eye movements is important to the designer's understanding of attention. For example, how do we achieve stable perceptions when our eyes are so frequently "swish panning" from point to point in the scene like motion picture or TV cameras, doing so an "impossible" three or so times a second? How are images from the two "cameras" (eyes) superimposed without apparent blur or distortion? There are numerous such fascinating problems in visual perception, many of which have not been settled to the satisfaction of either investigators or practitioners.

For present purposes it should be sufficient to clarify a few probable misconceptions relevant to the way we attend to, or give attention to, our visual world. The analogy between camera and eye is misleading in many ways, though it may be of limited use here. The retina of the eye (Figure 4) may be conceived as a very strange film in which the sensitivity varies from color in the center to black-and-white at the edges. Still stranger, if the film were 4 x 5 inches, the fine-grained portion of it would be limited to a central area no greater than 1/4 inch across, and the film would rapidly become coarse-grained toward the edges. (Figure 3) The result is a dual system in which the edges of the film, the course-grained* peripheral vision area (Figures 3 and 4),

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*The reader should realize that grain, either coarse or fine, is a characteristic of photographic film. The intended analogy is to the cells in the retina, which are very tiny and very numerous and tightly packed in the fovea but become thicker and much more widely spaced toward the periphery; hence the difference in acuity or sharpness (Figure 3) of foveal and peripheral vision. (Graham: 48)

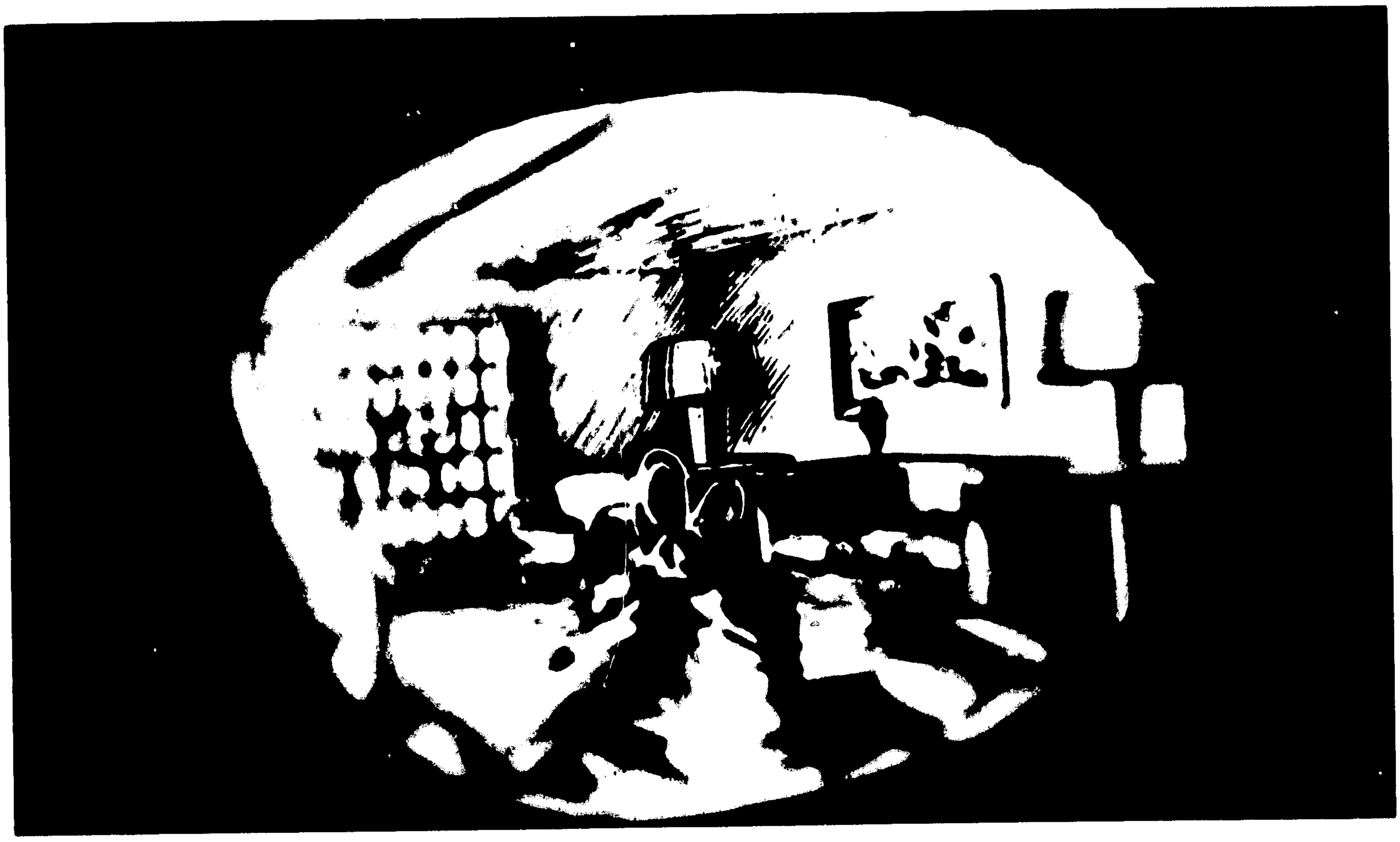

Figure 3. Representation of the field of the right eye, suggesting the difference in acuity between foveal and peripheral vision. (From The Perception of the Visual World by Gibson, Copyright by Houghton-Mifflin Co.)

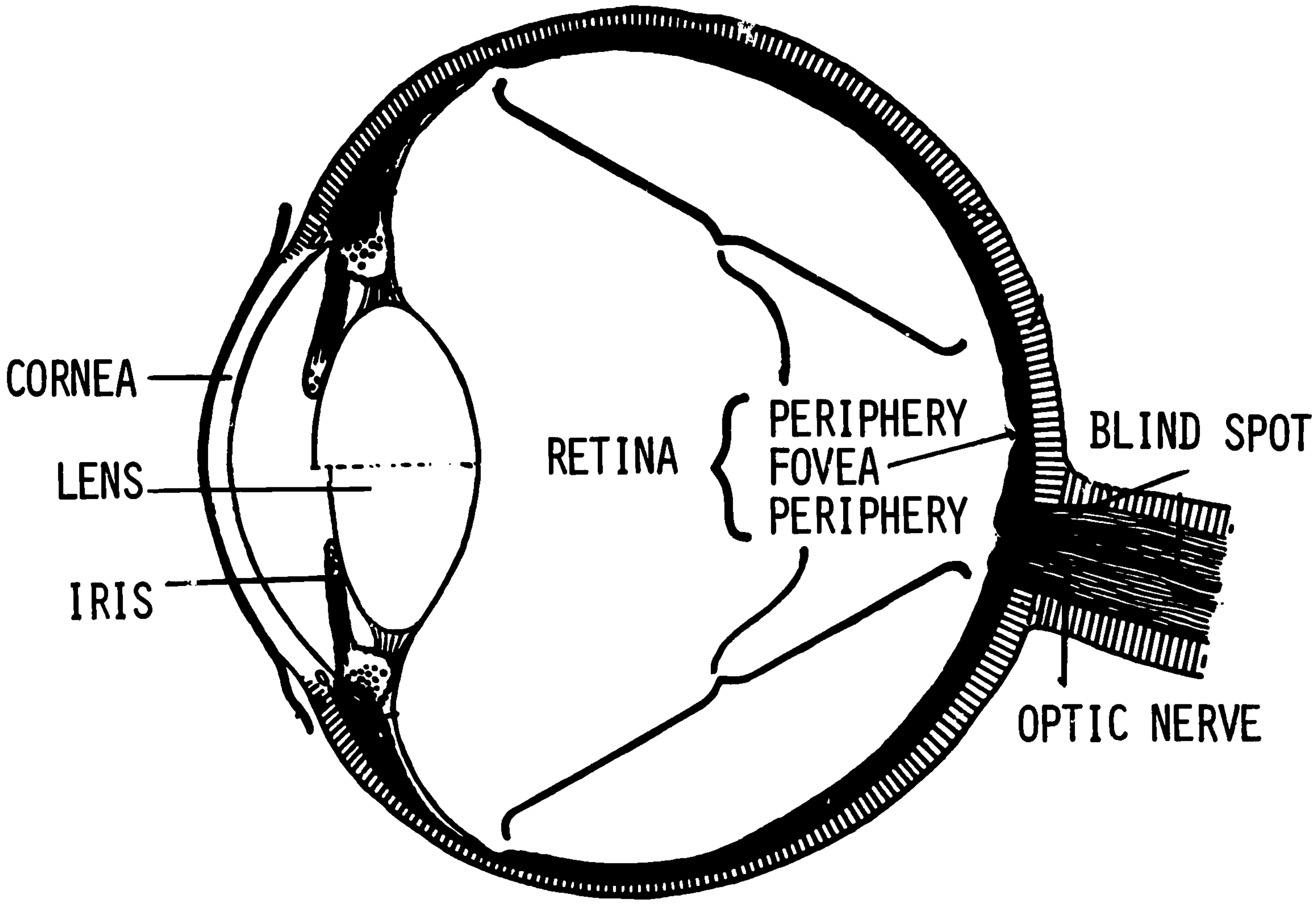

Figure 4. Principal parts of eye, showing the light-sensitive retina divided into fovea and periphery.

serve to detect the points in the environment to which the small central fine-grained area, the fovea (Figures 3 and 4), will be next directed. This suggests the mechanism of attention so far as it is controlled by external stimuli.

Such a visual system obviously has had great utility for survival. Peripheral vision is especially sensitive to changes in movement and brightness, both highly relevant to the detection of approaching danger, be it from prehistoric enemy or modern automobile. (Gregory: 91) Following this alert, the head and eyes are moved to center the threatening object on the fine-grained fovea where it can be critically examined and identified. This kind of interaction between peripheral and foveal inputs typifies much of visual perception. It is thus appropriate to speak of preattentive vision and attentive vision.

6a. Preattentive vision is largely peripheral and is wide angle, aotbe.* It provides a global, wholistic view of the visual field in which figures are separated from each other and located with reference to each other. (Neisser: 86-97)**

6b. Attentive vision is largely foveal and is narrow angle. It builds from the elemental to the complex in a process of analysis and synthesis in which figures are given full detail, color, shape. (Neisser: 86-97)

This is an attempt to both delineate and relate the parts of the dual visual system of humans, the peripheral and the foveal. It should be clear that they are intimately related and highly interdependent. Our awareness readily shifts back and forth between them. As we need to orient to a new situation or re-orient to a present one, we shift awareness to the wholistic and global condition. Within this field or context, and as we need more detailed information, we shift awareness to the foveal condition and direct the tiny central portion of the retina to each selected feature. Even while so narrowly attentive, however, we quickly become aware of changes in brightness and movement at the far edges of the field.

It is pertinent for the designer to realize that the above interpretation of visual perception gives status both to the global first impression of a message gained by its audience and to the more detailed view of it which the audience comes to develop. The two impressions or

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*All other things being equal. This is a reminder that principles in this report are interrelated. None applies in any all-powerful or absolute sense.

**Despite appearances, numbered statements of principles are <u>not</u> direct quotes.

perceptions are highly interrelated, hence the designer cannot afford to neglect either aspect of his message.

It is also presumed that auditory perception includes a preattentive phase, the output of which serves to direct the selective and attentive phases of audition. (Neisser: 194, 213)

It follows that the control of attention can be approached through control of the preattentive processes.

> 7. One form of stimulus control of visual attention is by a change in preattention, i.e., by the changes to which peripheral vision is most sensitive: brightness changes, movement. Similarly, auditory attention could be controlled by changes in volume, pitch, direction.*

On a deserted street the slightest movement is noticed, while in five o'clock traffic the stalled car or immobile person gets attention. A loud sound or an intermittent one may be noticed where sounds have been relatively low or steady.

Thus, if the screen is dark, gain attention by brightening it; if it is static, gain attention by adding movement. For example, the "popping on" of labels in an anatomy film makes brightness changes that attract attention.

> 8a. More generally, <u>man's attention is drawn to what is novel</u> (Forgus: 181), to whatever stands in contrast to immediate past experience or to lifelong experience.

For example, wind is noticeable on a quiet day, a lull on a windy day. Record rainfalls and heat waves attract attention, while normal weather does not.

While appearing to say very little, this is in fact saying something that is quite fundamental to human behavior. Question: How do I get the attention of my audience? Answer, two other questions: What is your audience attending to now, and what can you present them that is different? If they are looking at a series of black and white pictures, a color picture may attract their attention, or vice versa.

If a person is reading a book, what he has not yet read may be relatively novel as compared to what he has and thus may command his attention. Similarly, a story in film or TV form which continues to develop in a novel or not too predictable way may hold an audience's attention.

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*Guideline developed from Neisser: 86-97, 194, 213.

In sum, attention isn't necessarily drawn to the excessively loud, bright, or extraordinary; only to what is quantitatively or qualitatively different from what has been attended to.

8b. The kinds of stimulus novelty that have been shown to attract attention include color and shape. In visual displays containing several figures of one color or shape, a figure of different color or shape attracted attention. (Forgus: 181)

Such stimulus novelty the designer can readily use. Make the key words red or underline them. Exaggerate the features (shape) of a known person or object, as in caricature or cartoons, to draw attention to the whole figure or to particular relevant features of it.

However, such novelty can be overdone. The writer remembers a filmstrip in which successive frames dealt with the concepts of latitude and longitude. Unfortunately, the designer had introduced irrelevant novelty, novelty for its own sake. In each frame the globe was drawn in a somewhat different shape (round, flattened, oval) while the backgrounds changed color (red, yellow, etc.). Clearly, the most novel aspect of each frame had nothing to do with latitude or longitude.

Further supporting evidence comes from Navy training films in which the introduction of mermaids kept the trainees awake and attentive, but to something else than operating ships.

9. Man's attention is drawn and held by complexity. (Figure 5) Given a choice, people have been shown to spend more time looking at:

a. figures having more numerous elements rather than fewer.

b. displays having an irregular arrangement of elements.

c. elements in a group which differ in structure as opposed to being homogeneous. (Forgus: 181)

Presumably, something comparable occurs in reading, for complex material is read much more slowly with more foveal attention to individual words and more frequent recursions (looking back). Simpler material is read more rapidly with many words receiving no foveal attention at all.

The designer would certainly be ill-advised to add complexity to his messages just for the sake of gaining attention. And yet, a learner will not pay much attention to material that is too simple in content, pace, or treatment for him.

It would thus appear that complexity is a difficult factor for the designer to use wisely. Optimum levels would depend on the age and

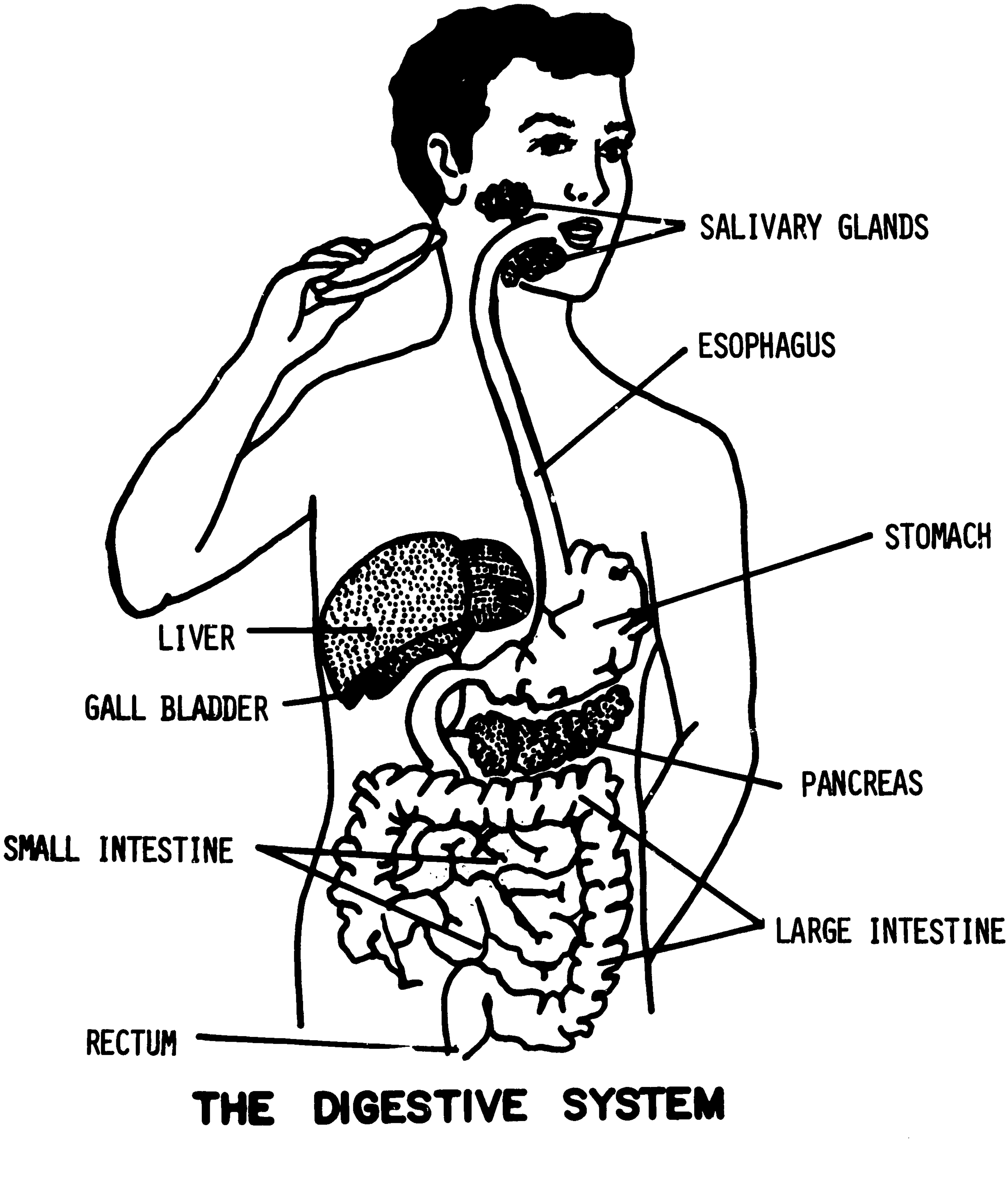

Figure 5. Relative complexity of the organs in the digestive system may draw attention to them and away from less relevant areas. (Based on illustration from <u>Broadening Worlds of Science</u> by Jacobson et al, copyright 1964 by American Book Co.)

sophistication of the learner, his interest in the subject matter, his level of aspiration, etc.

Here the programmer would have a distinct advantage. He could arrange for the more sophisticated to skip the beginning material entirely by correctly answering critical questions. Further, at subsequent stages in the program he would know a great deal about what degree of complexity might by then attract attention.

The last several principles, of course, deal with very dynamic sets of relationships, for what seemed novel or complex a few seconds ago is no longer. Attention is thus fickle and fleeting, at least to the extent that it is subject to the sometimes kaleidoscopic changes in the environment. However, man is clearly not at the mercy of his environment; he can direct his attention.

> 10a. Man directs his attention where he will, i.e., where his interest, experience and needs suggest.*

And where is that? Obviously, if he is interested in football, he directs his attention to the sports part of news broadcasts. If he has lost a credit card, he is very attentive to any object that looks like one. If he is hungry, he is interested in anything remindful of food, such as odors, vending machines, clock striking twelve, rattling dishes, store signs. Thus our man consistently attends to some things (sports), occasionally attends to others (lost things), and at regular intervals attends to others (food).

In order to make use of this principle the designer would need to know considerable about his audience. Otherwise, he is left with gross generalizations such as: boys are interested in (will give attention to) sports and mechanical things. This is of some use, for percentage can be taught with reference to batting averages and levers can be taught with reference to claw hammers and pliers.

Of greater utility would be a design strategy for directly influencing attention. This is usually done verbally: Refer to the chart on page 42; Notice which states border the Mississippi River; As you read this paragraph, pay attention to . . . . Such instructions have been shown to markedly influence what learners attend to and what they learn. (Vernon: 1962: 164-165)

> 10b. In directing his attention, man seeks a balance between novelty and familiarity, between complexity and simplicity, between uncertainty and certainty. (Vernon 1952: 2-3, 14-15)

Familiarity in excess produces boredom, while novelty in excess produces anxiety, and both lead to escape from the situation physically

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*Guideline developed from Berelson and Steiner: 100.

and/or perceptually. Thus, the designer's problem can be seen as maintaining some optimum mix between familiarity and novelty, simplicity and complexity, and certainty and uncertainty in his messages.

Summary

We have considered a number of stimulus characteristics which can influence attention: brightness changes, movement, novelty (changes in color and shape), complexity (relatively more elements, more variety in their structure and arrangement).

It would appear that these are examples of a more pervasive principle, namely change. Attention is drawn to changes in stimulation, changes from immediate-past experience and changes from long-term experience. In a sense, the more that new stimulation differs from the prevailing, the more distinctive or attention-getting it is. (Helson: 89)

This might account for the appeal of fads, of new clothing fashions. It may also account for the initial success of many instructional innovations.

For the designer, the findings point to the need for change, innovation, creativity. But these are not for the purpose of finding the one best kind of message which will thereafter be used repeatedly. A more desirable consequence would be the frequent introduction of change into the otherwise repetitive (dull) stream of instruction.

One word of caution: change or novelty should direct attention to the most relevant ideas in a message rather than the marginal or superficial.

We have also noted that attention is strongly related to the individual's interests, experiences, needs. And these can be appealed to in the gross--girls are interested in clothes, boys in space travel. However, attention can be appealed to directly, as well, through the use of verbal imperatives (look, listen, notice) as well as by asking questions and posing problems. The evidence is clear that messages will be attended to very differently depending on the suggestions or directions which precede them: observe, be ready to discuss, enjoy, etc.

CHAPTER 3

PERCEPTUAL ELEMENTS AND PROCESSING

This chapter will deal with that part of the perceptual process which in general follows attention. It deals with stimulus elements (brightness, color, line, area) which are familiar to the designer. Such sensory data are processed or modified at a number of points in the perceptual system, and this may influence what stimulus elements the designer provides.

11. Information is not simply transferred intact from the environment or from other humans to the perceiver. It is transduced, translated, transformed into something else that stands for it, i.e., it is coded, aotbe.* (Gregory: 7)**

A very useful concept at many levels of the communication process is that of coding. A common example of a code is the Morse Code used in telegraphy. Such a code is a system of signals for communication. Essentially all means of communication use codes. The English language is a code. Messages using it are encoded (put into code) by the communicator, and only those audiences knowing the code can decode them (take them out of code).

This provides an important lesson for the designer. His ideas are not transmitted directly by messages but go through a number of transformations--encoding, decoding, recording. For example, the concept of "cat" can be represented (coded) in various ways. The learner can experience the cat concretely as he pets and looks at it, or, with decreasing fidelity, as he sees a picture, hears a description, or sees the name "cat."

Moreover, all such coded inputs must be recoded during the processes of perception and learning. That is, the input is recoded into neural terms, which constitute the code or language of the brain, i.e., chains and patterns of electrical impulses. These internal chains and patterns represent the external objects, people, events somewhat as the Morse Code or as English does. There is no internal picture in the brain of what we see, no projected image nor TV-like image. (Gregory: 7)

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*Meaning, all other things being equal. This is a reminder that perceptual principles interact, are interdependent. They hold in some situations and not in others.

**None of the numbered principles in this report are direct quotes.

Much of visual recoding occurs at the retinal level,* and additional occurs at successively higher levels of the nervous system. There appears to be a hierarchical sequence in which groups or patterns of lower level signals are represented by (recoded into) fewer signals at a higher level, and groups or patterns of signals at this level are represented by (recoded into) still fewer signals at a still higher level.

From the designer's viewpoint, the more appropriate his encoding of the message the more rapidly and accurately it will be perceived, for recoding transformations involve time, are subject to error, and consume some of the capacity of the perceiver.

Perceiving Brightness and Color

Brightness,** or intensity, and color are basic attributes of a message that are under the control of the designer. There follow some principles of perception that deal with such attributes.

> 12. A change in stimulation is necessary for sustained sensitivity and normal functioning. (Berelson and Steiner: 89)

An absolutely unchanging and homogeneous sensory field, be it overall light or dark or colored, becomes perceptually the same as nothing at all. Persons confined to such undifferentiated environments have difficulty sustaining perception, become disoriented, and tend increasingly to hallucinate.

Further, human sensitivity varies widely with the conditions of stimulation. Sensitivity is lowest where stimulation is highest in intensity (as with a very loud sound), and sensitivity is highest where stimulation is lowest (as at night where the eyes are fully dark-

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*For example, at the retinal level visual input is coded almost immediately into three kinds of signals: red-green, yellow-blue, and white-black. (Boynton: 22)

"The neural activity evoked in the visual receptors by light passes through two or more synapses in the retina, one or more in the thalamus, and a dozen or more in the cortex. At each of these synapses there is a convergence of inputs and some sort of processing of the visual information. By the time the light stimuli are perceived and responded to, the information has passed sequentially through a great many stages of analysis." (De Valois: 87)

**A change in intensity of stimulation is represented (coded) as a change in the frequency with which a nerve cell fires and a change in the number of cells firing.

adapted). In effect, sensitivity is as great or as little as the conditions require. This is consistent with the principle of perceptual relativity noted in Chapter 1.

However, any particular level of sensitivity will decrease over time if the level of stimulation remains constant. (Berelson and Steiner: 91-93) That is to say, our sensory apparatus satiates, i.e., it becomes weary or fatigued under unchanging stimulus conditions.*

The designer may take all this to mean that his audience has physiological need for changing stimulation, and that it is his responsibility to provide that change in instructionally desirable ways. Otherwise it follows that the audience will induce change of its own choosing, such as looking elsewhere, if his message doesn't provide change within it.

However, in the realm of instruction there are severe constraints placed upon stimulation. Change for its own sake can readily become distracting and is not desirable so long as change can be introduced into the central flow of the message. Ideally, as a message develops, the page-to-page or frame-to-frame change in sensory stimulation is one-to-one with the changing flow of pertinent information.

It should be noted in passing that the dynamic qualities of sensitivity noted above influence the prospects for subliminal communication. The limen is the threshold or minimum level of energy that can be detected. Thus, the fact that the limen varies, between individuals and from time to time for any individual, makes the study and practice of subliminal (below limen) perception very difficult to control. Consequently its use in advertising or instruction to "plant" ideas without the observer's awareness is apt to be quite unreliable, particularly in mass or group situations. (Berelson and Steiner: 92 and 95)

One of the most basic laws of perception is Weber's Law, which follows:

> 13. The amount of change in energy necessary to effect a just-noticeable difference varies directly with the initial amount of energy present. (Berelson and Steiner: 95)

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*This has been demonstrated most dramatically with special apparatus by which a visual image has been "locked" or stabilized on one precise area of the retina. The perception of that image remains intact for only a few seconds. Thereafter, it fades and restores piecemeal, i.e., unified features of the image (such as lines and angles) reappear momentarily. (Forgus: 105) Of course, under normal conditions, the continuous movements of the eyes serve to constantly shift the position of an image on the retina and thus to avoid noticeable fading.

That is to say, the lighter the initial shade of grey the greater the change in illumination will need to be in order for the change to be detectable. Or again, the louder the sound track level the greater the gain in level necessary for it to be distinguished from the initial level.

This would seem to suggest that, where a considerable spread of intensities (light or sound) are to be distinguished in a message, the spread should be placed somewhere other than at the upper limits of the available range of intensities. However, there may be obvious reasons for doing otherwise in some situations, for example, where high levels of light or sound are necessary for a mood or where the characteristics of the medium (film or tape or drawing paper) impose constraints on the range of intensities used.

The kinds of changes just noted are changes in intensity such as brightness or loudness. Our visual and auditory receptors are also sensitive to changes in frequency, i.e., to changes in color and in pitch.

Color perception, in spite of the large quantity of research, is still only partially understood. The once-accepted theory of three primary colors (red, green, blue) is being challenged by the opponent-color theory, which assumes that yellow is also a basic color, making four altogether plus black and white.*

About 350,000 different hues can be distinguished. (Forgus: 50) However, the colors people normally identify and remember are those they can name, which varies between language communities. (Vernon 1962: 72)

> 14. In general, the order of preference among Western peoples is: blue, red, green, purple, orange, yellow. (Vernon 1962: 72)

Particular colors can give rise to particular emotions: red to excitement or anger, black or grey to sadness. These are in part learned and may vary between cultures.

> 15. Apparent brightness and color are influenced by adjacent brightness and color, and this adjacency can be either side-by-side in space or one-after-the-other in time. (Vernon 1962: 76, 77)

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*The opponent-color theory also assumes three pairs of receptors which are sensitive respectively to yellow-blue, red-green, and black-white. The two members in each pair are opponents, either one is experienced or the other. Thus, a yellowish blue cannot be experienced nor a reddish green. (Hochberg: 21-23)

A piece of grey paper looks lighter on a black surface and darker on a white surface. (Figure 6) A contrast effect also occurs between adjacent colors, especially between complementary colors:* blue and yellow-red, green and red-purple, yellow and purple-blue, red and blue-green.

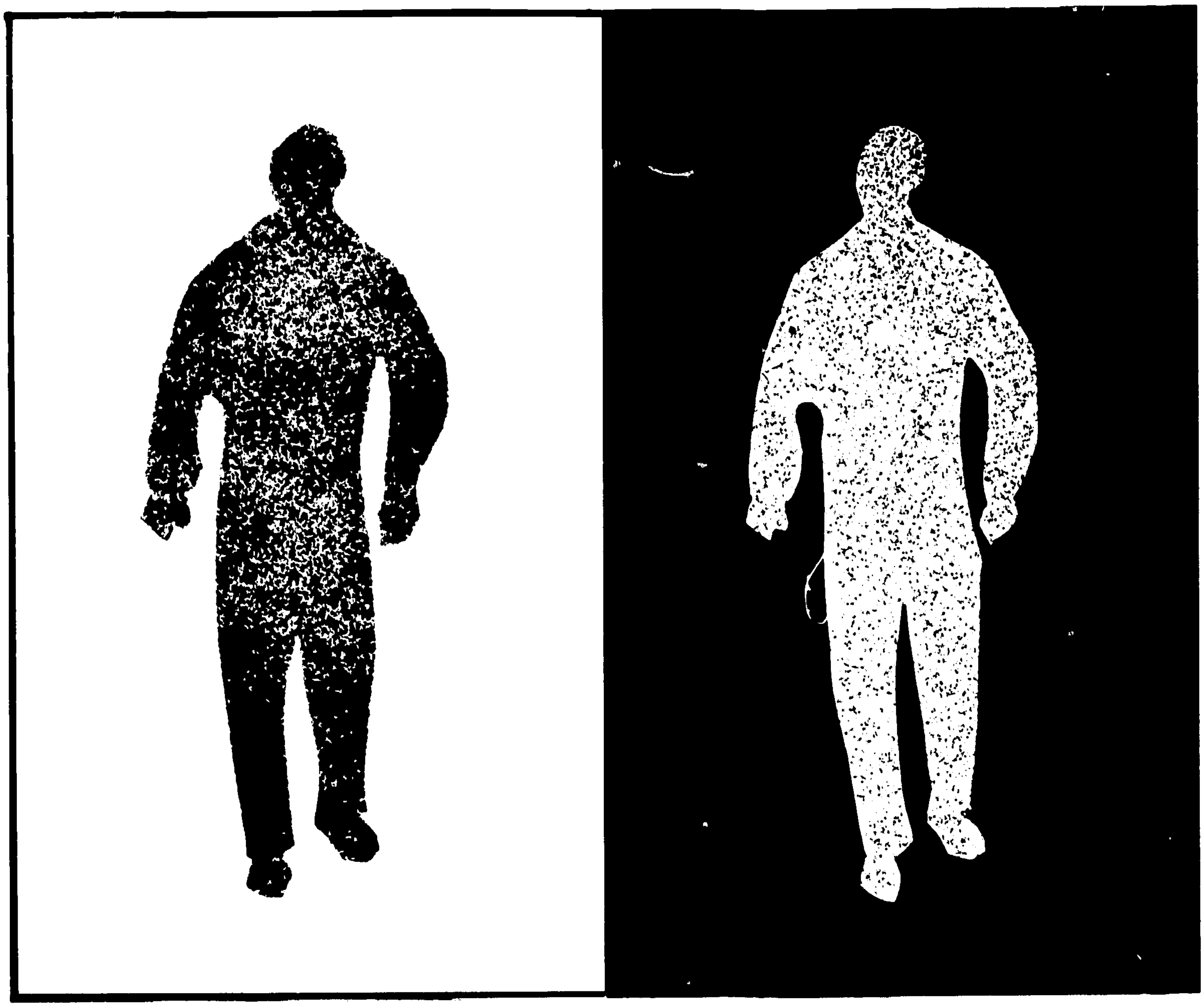

Figure 6. Apparent brightness of identical figures is relative to the adjacent brightnesses, white ground or black ground.

These can be seen as specific examples of the principle of perceptual relativity, Chapter 1. Insofar as the apparent differences

*Four were chosen to be consistent with the newer four-color opponent theory. Within the three-color system the complementary colors would be blue and yellow, green and magenta (red-blue), red and cyan (blue-green). (Hochberg: 21-23) between adjacent brightnesses and colors are accentuated, the phenomenon is related to a more general tendency for perceived differences between objects, people, events to be accentuated. This is discussed in Chapter 6.

However, familiar objects are perceived as having their known brightness and color over a wide range of given brightnesses and colors. This is called brightness and color constancy and will be discussed in Chapter 6.

Perceiving Elemental Features

Stimulus features or attributes are the physical characteristics of stimuli. They are the brightness, color, texture, form, size characteristics which designers select and manipulate as they construct message materials. A very large number of types and degrees of such features are available to the designer. He must select those which are judged to be relevant to the objectives of the communication and then arrange them appropriately in time and space.

The search for basic elements and units of visual perception has a long history* and continues today. Current research interest is no longer in points of energy, but instead is in larger configurations called stimulus features. These are the lines, edges, angles, contours, movements of the retinal image to which particular brain cells (feature analyzers) respond differentially. (Hochberg: 64 and 65) Such features are potentially of great interest and import to the message designer, for they appear to be some of the elements with which a graphic artist and a photographer work.

> 16. Certain kinds of stimulus features, such as contours, are accentuated in perception, while others, such as uniform areas, are not. (Graham: 122-123)

For example, physiological evidence suggests that contours and edges are one of the most "exciting" visual phenomena we encounter. That is, a given cell in the visual cortex of the brain will have a certain receptive field (area of light-sensitive cells) in the retina. These receptive fields are of different shapes as shown in Figure 7. Images on the retina which correspond to the shape of a receptor field will evoke maximum firing of the associated brain cell.

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*It was once thought that knowledge of each of the presumed elements of visual perception (points of energy such as of brightness, hue, and saturation) could by addition explain our everyday experience of the combinations of these elements in the images of objects and events. But the whole was found to be greater than or different from the sum of its parts. Consequently, research interest has diminished with reference to points of energy as basic elements. (Hochberg: 61)

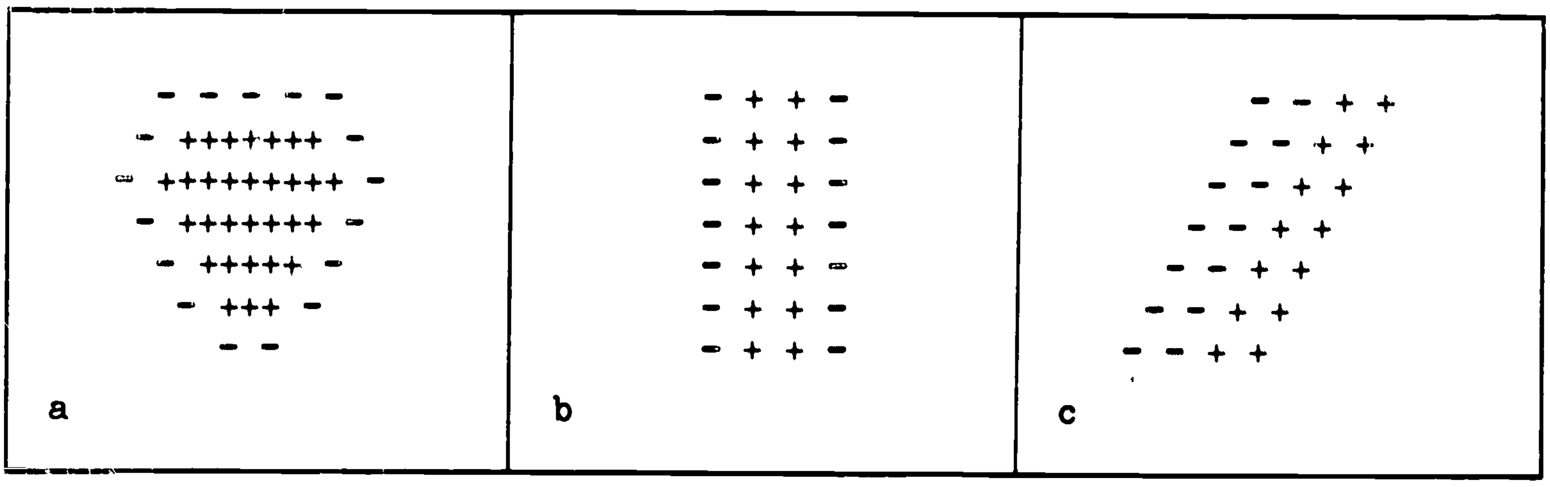

Figure 7. Receptive fields, i.e., regions of the retina which influence the firing of a brain cell (geniculate or cortex). Light on + areas increases the firing, while light on - areas decreases the firing. (After Hubel and Wiesel: 152)

Note that a stimulus consisting of a light spot in a dark field would correspond to receptive field "a" and would thus, if imaged on such an area, cause the associated brain cell to respond maximally. Similarly a vertical white line or bar would match field "b", and a diagonal edge (dark above and light below) would match field "c". The movement of the appropriate line or edge through the appropriate field (b or c) would be a still more "exciting" stimulus feature. The uniform illumination of such fields causes only minimal firing of the respective brain cell.

In some such ways,* stimulus elements or features which are imaged on the retina become recoded into the firing of single brain cells.

This fascinating new area of research is just beginning to probe more deeply the mysteries of visual form perception, and may eventually yield basic guidelines for message designers. For now it serves mainly to re-emphasize the marked changes that sensory input undergoes in the human nervous system.

17. Horizontal and vertical lines are perceptually more stable than lines at other orientations. (Forgus: 139)

Horizontal and vertical lines appear to be more readily perceived than slanting lines, or at least they provide more stable and reliable anchor points. Deviations from horizontal or vertical lines are more readily detected than deviations from a line at 30 degrees from vertical, for example.

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*Another type of brain cell has been found which is not so localized in its sensitivity. It will fire selectively and maximally whenever a particular type of contour (size, shape, orientation) is presented anywhere within a relatively large area of the retina. (Graham: 122-123)

This would seem to be consistent with artists' conception that a horizontal or vertical line feels stable while a diagonal line feels more dynamic or active.

> 18. Lines seem to carry information by way of the following: location of the point of origin, curvature (if any), direction, length, point of change (angle or arc), terminus or continuation with another line. (Hochberg: 90-91)

Contrariwise, a line continuing in the same direction or on the same arc is relatively low in information until it changes in some way. For a mathematician, a line is adequately defined by the locus of the beginning point and end point. All points in between are predictable, redundant, unnecessary.

There is evidence, too, that a straight line is very quickly perceived as compared to a less regular and less predictable line. As suggested earlier, we seem to have feature analyzers in our perceptual system which quickly detect the presence of such regularities. This oversimplifies the matter, for an artist knows that a line has other very important characteristics such as width, color, quality (feathered as with a brush, etc.). (Figure 8)

Lines are, of course, very fundamental to the graphic artist, and contours separating light and dark or variously colored areas are fundamental to the lighting man and cameraman. Lines and contours establish the borders of objects, they separate areas, they contribute to the feeling or affective tone of an image.

Dark lines constitute handwriting and print. Lines are used to enclose important paragraphs, to underline important words. Light lines or areas between rows of print serve to separate and space and aid legibility.

From the elements, the stimulus features, discussed in this chapter, the perceiver constructs objects, people, events, as discussed in the chapter to follow.

Summary

One of the key concepts of this chapter is that communication is typically by means of codes, such as in language or diagrams or maps. The designer puts information into codes (encoding) while the audience takes it out of those codes (decoding) and, as part of the perceptual and learning processes, recodes the information in neural terms, the language of the brain. Thus, information is in no sense transferred intact, rather it is transformed by both designer (encoder) and audience (decoder). The designer and his audience must know the same codes, including words, numbers, symbols, gestures, and (to a degree) pictures. Verbal and pictorial codes will be considered in some detail in the following chapter.

Figure 8. Suggestions of the range of information, affective and cognitive, figural and textural, which lines and contours (edges of areas) can provide.

Stimulus features such as dots, lines, contours, colors, brightnesses, and movement are the basic elements of visual messages. Designers select them and organize them in time and space. Such stimulus features also appear to be basic units in the processing of visual information by our nervous systems.

Lines and edges appear to have marked perceptual significance, a fact long known by artists, recently being confirmed by physiologists, and of continuing import to instructional message designers.

Changing stimulation is necessary, not only to attention but also to sustained sensitivity. Otherwise, perceptual processes satiate, fatigue. It is the designer's responsibility to provide changes in stimulation that are of instructional consequence.

Adjacent brightnesses and colors interact. A black letter or line on a white paper are in mutual opposition, the black appearing blacker and the white whiter. Similarly, complementary colors are in mutual opposition. A yellow or orange figure will be readily perceived on a blue background; a red or purple figure on a green background.

Colors arouse emotions, most such associations apparently being learned. Green may be pleasantly associated with grass and trees; red with lipstick and traffic lights; blue with deep water and open skies. Knowledge of such common associations plus those peculiar to particular peoples (red, white, and blue for the USA) will aid the designer in making wise choices.

CHAPTER 4

PERCEPTION OF OBJECTS, PICTURES, WORDS

Out of the elements or features discussed in the last chapter the perceiver constructs objects, pictures, and words. The perceptual principles related to this construction process will be considered in this chapter. Because words and pictures are of primary interest to the designer, particular emphasis will be given them.

The perceiver does not take snapshots of the whole visual scene. Rather a process of analysis and synthesis constructs figures (objects, pictures, words) out of stimulus features.

The visual analysis of an object produces a number of successive inputs, about 3 per second, as each new movement of the eyes brings new aspects of the object onto the fovea. On the basis of this analysis, the elements of sensation are organized into larger wholes or configurations, in a sense building up or synthesizing impressions of discrete objects and events from units of sensory data.

This is a very complex process and has been called analysis-by-synthesis to suggest the essentially constructive character of the process. (Neisser: 94-95) An object is visually perceived by being rapidly constructed in increasing detail from numbers of foveal inputs, all within the wholistic field provided by peripheral vision. Importantly, the product, while correlated in some ways with the stimulus object, is markedly different from it. The product is in neural code, as noted in the preceding chapter.

Objects

During this analysis-by-synthesis process, the figure (object) becomes clearly differentiated from the ground, and detail within the figure is revealed or built up. (Neisser: 140)

19. The figural portion of a stimulus, such as a person or object or word, is given more attention, is perceived as solid and well-defined, and appears to be in front of the ground, aotbe.* The common contour between figure and ground belongs to the figure. In contrast, the ground attracts less attention, is perceived as amorphous and indefinitely defined, and appears to be behind the figure. (Berelson and Steiner: 104) The

*Aotbe means all other things being equal. It applies to all numbered guidelines in this report, though only the first in each chapter is so labelled.

perception of a figure and a ground appears to be a rapid and spontaneous initial part of the analysis-by-synthesis process.*

It follows that a designer will want to arrange to make his most important message elements figural. Elements perceived as figures will typically be not only bounded, but boundaries will be well-defined, and there will be an apparent internal unity and solidity. However, in many pictures the figure-ground relationship is not as reliable nor as clear cut as in the simple drawings used in early studies. There may be multiple figures competing for attention, and the ground may (contrary to expectations) appear to approach closer than the figure. Also, it is clearly the case that as man visually explores a scene, one aspect of it after another becomes figural in the sense that it comes to dominate his attention for awhile.

It is also worth noting that while in some cases the ground may be nothing but the undifferentiated white paper on which a word is printed or a drawing is made, it may in other cases be very informative. Particularly where the figure is somewhat ambiguous, the ground may determine categorization. For example, a man with unshaved face, long hair, old clothes, and shoulder pack may in a street corner setting (ground) be classified as "hippie," while in a desolate wilderness be classified as "prospector."

The so-called figure-ground relationship is not limited to pictorial stimuli. The printed word can be a figure on a page ground, and the spoken word can be a figure on a ground of car engine noise. A melody can be perceived as a figure on a ground of accompaniment. A sound may be figural because of its volume, pitch, rhythm, or greater interest for the perceiver. In the jumble of conversations at a party we can selectively tune in (make figural) one person's voice over all the others (ground).

20. A given contour can belong to only one of the two areas it bounds and shapes, and whichever side it shapes will be perceived as figure.** (Hochberg: 83) The most definitive characteristic of a figure is its boundedness. "Good figures"***

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*Despite the format employed, none of the numbered guidelines is a direct quotation.

**Reversible figures (Figure 9) lack sufficient cues as to which side of a contour is figure and which is ground, hence the vacillation. Fortunately, such figures are rare in our experience. A message designer will typically deal with closed figures within which may be added other features such as interior detail or surface modeling or shading, thus assuring unambiguous delineation into figure and ground.

***Good, as used here, is not a value (good vs. bad or evil) but a quality of simplicity, regularity, stability.

are closed, they exhibit a continuous contour. And of the closed areas in a field, the smaller and the more symmetrical will be more likely to be perceived as figures. (Hochberg: 86)

This provides the designer with some hints as to what constitutes a "good figure" and thereby suggests desirable characteristics for the important objects, places, and events in his messages. (Figure 9)

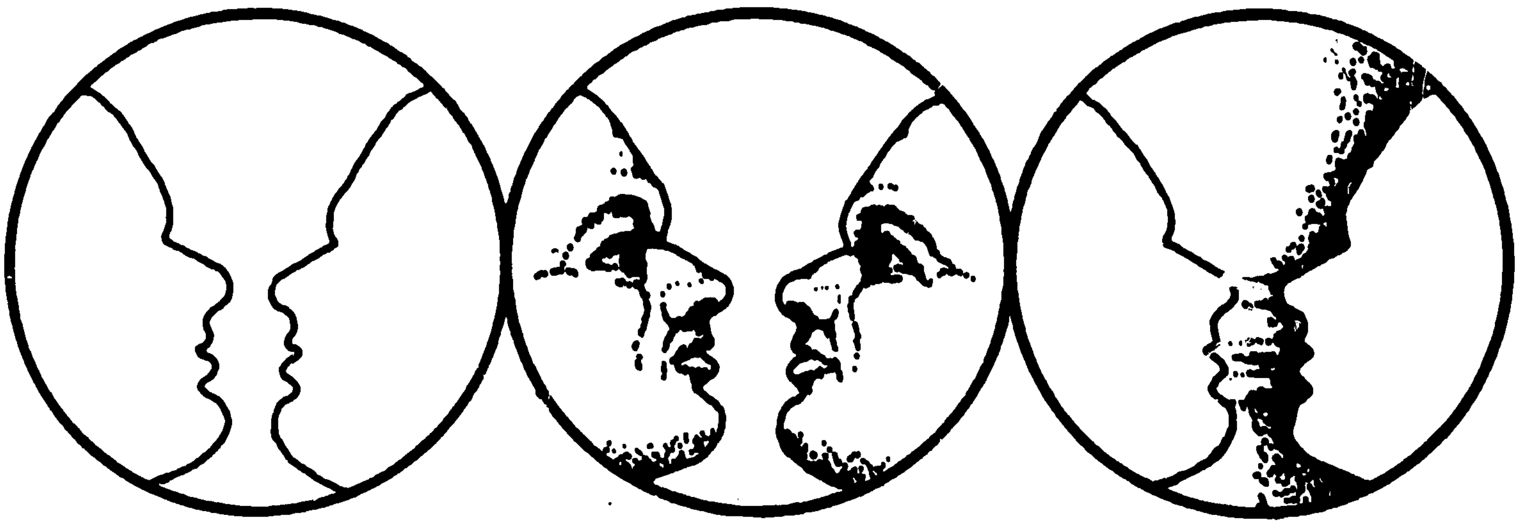

Figure 9. Effects of various degrees and kinds of designer control over what will be perceived as figure.

The organization of perception into figure and ground is a basic example of the general principle of perceptual organization, as noted in Chapter 1. More complex types of perceptual organization will be dealt with in subsequent sections and in Chapter 6.

21. Where lines or contours are overlapping or competing with each other, the emerging figure will tend to be the one with good continuation, i.e., having more continuous and uninterrupted straight lines or smoothly-curving contours.* (Hochberg: 86) (Figure 10)

*This principle is employed in camouflage. The distinguishing contours and features of a figure are made continuous with the surrounding area such that the figure, man or machine, no longer exists in a perceptual sense.

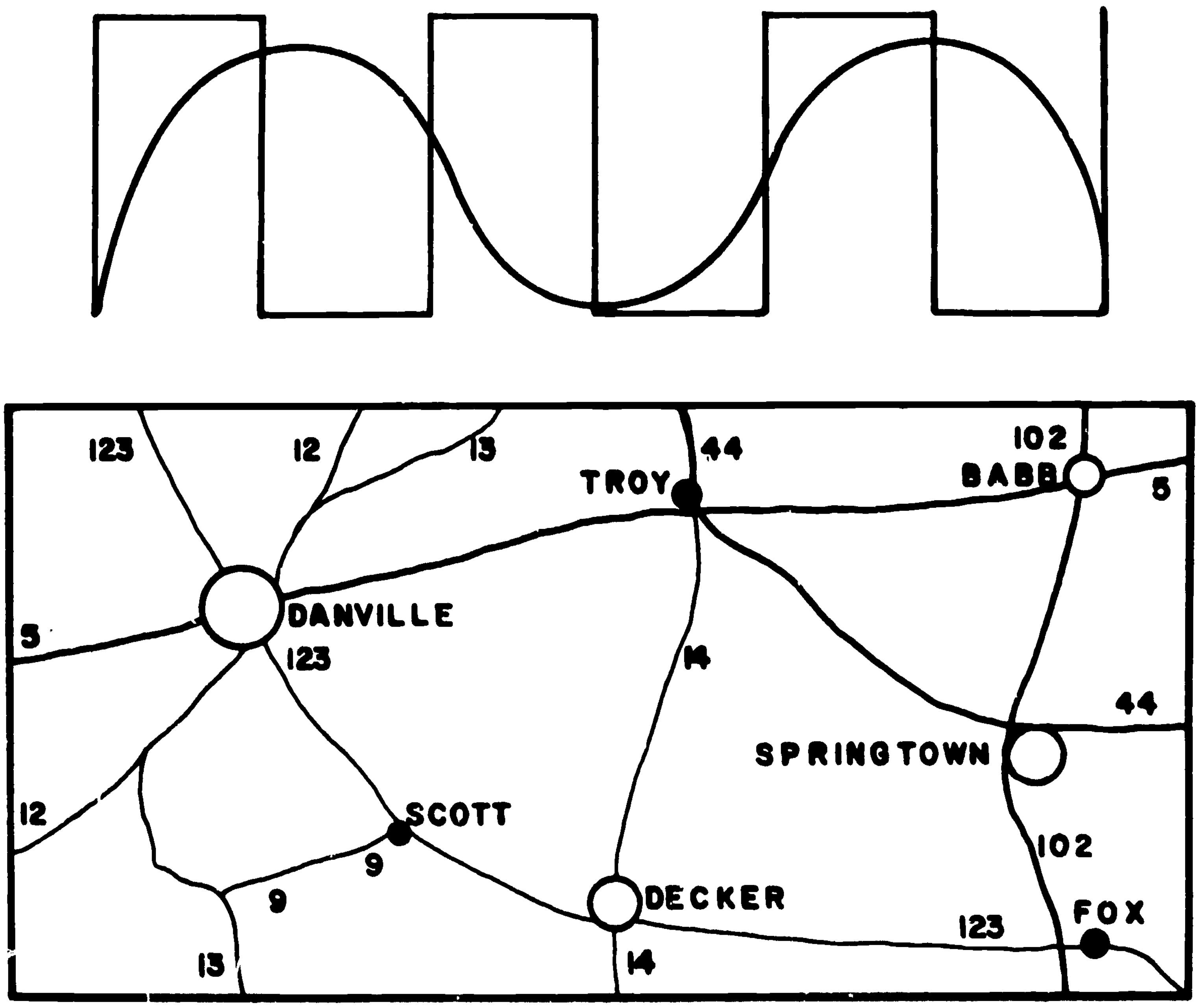

Figure 10. Abstract example (above) shows good continuation of the curving line despite the rectangular line, and vice versa. In map example (below) some of the routes through cities and towns exhibit good continuation and some do not.

Such regular contours are more readily perceived in the sense that they appear to require fewer and shorter fixations (the pauses between eye movements) and thus apparently to provide information which takes less time to process. (Mackworth and Morandi)

Carried to its extreme, this principle might influence the designer to use only straight lines or regular curves or symmetrical figures.

Processing of such information would be rapid, but interest would probably be brief. Perhaps this principle interacts with familiarity-novelty factors as follows: If the object is new to the audience, use representations which are easily processed (straight lines or regular curves); while if the object is quite familiar, use representations which are more irregular or unusual.

> 22. Where alternative figures can be constructed by a perceiver, the most likely will be the simplest and most symmetrical figure which the available stimuli allow. (Hochberg: 86, 87)

This has been referred to as the Minimum Principle in the sense that differences and complexities are minimized. (Hochberg: 87) The idea is remindful of the Law of Parsimony in science whereby the most economical or least complex explanation for a phenomenon is preferred.

Perhaps a key part of this principle is, "which the available stimuli allow." When the available stimulus is a traffic sign it should allow only one unambiguous percept, but where the stimulus is a painting it may be appropriate to allow a variety of interpretations, each "economical" to particular observers.

In fact the Minimum Principle may be anathema to a creative artist, for he seems to prefer asymmetry. It, for him, creates tension and uncertainty. Just the opposite usually characterizes the programmer's intent: If there is much uncertainty in how the audience will perceive or respond, then re-program or re-design so as to reduce uncertainty.

Probably the products of the instructional message designer should generally be situated between the traffic sign and the painting. The most economical perception of his work should be something relevant to the instructional objective intended, but perhaps there should be enough asymmetry in his work to make the act or product of perception interesting. The puzzle is in deciding just where in a display or figure to introduce asymmetry or complexity.

It may be that the point of greatest (within limits) relative asymmetry and complexity in a display should coincide with the point of greatest relevance to the objectives. For example, a globe may be pictured on a tilt, not just because it appears more dynamic that way, but also because the asymmetry may call attention to a phenomenon central to the understanding of seasons in the northern and southern hemispheres.

> 23. The perceived complexity of figures can be estimated to a large degree with reference to such features as lines and angles, or more specifically, the overall number of such features and the number of different kinds of such features. (Hochberg: 90-91)

Increasing the number of lines and angles not only increases complexity but also potentially increases the information that a perceiver can extract from a figure. For example, a cube can be accurately depicted from one angle of view as a square (assuming flat lighting). In a way, this is the most economical and symmetrical depiction of a cube, but according to the minimum principle it will be perceived as simply a two-dimensional figure. More information, more asymmetry, more lines and angles (and shadings and shadows) are necessary to depict the third dimension. (Hochberg: 87)

Signs

Implicit in much of the previous discussion has been the distinction between the channel or sensory modality (vision, audition) the perceiver employs to receive information and the form or code (verbal, pictorial, etc.) in which the information is transmitted. The latter is also called a sign in that it stands for or refers to something. Both the word "apple" and the picture of an apple are signs for, refer to, a particular fruit.

Although concrete objects such as rock specimens and green plants are commonly employed in instruction, most instructional materials are composed of signs in that they <u>stand for</u> some object or event or relation. Iconic signs* consist of objects called pictures, globes, maps, diagrams, geometric figures, etc., while digital signs* consist of objects called words, numbers, etc. Signs are not instructionally important in themselves (except in spelling and writing) but only in what they represent or refer to, i.e., their referents. Digital signs, such as words, do not resemble their referents, while iconic signs, such as pictures and diagrams, do resemble, at least to some degree, their referents. (Knowlton)

Signs are frequently confused with perceptual modalities. The designer should be clear in his distinctions between them. Words, digital signs, may be perceived in either visual or auditory modality, while most iconic signs are perceived visually. It seems appropriate to refer to some auditory signs, such as "moo" and "bang," as iconic because they "resemble" or are the characteristic sounds of that to which they refer. Similarly, sound effects used in radio, TV, and film can be considered iconic. Perhaps even the voice quality of a particular speaker in a sense "resembles" or is characteristic of him and is thus iconic.

One of the perennial problems of the message designer is that of choosing between modalities (audition or vision) and between signs (digital or iconic).

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*Technically, one should distinguish between a sign vehicle (the physical object such as a photo or a printed word) and a sign (that upon which meaning is conferred by the viewer or interpreter of such a physical object). However, for present purposes this distinction will be overlooked.

24. The perceptual conditions for learning through one modality (vision) will differ importantly from those for another modality (audition), and the perceptual conditions that employ one type of sign (digital) will differ importantly from those that employ another type of sign (iconic).*

The above four categories are important distinctions for the message designer which the following section will attempt to amplify. However, the principle as stated is very general. This is because basic research in the area is just beginning and much is as yet unknown. Consequently, the remaining principles in this chapter should be taken as relatively tentative, and several cannot properly be ascribed to a particular source, though they are not inconsistent with perceptual research literature.

Modalities

25. Vision is a sense that is superb for representing spatial distinctions but relatively poor for temporal. Audition is a sense that is superb for representing temporal distinctions but relatively poor for spatial.**

These two senses can thus be understood as complementary. Each compensates for the inadequacies of the other. Each makes a unique contribution to informational input. However, there is some interchangeability. Audition is to a degree spatial, for we can fairly well identify the direction of the source of sounds. Vision can frequently distinguish between successive events, but successive pictures in a motion picture are seen as one, i.e., they are not temporally distinguishable.

The above principle provides the designer some initial hints for his modality decisions.

25a. If a concept is basically spatial, like mountain or mile or cube or anatomy or leaf shape or big dipper or Venus de Milo, then vision is appropriate.** Also where it is desirable to hold a message in the perceptual field of an audience for some time, then vision is appropriate. Auditory sensations fade rapidly and for critical examination must be presented repeatedly.

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*Message researchers frequently conceive of visual as synonymous with iconic, though in fact vision encompasses both verbal signs and iconic signs. Psychological researchers frequently treat visual phenomena as limited to the verbal type of sign or code.

**Studies of perceptual discrimination provide a basis for this. Such studies indicate that vision permits finer spatial discriminations than does audition, while audition permits finer temporal discriminations than does vision.

25b. If a concept is basically temporal, like rhythm or second or before-after or frequency or poetry or music or speech, then audition is appropriate.*

Because temporal concepts are transitory, they frequently are translated (coded) into spatial form. Speeches are put into print, clocks represent time in a spatial manner, musical scores are represented in space (simultaneous events spaced above and below, sequential events spaced left to right). Extended periods of time can be represented spatially. The seasons, years, eons are frequently depicted left-to-right on time lines. These translations of time to space involve conventions (codes) which must be learned. The designer must either teach the code or be sure his audience knows it.

25c. If a concept involves both space and time, such as speed or plant growth or life cycles or erosion or city growth or earth orbit or the westward movement, then both vision and audition can be used. Audition would probably take the form of naming, describing, or calling attention to the spatial changes perceived visually.*

The temporal aspects of space-time concepts can also be roughly implied by the temporal order in which spatial events are presented to vision. Thus events that occur early in American history or first in a chemical process are presented before the subsequently-occurring historical or chemical events are presented.

26. In general, the perceptual modality used in the final testing or application situation should be the modality employed during instruction. (Severin: 241-243)

Thus the designer's analysis of a problem must include the final performance conditions. If the learner is to write a description of a chemical test for sodium, he should practice that response; if he is to make such a test in a laboratory, he should practice that. Instructional messages will vary accordingly.

Other considerations in the choice of modality are those of channel capacity, which will be considered in the next chapter, and of sign, which will be considered here.

27. Digital messages (words, numbers) can be perceived through either auditory or visual modalities or both. Iconic messages can only be perceived through vision, except for the occasional iconic sound. (Knowlton)

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*Based on principle #25.

Thus a designer employing digital signs can capitalize on either their spatial characteristics (print) or their temporal characteristics (speech), for he can appeal to either modality.

A designer employing iconic signs is constrained for the most part to spatial characteristics and visual modality. However, as noted earlier, the sequence and duration of iconic presentations provide a temporal dimension to vision.

Words and Pictures

The choice between sign types, digital or iconic, has not had the benefit of enough substantial research.* The designer has proceeded intuitively or has just preferred words over pictures or vice versa. The choice has been further weighted by institutional commitments toward one or the other--publishing houses, film companies, etc.

What follows is a consideration of the few generalizations that appear to be emerging from basic studies, most of them recent.

> 28a. The relative utility of each sign type is in part determined by the duration of perception (called short-term memory) and the available output capabilities. Digital signs have distinct advantages on both counts.**

What we perceive, auditorially or visually, is apparently held for very short periods of time in what is called short-term memory. Initial recoding operations are said to occur at this stage. Verbal materials have an advantage at this stage because a sentence (perceived either visually or auditorially) can be restated a number of times subvocally, like talking to one's self, thus stretching verbal short-term memory (sometimes called echoic memory). (Neisser: 199-206) There is no comparable way to rehearse pictorial information in visual short-term memory (called iconic memory) (Neisser: 16-22), though an artist may be able to covertly rehearse the drawing of a simple figure.

The distinction is further accentuated by the fact that most people in our culture can write, but few can draw. The effect is again to favor

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*Most studies have until recently been media comparisons: TV versus live teacher, film versus textbook, etc. Few of these provide clearcut comparisons either between modalities or between signs.

Further, the status of the digital sign for study and teaching purposes has generally been held to be well above that of the iconic sign. Exceptions are those academic areas committed to the iconic (such as fine arts, TV, audio-visual) and those dealing in part with spatial concepts (geography, geology, biology, physics).

**Principle based on sources and discussion which follow.

verbal information, for a short-term verbal memory load can be output readily into "external memory" (the written word) for an indefinite duration of storage. The only readily available "external memory" for pictorial information is the photograph (perhaps also the Xerox or other copies suitable for two-dimensional iconic presentations).

28b. Partially compensating for the output advantages of digital signs are two aspects of iconic presentations:

1. They can be (usually are) recoded by the perceiver into digital form (name or description) and as such can readily be output. (Neisser: 36)

2. They are usually available to the senses longer than digital signs in auditory modality, thus renewing short-term iconic memory much as subvocal rehearsal renews short-term digital memory.

The recoding of iconic signs into digital signs is so important that the designer should arrange to facilitate it. There are at least two reasons for doing so:

1. Long term memory for pictures and objects is aided by the names for those pictures and objects.

2. Providing names for or descriptions of pictures and objects can provide a set which increases the probability that the audience is perceiving and interpreting them as desired. (Haber 1968) Words direct attention toward and aid in the categorization of pictures and objects.

Obviously, however, we also possess some means for non-verbal recoding and retaining at least some features of objects and pictures before iconic memory fades.* Although we retain some, perhaps most, iconic information by recoding it into verbal form, this would not account for the remarkable efficiency of our visual recognition memory for objects and events. We readily recognize the faces of friends, though we could not easily draw accurate likenesses of them.** Further,

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*Some people possess what has been called photographic memory or eidetic imagery. They can recall vividly and in detail a picture or event previously perceived. As they are doing so their eyes move as though surveying a scene. (Rapid eye movements frequently also accompany dreams during sleep.) Eidetic imagery appears to be incompatible with adult urban living, for in this country few except children possess it, while in Nigeria rural adults do but urban adults don't. (Neisser: 148-151)

**Studies requiring the subject to reproduce from memory a pictured object (an iconic sign) have typically yielded inaccurate or much simplified reproductions. It is not clear, however, whether the it is difficult to see how a sufficiently definitive list of verbal descriptors could be accessed and tested with sufficient rapidity to account for the immediacy of the experience of recognizing a friend's face. The same holds for our recognition memory for myriad objects and places we have encountered. We may have names for many of these objects and places, but the names are not posted on them to assist in the recognition process.

We generally can construct from memory a less-than-vivid image of familiar objects or places. These mental images, though acknowledged, are typically given little status, by psychologists, as vehicles of thought. (Neisser: 157) Words are for thinking. But this position is being challenged today, though without denigrating the status of words. The idea is simply that we think productively in several ways, one of which may be by recourse to imagery.* Associative memory has been shown in some cases to be facilitated by deliberate use of mental imagery. (Paivio 1967) Creative persons in fields as divergent as art and science have reported that "thinking visually" is a useful technique. We do appear to make use of iconic models to think about and communicate certain complex relationships. For example, most models of the human communication process have resorted to circles or squares connected by lines and arrows. Comparable elements are used to represent the flow of computer operations (flow diagram) and for PERT analyses of complex man-machine systems.

The idea that imagery, whether generated by the audience or provided by the designer, can facilitate memory and creative thinking is noteworthy. Designers have easy access to images, and through them can perhaps influence the imagery of their audience.

> 29. There is considerable evidence that objects and pictures of objects (line drawings) are better remembered than their names. These results have been found for a variety of learning conditions, including recognition, paired-associate, and free recall. (Gagné and Rohwer: 394)

Explanations are varied, but a common one is that objects and pictures are recoded into names during perception, the result being essentially the same as if the name had been the stimulus. But the object

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simplification occurred as a part of the perceptual and memory processes or as a consequence of subjects' inability or unwillingness to draw with greater precision. Requiring subjects to draw more carefully has resulted in greater accuracy of reproduction. (Neisser: 138, 139)

*It has even been suggested that the study of imagery, long thought to be very subjective, could be objectified and made suitable for scientific study in the same way that formal (verbal) logic achieved rigor, i.e., by putting the thought down on paper where it was public and could be examined systematically. This could be done for mental images as it was for words. (Harre: 13-14) or picture exhibits additional features which make it more memorable. (Figure 11) For example, a simplified drawing of a man may still suggest his expression, stance, clothes, or height, while the word "man" suggests little except type style, which is probably so common as to be unnoticed. (Jenkins, Neale, Deno)

30. There is considerable evidence that concrete words are better remembered than abstract words. (Gagné and Rohwer: 394)

Explanations include the position that concrete words arouse more associations than abstract and thus provide more ways to remember them.

The designer should note the consistency between the last two principles. They seem to agree that throughout the concrete to abstract continuum (from objects to abstract words) the more concrete is better remembered than the more abstract.

Again, concreteness appears to aid memory because of the extra attributes it provides, whether perceived in pictures or associated with concrete words. Following this lead, the designer might want to greatly embellish his messages with exotic pictures or colorful phraseology so as to provide more extras and further facilitate memory. However, in this way channel capacity or recoding capacity would soon be exceeded. (The problem of capacity will be discussed in Chapter 5.)

Further, it would certainly be a mistake for the designer to conclude that the more abstract messages are generally undesirable or to be avoided. Rather, abstraction is the goal toward which learning typically moves within a subject matter. The more concrete phases of instruction are to be seen as means to that end.

31. In general, instruction for the new learner in a subject area should begin with the more concrete messages and move to the more abstract as the learner proceeds to higher levels of the subject. This holds for learners of all ages.

Additionally, the degree of concreteness at any level of a subject matter should be greater for the first grader than the twelfth grader. (Berelson and Steiner: 196-198)

This principle further qualifies the prior two principles. It places greater or lesser emphasis on message concreteness depending on the age of the learner and the extent of his knowledge. (This idea was also discussed in Chapter 1.)

A distinction must be made between the concreteness of a message and the concreteness of the concept being presented. They need not be the same. Probably it is the teaching of abstract concepts that can profit most from concrete messages: examples, illustrations, analogies, models, diagrams.

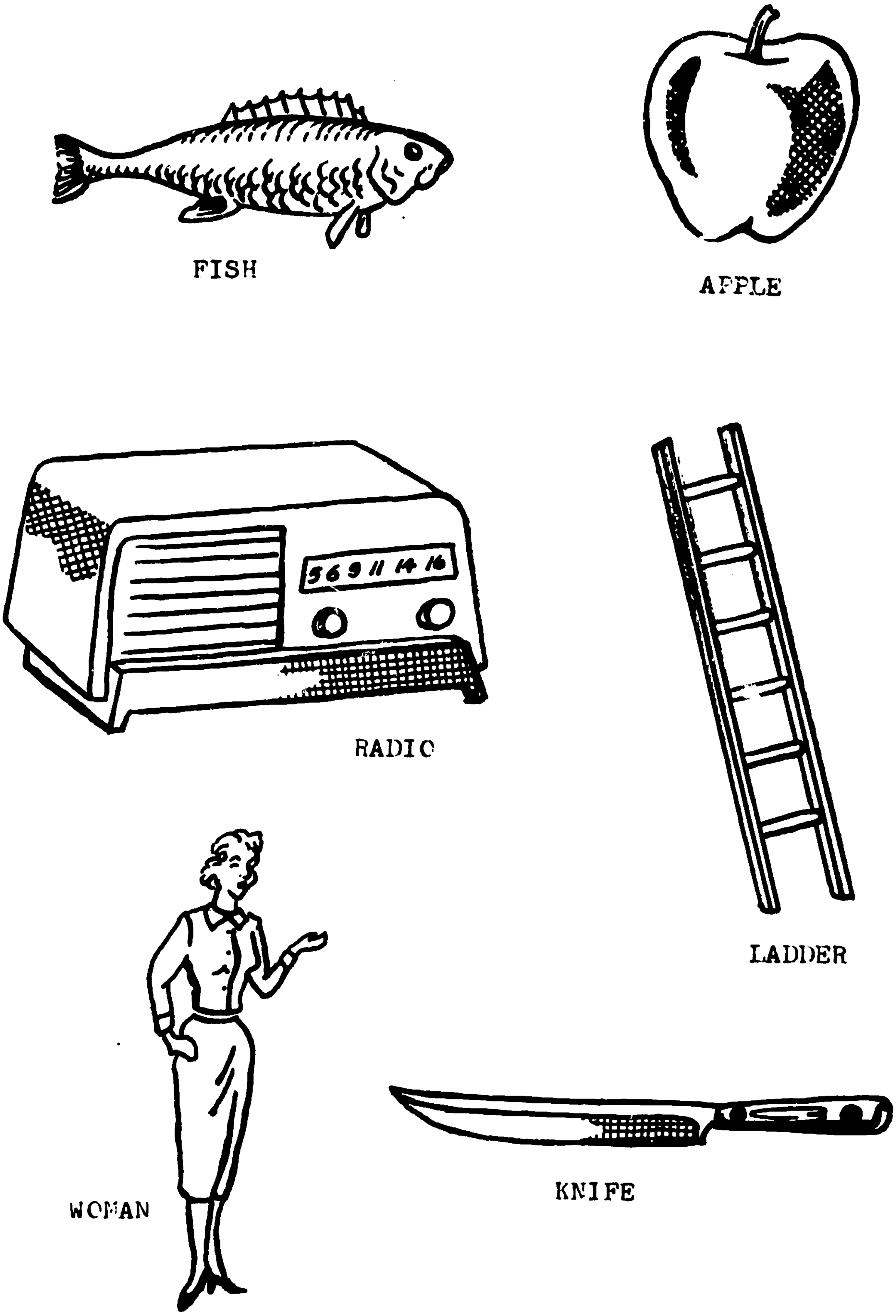

Figure 11. Examples of pictures and words used in study by Jenkins, Neale and Deno.

32a. In general, an effective combination of iconic and digital signs appears to be a pictorial stimulus and a verbal response* or label or description. (Gagné and Rohwer: 391)

This is consistent with much of our perceptual encounter with the world. We meet people and learn their names; we observe moisture forming on windows and hear the term condensation; we notice on a map a rectangular area with a diagonal southern border and see the name Indiana.

As this principle implies, one way to solve the digital vs. iconic dilemma is to use both. Within the limits of channel capacity, this strategy appears to have much merit.

The principle is also consistent with the concept of perceptual coding discussed in the preceding chapter. To the extent that a word labels or categorizes or comes to stand for a pictured object or event, that word facilitates the coding process.

32b. In general, an effective combination of digital signs is a more concrete word as stimulus and a less concrete word as response. (Paivio and Yarmey)

Note that this principle is consistent with the preceding one. Learning is facilitated where the stimulus is more concrete (whether digital or iconic) and the response is less concrete (or more abstract).

Words

The preceding account of the perception of signs dealt with both digital and iconic signs. Because digital signs have been studied more extensively, some additional aspects of perception can be noted with reference to them.

Stimulus features were discussed in this and the previous chapter. Extensive searches for the basic features or units in verbal perception have revealed that there are several instead of one. A person can listen or look for letters, syllables, words, phrases depending on the situation. (Neisser: 189)

It is apparent that we recognize words in reading without identifying all letters. Some of the features used are the redundancy of spelling patterns (random removal of letters, within limits, leaves intelligibility intact) and the overall shape of words (letters extending above and below the line, overall length). (Neisser: 105)

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*Studies of paired-associate learning show pictures to be most effective in the stimulus position and words most effective in the response position.

It is also apparent that we do not identify every word in reading. We read too fast for that, making only about 3-4 fixation pauses per line of reading and consuming about one second in doing so. (Neisser: 135) Further, foveal vision would permit no more than one five-letter word to be in maximum sharpness for each fixation. (Taylor, S.) Language redundancy accounts for part of our success in skipping words, for many words or parts of words can be removed from print or speech without seriously impairing meaning. Also the context of words within phrases and sentences permits accurate guesses or hypotheses about the meaning which are based on only partial perception.

Discussed at the beginning of this chapter was the analysis-by-synthesis process by which objects, words, and pictures are visually constructed. A similar process is said to occur in auditory perception. (Neisser: 194) Words and phrases are constructed from the temporal sequence of auditory features. This requires extensive short-term memory, because the exact meaning of a sentence strung out in time may not be apparent till the end. Meanwhile, all the rest of the sentence must be held in short-term memory.

Some of the cues useful in the perceptual construction of speech are: function words (the, in, we, and, after, etc., which occur very frequently), common endings of words (ly, s, ing, tion), rhythmic patterns of speech, and word orders (noun before verb, etc.). (Neisser: 259-265)

Summary

This chapter first dealt with the perceptual process by which objects, words, and pictures were constructed from the stimulus elements or features discussed in the previous chapter.

The concepts of figure and ground were introduced and considerable attention was given to the attributes of a "good" figure which a designer could employ. Among these were boundedness, closed area, continuous lines or contours, symmetry, simplicity. Briefly considered were the rival demands for figural symmetry (good figure, readily perceived and coded) and asymmetry (creates interest, tension).

The last part of the chapter endeavored to make three distinctions which are basic to the designer: that between sensory modality or channel and sign, that between auditory and visual channels, and that between digital and iconic signs.

The visual channel was represented as especially appropriate for representing spatial concepts such as "immigrate," the auditory channel for representing temporal concepts such as "poetic meter," and the combination for representing spatial-temporal concepts such as "four seasons." Exceptions to these relationships were noted.

The channel(s) should be chosen for instruction which will be encountered by the learner in the test or application situation. Language instruction for the purpose of reading the literature will emphasize vision, while that for the purpose of working or studying in the foreign country will include a great deal of audition.

Several advantages of the verbal or digital sign were discussed including the interchangeability of modalities (either speech or print) and the ease of outputting or recording.

Pictured objects, iconic signs, appear to be memorized more readily than their names, digital signs, presumably because of the greater number of perceptually available attributes.

Iconic signs also function well as stimuli with which words are to be associated. This seems consistent with the construction of films in which the narrator names, explains, and points to the critical aspects of the pictorial material. The associated words appear to facilitate both the recoding and the recall of pictorial material.

All the above have implications for the choice of medium, but the chapter deliberately avoided mention of the fact till now. The point is that rational media decisions can best be made after a consideration of suitable modality types and sign types. Of course, other factors must be considered as well, primarily the economic ones, but these are outside the scope of this report.

CHAPTER 5

PERCEPTUAL CAPACITY

Once the designer has gained the attention of his audience, he has the problem of maintaining an optimum level of stimulation, not too much and not too little. But how much is too much and how little is too little?

> 33. In general, it can be said that the greater the amount of processing (coding) required for certain information the less the capacity for that and other information, and vice versa, aotbe.* (Moray: 87)**

The implications for designers are obvious. The more codable a message the greater the perceptual capacity for it. Thus, intelligent use of the codability factors, discussed in previous chapters, will in effect permit the designer to present more information in a given time. Some of these factors were the goodness of the figure (straight lines and regular contours, symmetry, closedness), the use of words to label pictures, the use of regular word order (noun then verb then object), the use of relatively simple pictures (line drawings).

Interestingly, there is some evidence that well organized, readily coded material can be presented too slowly for perceptual and learning purposes, allowing students to perform unnecessary or erroneous recoding operations. (Neisser: 222)

More specifically, how much can a learner perceive and how much can he learn at one time?

> 34. An individual can perceive at a glance up to about seven items.*** (Miller: 195) That is, for familiar objects he can report some attributes about them: number, name, etc.
>
> Similarly, an individual can store in immediate memory up to about seven familiar items. (Miller: 196)

Of course the designer cannot continue to bombard his audience with

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*All other things being equal, which is a qualifer for this and all other numbered guidelines in this report.

**The reader must avoid considering the numbered guidelines as direct quotations, for none are.

***The so-called "magic number" of 7 +/- 2 has been found across a wide variety of stimuli and across modalities: vision, audition, etc. It appears to be a reliable measure of human capacity.

seven different items every few seconds, but the principle does provide him a very useful point of reference. A more dependable ball-park figure for regular design use would be five items.

One of the difficulties in applying this principle is that of defining an item, for it can vary greatly in size. It may be a single digit or letter, a five-letter word, or a well-known phrase. An item must be a meaningful unit. For example, for a beginning science student V E L O C I T Y might initially be eight items (letters) which quickly would become three (VEL O CITY) or two (VELOC ITY). Later, when velocity, distance, and time become meaningful concepts, each will be an item. Eventually, all three will become one item, $V = d/t$.

Thus, for each phase or step in such instruction the designer would choose an appropriate size of item, the maximum size being the largest or most inclusive unit which has been encountered and used enough to be meaningful.

35. In general, the perceiver partitions the available information into as large or as appropriate an item size as the stimulus and his experience and intention allow. He is said to chunk or cluster or group. (Miller: 198)

Faced with the task of checking a complex instrument panel, the operator may group various instruments so that 20 instruments become five groups. Much research has gone into the problem of designing the layout, scaling, size, etc. of such instrument arrays so as to maximize the amount that can be perceived at once.

Similarly, the student who must learn 16 new words may, initially at least, seek ways of grouping them: alphabetically by first letters, by related meanings, by spatial arrays such as columns or lines. The groups may be imposed by the student, and their use would depend on his prior associations or his success with alternative grouping strategies. For example, the writer learned the sequence--Phylum, Class, Order, Family, Genus, Species--by means of the mnemonic device: Post Card OF George Shaw (name of a friend). This reduced six separate items to one.*

*Such behavior as this has been one of the frustrations of researchers trying to study rote learning. Nonsense syllables were intended to control for prior experience, and varying the order of presentation was intended to remove tendencies to group. Recent evidence indicates that subjects nonetheless employ some coding or grouping strategies in spite of all efforts to eliminate the possibility. (Battig)

Grouping can also be facilitated by the character of the stimulus. As a consequence of the order (patterns, groupings) inherent in a situation, less order needs to be imposed upon it by the observer, and perceptual information is more readily processed, categorized, and acted upon.

36. The better organized or patterned a message is perceived to be, the more information the observer can receive (and process) at one time and/or the better he will retain what is perceived. (Bruner: 24) (Berelson and Steiner: 166)

For example, a string of nine digits is more difficult to learn than three strings (groups) of three digits, as the telephone company knows full well. Here the genius of the designer is important. By such devices as the appropriate spatial arrangement or temporal ordering of message elements the designer can facilitate perceptual grouping and hence increase the perceptual capacity of his audience. Particular techniques and examples were introduced in Chapter 1, and more will be considered in Chapter 6.

37. The more familiar the message to its audience the more readily it is perceived. (Berelson and Steiner: 113, Vernon 1962: 29) Thus, message familiarity increases capacity.

Reading rates vary directly with the familiarity of words and relations in the passage. Unfamiliar material takes longer, involves more re-reading.

The designer can thus maximize perceptual capacity and facilitate learning by using familiar examples, digital or iconic, and by referring back to previous learning.

This principle is consistent with the concept of readiness. When the learner has the prerequisite knowledge, he is ready for messages that employ that familiar and meaningful knowledge in the next level of instruction.

Programmers and those who design large units of instruction can make most effective use of this principle, for they know what aspects of the subject have at any point become meaningful and familiar. More particularly, they can systematically arrange for those very aspects to become familiar which will be needed for understanding the next concept. Thus, capacity is not exceeded at any point.

Next to be considered are the capacity problems associated with single and multiple channels. Some instructional materials involve one channel or modality such as vision, while others require two or more channels or modalities.

Single Channel Capacity

As already indicated in this report, our perceptual capacities are quantitatively limited, but the types and consequences of the limitation remain in dispute. One view has been that the many simultaneous sensory inputs converge through a selective filter to a single channel of fixed capacity, such as the channel from one ear, for example, or one modality (vision, audition). This model is now being questioned, so that generalizations to practice which are based upon it are premature. For one thing, channel capacity appears to vary. It can be improved with practice. For example, with practice, one can search for several letters (in a series of rows of randomized letters) as efficiently as he can search for one. (Neisser: 70)

An aspect of the single channel capacity problem having importance to designers is that of redundancy. Everyday speech is generally so redundant that large amounts of it can be clipped out without much loss in intelligibility. The clipping can be done electronically with sound recordings so that a fraction of the recording is removed every fraction of a second, the result being called speech compression. Studies show that speech can be compressed to 50% of its original length while remaining over 90% intelligible. (Foulke: 26, 132)

However, redundancy can also be controlled by the writer or speaker. Instructional film narrations, being under severe time limitations, are usually written and re-written so as to eliminate most redundancy, most repetition. Under these conditions a rate of 97 words per minute seems to yield more learning than 45 but the same as 142. (Hoban and van Ormer: 8-28) Where the narration is written so as to deliberately incorporate considerable redundancy, a higher rate would probably be acceptable.

Pictorial capacity has been investigated only recently in a few studies. One study indicates that recognition memory for pictures (mainly magazine illustrations) can be quite impressive. After a self-paced look through a group of 612 different pictures, subjects were able to recognize a sample of 68 with a median accuracy of 98.5%. This amazing recognition accuracy followed perception of each of the 612 pictures for an average of only 6 seconds. The recognition accuracy was still high, over 90%, a week later, though it had dropped to chance level four months later. (Neisser: 98)

In another study (Haber: unpublished) subjects were shown 2,560 pictures (assortment of amateur and professional slides) for 10 seconds each. This took four days at 640 pictures per day. There followed a recognition memory test of pictures sampled equally from all four days. Mean accuracy was over 90%.

38. For verbal materials in a single channel situation, the visual channel (printed message) appears to have greater capacity than the auditory channel (spoken message). At least, it seems clear that the more difficult or complex the verbal material the greater the advantage of the visual channel over the auditory. (Severin)

Less clear is the case for using both channels for verbal material. The designer will want to consider the evidence given in the section on Two-Channel Capacity.

It is important for the message designer to remember, as the above principle implies, that verbal auditory information presents special perceptual problems. For one thing it is strung out in time and usually allows for no repetition. (Neisser: 174) If a reader misses a word, he can stop and look again; but a listener has no such option unless he can stop the person who is speaking or reverse the tape recorder. The problem of auditory selection may be particularly difficult in instructional situations. For example, it may be impossible to follow the teacher's speech under classroom conditions which inhibit the normal adaptive process of moving closer to the selected speaker and farther from too talkative neighbors.

Recorded speech of television or film may be difficult to perceive where the recording includes even a moderate level of noise or competing conversations. The problem is that such recordings do not permit the directional localization of sounds. Normally, we can turn ears and attention to sounds from one direction and thus effectively reduce noise or competing conversations from other directions. (Neisser: 178) This selectivity by way of localization is not possible when all sounds, desirable and undesirable, are coming from the same direction, from the audio speaker system. It follows that audio recordings of speech for instructional purposes must be exceptionally well controlled if the full capacity of this channel is to be realized.

Two-Channel Capacity

The two-channel research which has been most controversial for message designers has been that by Travers. On the basis of an extensive series of studies he states the implications for designers as follows:

> "The evidence indicates that multiple sensory modality inputs are likely to be of value only when the rate of input of information is very slow. . . . The silent film with alternation of picture and print would appear to find much theoretical support as a teaching device."

"The quest for realism and the emphasis on realism which has characterized the audiovisual field emerges as the worship of a god who may not be too helpful to the faithful. . . . For example, a line drawing of the wiring of a television receiver is much more effective in transmitting information useful in assembling a kit than is a faithful photographic reproduction." (Travers: 14)

Though the above statements don't follow directly from the studies reported,* the indication that multi-modal materials such as classroom films are frequently overloaded with information does seem highly probable. The fact that a second showing of a film may increase learning by 35% is supporting evidence. But then, re-reading a text or listening twice to a tape recording (both single channel) can also produce increments in perception and learning. (Of course, part of the gain on second exposure is due to repetition, to seeing the same material twice.) It seems probable that most instructional materials are informationally overloaded, a condition that becomes most acute where presentation is at a fixed pace (TV, film, sound filmstrip). This is least characteristic of programmed materials, in which information is more carefully rationed, and the learner is constrained to perceive and learn a certain portion of it at a certain time and at his own pace.

Another point is that though a sound film may be overloaded, it has been shown in several instances to produce more learning than either the sound or picture separately. (Hoban and van Ormer: 8-21) This finding suggests that the two-channel aspect of such instructional films is not a deterrent to perception and learning.

Practically speaking, the channel overload can be seen to be of little consequence so long as the relevant portion of a message does not exceed capacity, and so long as the learner selectively perceives that relevant portion. (Figure 12) To that end, a variety of design devices for influencing perceptual selection were discussed in Chapter 1.

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*The multiple-modality studies were limited to the case where there was redundant information in visual and aural channels. Typically, the same words were presented to both modalities. Under these conditions no difference was found for perceiving meaningful words whether they were presented simultaneously to both modalities or separately to either. However, at very high presentation rates (faster than 300 words/minute) the two modality (audiovisual) condition was superior. (Travers: 53, 251)

The realism studies compared learning from a realistic demonstration with that from line drawings containing only relevant cues. There was no difference in initial performance, but there was a difference on a transfer task which favored the realistic demonstration. (Travers, 211)

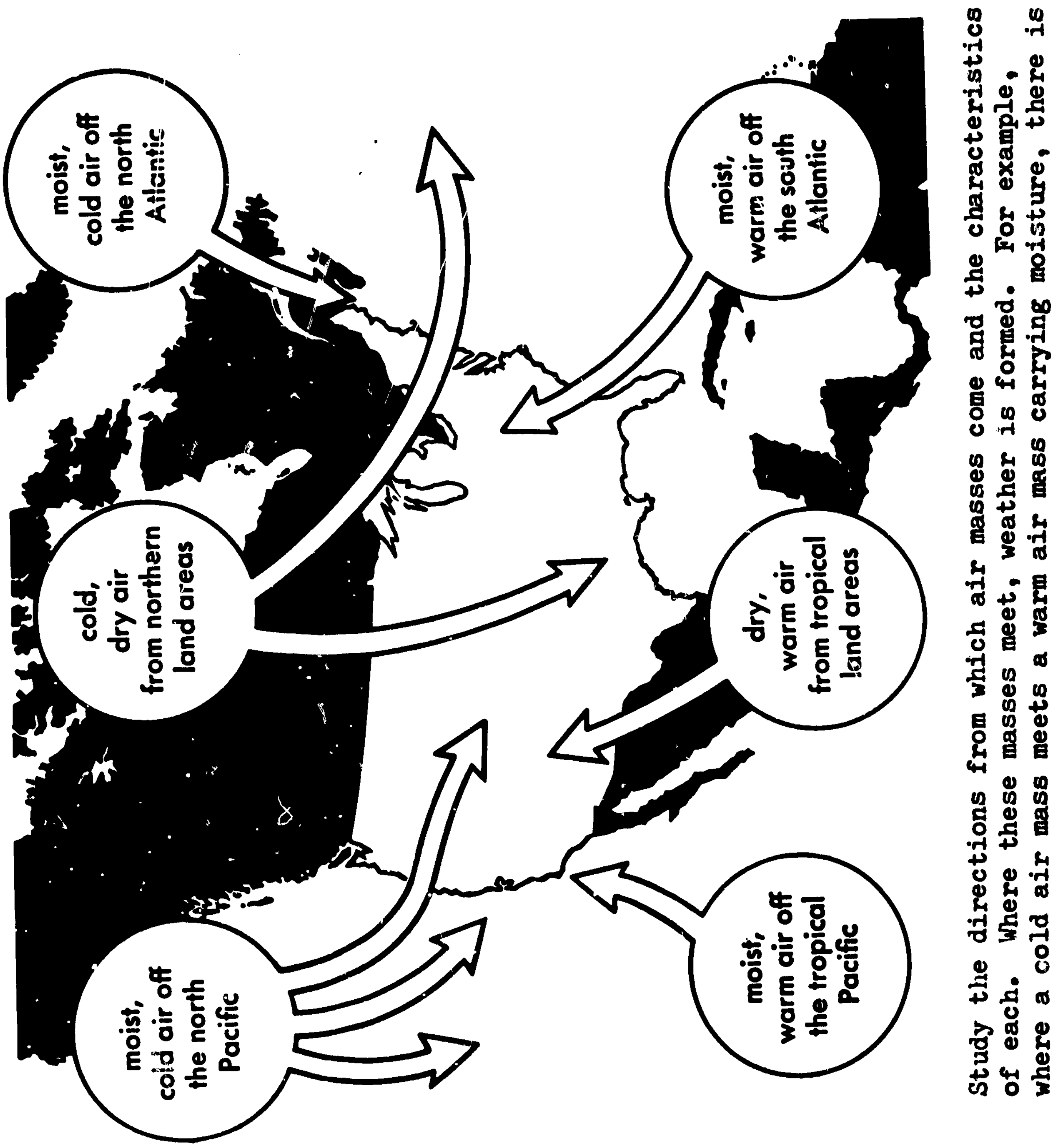

Figure 12. While this illustration is potentially overloaded and ambiguous, the caption directs the attention of the student and aids him in interpretation. (From The World of Matter-Energy, by Brandwein, Beck, Strahler, Hollingworth, and Brennan, Copyright by Harcourt, Brace and World.)

It seems probable that research to date, being focused narrowly on the one- or two-channel issue, has failed to take adequate account of the type of relationship between information in each channel: redundant or non-redundant, meaningfully related or unrelated. Such relationships are considered in a more recent analysis of Travers' work and that of others. It makes the following predictions:

"a. Multi-channel communications which combine words with related or relevant illustrations will provide the greatest gain because of the summation of cues between channels.

b. Multi-channel communications which combine words in two channels (words aurally and visually in print) will not result in significantly greater gain than single-channel communications since the added channel does not provide additional cues.

c. Multi-channel communications which contain unrelated cues in two channels will cause interference between channels and result in less information gain than if one channel were presented alone.

d. Single-channel communications will be superior to condition c (above), equal to condition b, and inferior to condition a. . . ."

"All of these predictions assume that testing for gain from these communications will be in the channel or channels of presentation, . . ." (Severin: 243) (underlining added)

While the above is not sufficiently well supported to be given the status of a principle, it seems consistent with much of the research to date. In the estimation of this writer, the designer would be well advised to follow it at least until more definitive research work has been done.

Parenthetically, the possibility that many instructional materials are already informationally overloaded raises some doubts about the further jamming of the perceptual channels through the use of multiple media, wrap-around screens, 3-D sound, and other stepped-up rates of audio and visual delivery which are characteristic of our time. Perhaps these are appropriate where their intent is not to inform in the usual pedagogical sense but to overwhelm, impress, exhilarate, "send." Informational overload may be an essential stimulus condition for such outcomes.

Summary

This chapter has related material from previous chapters plus new material to the problem of perceptual capacity. Obviously, the designer wants to communicate as much as possible per message or per unit of time, but the capacity of the learner to perceive, recode, and store information sets very important limits.

The reciprocal relation between recoding difficulty and perceptual capacity is crucial. The more difficult the message is to perceive, recode, learn, the less the capacity remaining for additional input. Much of what has been covered under various headings concerning the facilitation of coding applies here: sentence structure (normal word order, active voice); picture structure (good figures); stimulus chunking, clustering, or grouping; familiarity and meaningfulness; appropriate use of signs and modalities.

Estimates of single-channel capacity are still tentative. For words presented auditorially the estimates range up to 400 words per minute for a prose passage (Travers: 258). Much less is known about pictorial capacity though subjects can remember (recognize) with 90% accuracy over 2,500 pictures which have been presented at the rate of one every ten seconds. (Haber: unpublished)

The weaknesses of the auditory channel were noted, particularly for difficult material. The lessons for the designer are clear: shorter sentences for auditory material, more redundancy, and excellent technical quality.

Multiple-channel capacity has been a recent source of controversy among researchers. The case for simultaneous processing of information in two modalities or of two sign types is still to be unequivocally demonstrated, though motion picture and TV producers may be convinced that one can hear a track and see the action simultaneously. In fact, of all the possible combinations of modality and sign, the one that appears to be most compatible and to permit the highest information load is the auditory modality (verbal sign) in combination with the visual modality (iconic sign), i.e., the slide and tape presentation, the film, television, the teacher talking while showing an overhead transparency, etc. Thus, employing separate modalities, each with differing signs, should permit the perceiver to select one or the other with minimum interference or, to a degree, simultaneously perceive both. We certainly come to such situations with a great deal of prior experience, for example, experience in simultaneously seeing a person and hearing his name.

It does appear that the message designer can act as if simultaneous processing occurs in the perception of complex multimodal and multisign media, for even if there is not simultaneous processing, there is at least very rapid alternation between separate sequential processing.

In general, certain message features or patterns (as discussed elsewhere in this report), whose consequence is to facilitate perceptual processes, will have the effect of increasing perceptual capacity.

CHAPTER 6

PERCEPTUAL DISTINGUISHING, GROUPING, ORGANIZING

The principle of perceptual organization was introduced in Chapter 1, and in the preceding chapter perceptual capacity was related to stimulus organization. This chapter will considerably amplify these principles and add others.

Man's processes of perception and categorization are facilitated by the perceived regularities in the environment. Arranging for perception of these regularities is an essential part of the designer's task.

Environmental regularities are important for three reasons. First, perceived regularities make it possible for us to categorize and thus cope with the great quantity of sensory information bombarding us. Second, perceived regularities are the bases for much of our knowledge, concepts, opinions, attitudes. Finally, the organization of messages is one of the designer's prime means of influencing his audience's perception of those regularities.

A perceptual field is organized and regularities become apparent through a process of both analysis (distinguishing or separating) and synthesis (combining and grouping). Both will be considered in this chapter.

Distinguishing and Grouping

The process of distinguishing one figure or feature from another in the field is referred to as perceptual discrimination. Perceiving differences, i.e., making discriminations, is one of the most basic aspects of perceiving and learning.

> 59. Objects and events perceived as different, as standing in contrast along one or more dimensions, will tend to be distinguished from each other and be separately grouped in perception, aotbe.* (Taylor, I: 59-60, Berelson and Steiner: 100)**

The process of perceiving a difference or making a discrimination will obviously be aided by instructional materials in which the differences between objects, events, or ideas are made apparent. (Figure 13) More particularly, the differences shown should be relevant differences,

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*Aotbe means all other things being equal. It is meant as a reminder that all principles in this report are relative, are interdependent. Their effect may be nullified by other factors.

**Numbered guidelines are based on references given but are not direct quotes.

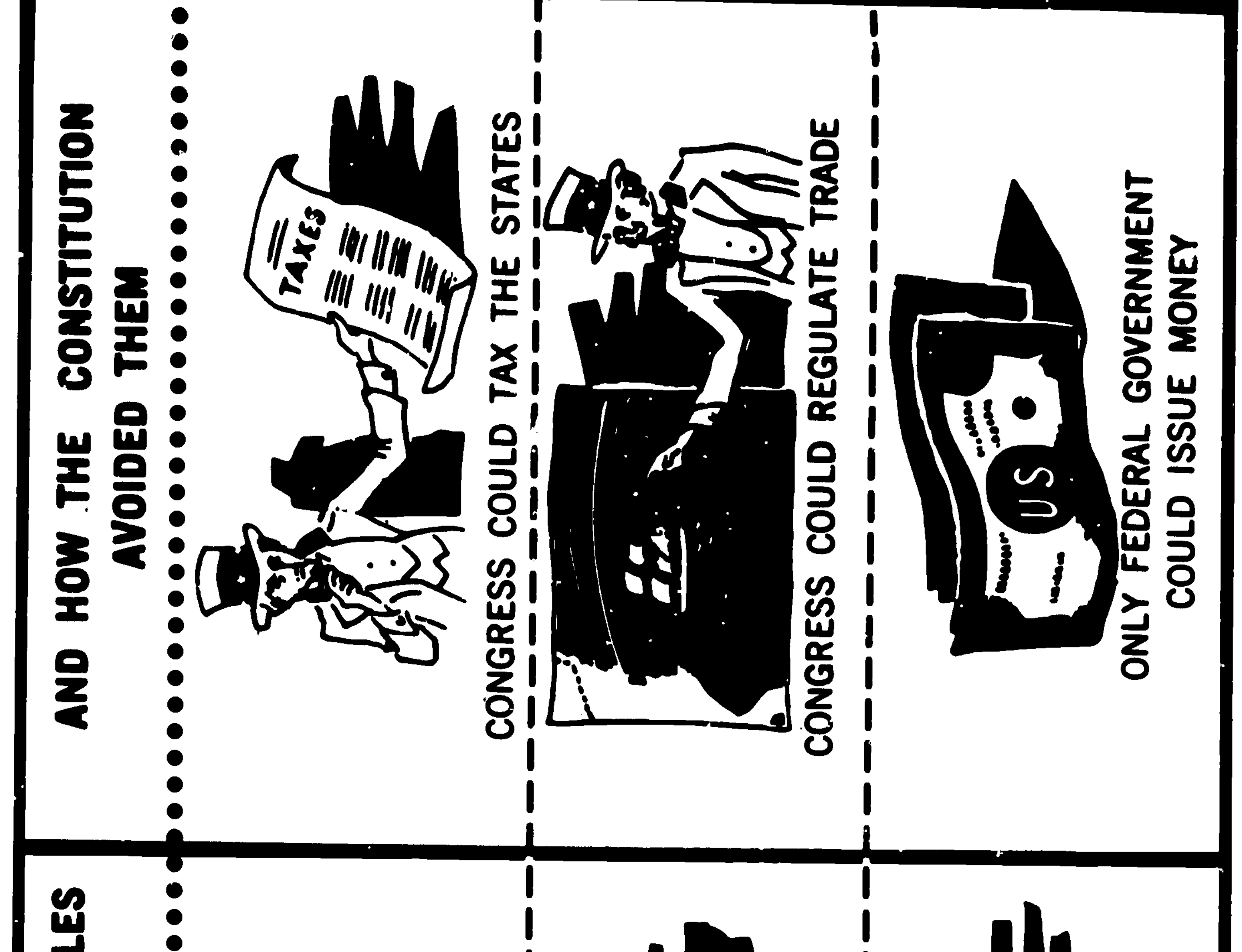

Figure 13. Side-by-side arrangement of characteristics of Articles of Confederation and of Constitution facilitates perception of the differences. (From West's Story of Our Country, by Gardner, Copyright by Allyn and Bacon)

i.e., those that define or provide the criterial evidence for the desired discrimination. (Gibson: 72-73)

Supporting evidence comes from studies of concept learning which suggest the importance of perceiving what are not examples (negative examples) of a concept as well as what are examples of it (positive examples). (De Cecco: 407-410) The concept "pine tree" is more reliably learned where several non-pine trees (fir, spruce) which are frequently confused with pines are shown as well. Learning the distinctions between one group and another may be an essential part of learning the characteristics of each group.

Perceived difference or contrast is often employed in message design in order to separate or space. Chapter headings separate ideas or events in a book, frames separate the parts of a filmstrip or a self-instructional program, fades to black separate sequences in television, color separates countries on a map.

Perceived difference or contrast also serves to accentuate critical portions of a message or to cue responses to it. A speaker may raise or lower his voice to call attention to important words or phrases. Capital letters and italics stand in contrast. The artist and cameraman employ many emphatic devices: color, brightness, contrast, etc.

The process of determining which distinctions need to be made and in which context may be an essential part of the design task. For example, it seems probable in driver training that some discriminations are better learned from reading the state laws, others from trial and error in a simulator, and still others in a driver training car. A thorough task analysis of each aspect of driving should reveal the kinds of discriminations to be learned and might suggest suitable conditions for perceiving and learning each.

As noted earlier, it is only by perceiving regularity amid all the diversity that we can learn to cope with the complexities of the world. To this end the perception of similarity is essentially the counterpart of perceiving difference.

> 40. Objects and events perceived as similar, in any of a number of ways such as appearance, function, quantity, direction, change, and structure, will tend to be grouped or organized together in perception. (Taylor, I: 58-59)

Learning to recognize and label the important similarities of our world is certainly a primary objective of formal education. It underlies the formation of concepts, principles, generalizations. (Figure 14) Clearly the more ways in which two things appear to exhibit common characteristics, the more likely they are to be perceived as related, as belonging to some common category. Thus, if the designer desires to

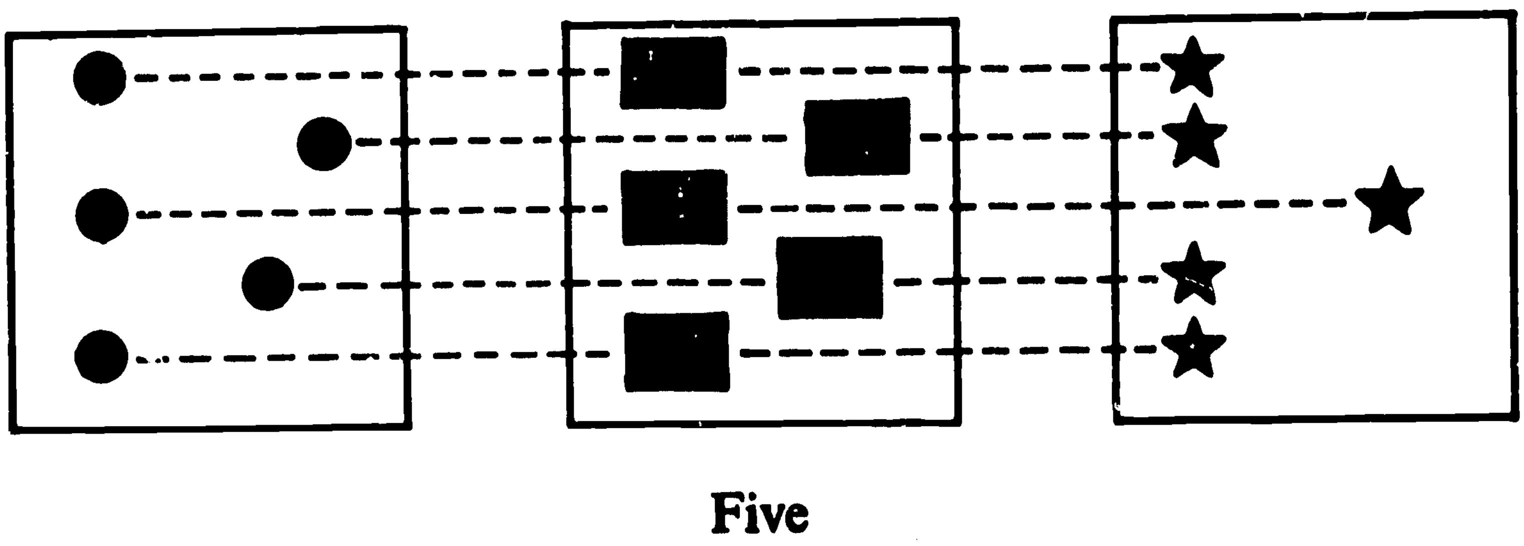

Figure 14. The horizontal lines facilitate grouping by similarity (concept of five) instead of grouping by difference (circles, rectangles, stars). (From Introduction to Mathematics by Brumfiel, Eicholz, and Shanks, Copyright by Addison-Wesley)

communicate that two languages are of common origin, or that several widely dispersed land forms are of the same type, he can so select the conditions of perception as to emphasize common attributes and de-emphasize the differences.

One of the most apparent consequences of perceiving similarities is the act of grouping. Perceptual grouping or organization is facilitated by stimulus conditions in which relevant similarities are displayed and apparent differences are eliminated or made less apparent.

Of course, in practice the design task is never as simple as this would suggest. For one thing, people differ in their tendencies to select attributes that are alike, i.e., some are more analytically inclined and tend to perceive subtle differences instead of apparent similarities. Then too, as noted in Chapter 2, man's attention is powerfully attracted to novelty in his environment, so that similarities that are obvious or quickly perceived may not sustain attention for long.

This principle is consistent with research on concept teaching, which indicates that a variety of positive examples of a concept be presented at once so that the similarities, the defining attributes, would be apparent. (De Cecco: 412) For example, the concept of isosceles triangle could be represented by an array of examples, all of which had two equal sides, but which otherwise differed systematically in various irrelevant ways, such as size, shape, position, etc.

41. Once a figure or pattern is fully distinguished from its ground and organized, the various elements within it tend to be perceived as more homogeneous than they in fact are. (Berelson and Steiner: 109-110) Further, distinctions between one figure and another may become accentuated. (Berelson and Steiner: 118-119)

This is to say that perceived similarities and differences may be greater than actually exist. So it is our own views and actions seem more internally consistent and those of our friends seem more congenial than they in fact are. Social organizations are seen as "good figures" in that individual members "belong" by way of their common qualities. Unfortunately, people of a certain race may be perceived as all alike, and people in certain groups (doctors, farmers, policemen) as being the same. (The illusion is aided in the latter case by the similarity of uniform.) Differences are minimized, are assimilated.

Likewise, the perceived difference between a figure and a ground may, once stabilized, be experienced as a greater contrast than actually exists in the relative energies of the stimulus. So, too, in social perception, for we tend to exaggerate the difference between those we like and those we dislike. "Our" way of thinking about or doing things may appear unique to us, no one else has things figured so wisely. Differences between political parties are accentuated while those within one's own party are minimized, are assimilated. Judgments of good and evil may be so contrasted that no relativities are distinguished. All shades of grey are distorted into black and white.

This principle may be either an aid or an impediment to the designer. Where distinctions and similarities are difficult to perceive, accentuation may be facilitative. However, where prior distinctions and similarities, already accentuated, must be changed, the designer may be faced with one of the most resistant-to-change behaviors he will encounter.

42. Objects and events encountered in proximity with each other, i.e., close together in time or space or in the same context, will tend to be perceived as somehow related. (Taylor, I: 58) Both similarities and differences may become more apparent.*

Things appearing close together in either time or space are apt to be perceived as belonging in some common category or as functionally or causally related.

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*It is worth noting that similarity and proximity factors are typically difficult to separate in practice. If their effect is in a common direction, all is well. If not, it may be difficult if not impossible to predict in advance which effect will predominate. There is some evidence that whichever one is initially dominant will tend to persist even though the other is strengthened. (Forgus: 118)

Temporal proximity is readily arranged and can produce strong perceptions of causality that may or may not be appropriate. A film maker can record a ball crashing through a window many days before and many miles away from where he records a baseball player hitting a ball, but causality will be strongly perceived so long as the two scenes are shown in the proper temporal relationship. However, a newsreel cameraman can inadvertently misrepresent the impact of a politician's speech by recording the chance expressions of members of the audience. A pained expression that really means, "I ate too much," can by proximity to a critical part of the speech be interpreted as, "I don't like what you're saying."

Spatial proximity is also readily arranged by the message designer. For example, he can place two pictur s or two sentences side-by-side on the same page or on a slide. Such a message strongly invites comparisons, both of difference and of similarity.

This principle is particularly useful either where distinctions or similarities are subtle or where they involve a number of attributes. In the latter case, proximity functions to reduce memory load, i.e., with differences or similarities simultaneously apparent, the learner need not remember all details in the two examples, just the relevant parts. For example, the similarities and differences between two presidents can more readily be perceived where their terms of office, parties, beliefs, actions are listed side-by-side, item-by-item, instead of on separate pages and mixed in with other information.

Proximity gains further significance because it is not only a stimulus condition for perception but also for learning as well, though under a different label, namely contiguity. Events that occur close together, i.e., that are contiguous, are considered likely to become associated or learned. Contiguity is one of the basic laws of learning.

In sum, objects and events perceived as similar in any dimension or as proximate may be grouped and given a label. Some groupings are of objects which are perceptually identical, such as manufactured products. Such groupings, a series of cups or pencils, for example, are very useful in teaching children to count or in teaching the concept of "set." Other groupings are formed, not only because of perceived similarities, but in spite of perceived differences. Such groupings are called concepts.

> 43. Familiar objects maintain many of their perceived characteristics (brightness, size, shape, color) almost independently of changes in stimulus conditions. This phenomenon is called perceptual constancy. (Berelson and Steiner: 113)

Each of the perceptual constancies (brightness, size, shape, color) can be considered a kind of concept in that they involve the perception of regularity or invariance across widely divergent conditions of stimulation. (Forgus: 290)

As noted earlier, a piece of paper will be perceived as "white" under extreme conditions of brightness ranging from daylight to moonlight (brightness constancy). A VW "bug" comes to be perceived as having invariant size and shape, though at different distances and angles its image on the retina will be radically different (size and shape constancies). (Figure 15)

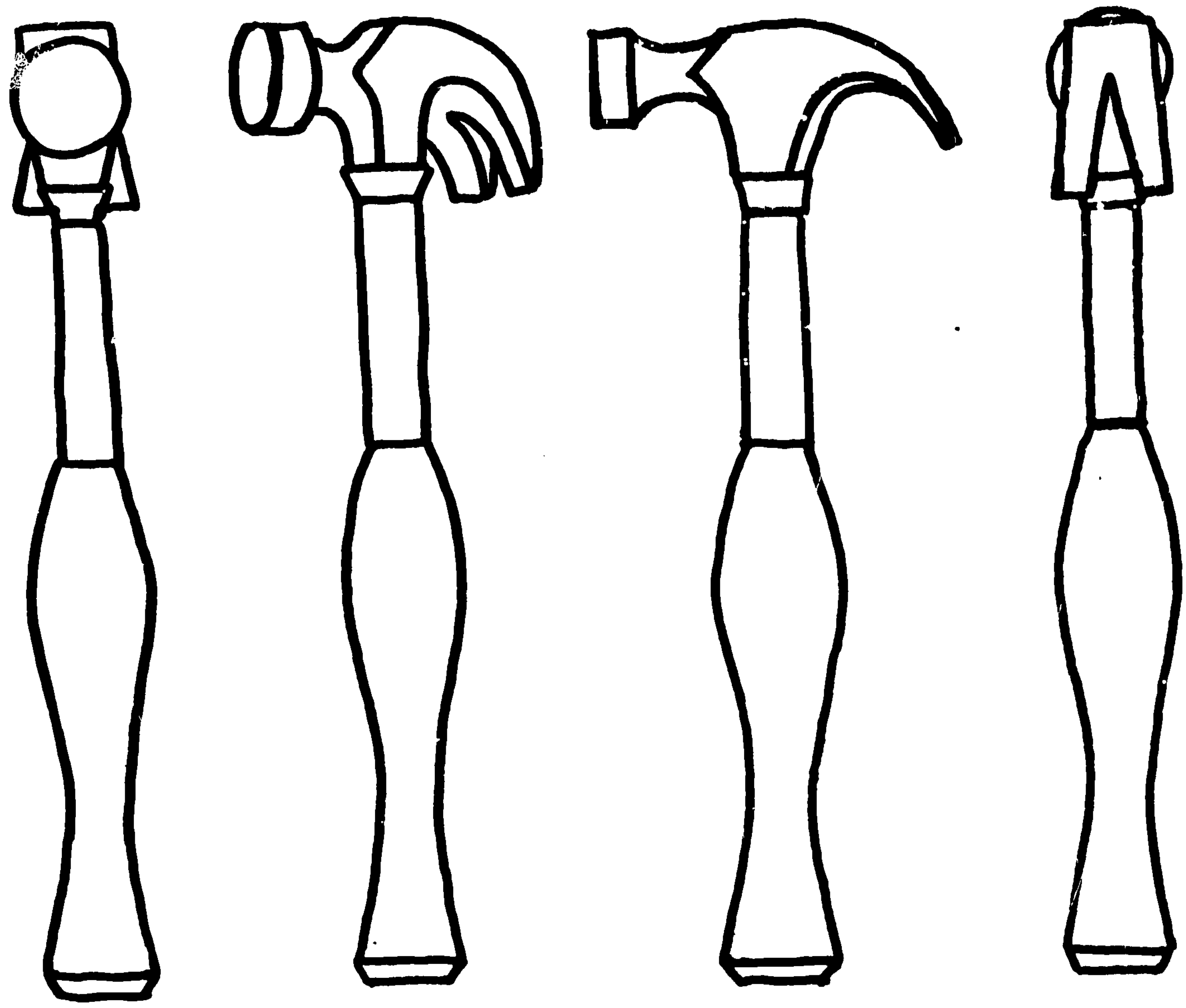

Figure 15. Familiar objects usually perceived as having a constant shape despite markedly different appearing shapes.

The phenomenon of perceptual constancy is generally a remarkable ally of the designer. Familiar objects, however minimally and variously represented, will tend to be perceived as having the known attributes of such objects. People can be represented as tiny as ants, grass as grey, and table tops as a line or square or any kind of parallelogram. However, the situation is quite different for representing new and unfamiliar objects. Here it may be necessary to introduce a scale for relative size, to display all sides and surfaces, and to render the object in accurate color.

Relating and Organizing

In addition to perceiving the regularities of difference and similarity, man also perceives regularities of relationship. In the following section several stimulus conditions for the perception of relationship will be noted.

The likelihood that certain things will be grouped in a common category varies with stimulus conditions. These are typically conditions of relationship between things, and they lead to such fundamental types of perceptions as cause or effect, before or after, better or worse.

> 44. Perceptual grouping will be facilitated where objects and events are encountered as comprising or contributing to a common idea, pattern, rhythm, structure, or organization. (Forgus: 113, Vernon 1962: 52)

It is tautological to state that where stimuli are patterned perception will be patterned. It may also be erroneous to so state, for cognitive patterns may depart markedly from stimulus patterns. Nevertheless, there are many reasons for patterning in message design. At minimum, perception is more efficient where stimuli are pre-patterned, or where they are "good" and symmetrical, as noted in previous chapters.

Also, knowing that an audience will impose pattern or regularity where stimuli are ambiguous, the designer would logically pre-pattern stimuli in a way consistent with his objectives.

One of the simplest temporal patterns is alternation, what in kindergarten is known as "taking turns." Many an adult conversation is patterned the same way, and thereby becomes more readily perceived. However, such simplistic patterns can readily be overdone. Consider a film in which closeups alternate mechanically with long shots. The effect can be to induce boredom or sleep.

Man can cope with much more complex patterns. He perceives, learns, and comes to anticipate certain language patterns, for example. Nouns are preceded by adjectives, verbs by nouns. Capital letters begin sentences and periods end them. Man is intrigued by the more complex patterns of events we call "plays," whether in chess, football, or politics.

Thus, it can be seen that perceived patterns range from simple to complex, from certain to uncertain, and the designer can choose the pattern appropriate to his needs. Importantly related is the finding from learning research that stimuli that are properly patterned or "chunked" are much more readily learned than the same stimuli presented in an undifferentiated fashion. In fact, where pattern or structure is not evident in the stimulus we must generally impose some regularity on it in order to remember it at all.

Spatial Structures

45. A variety of spatial arrangements, patterns, or structures influence the perception and learning of relationships.*

The following five types of spatial arrangements have been employed, in varying degree, to suggest relationships in various subject areas. None, except proximity, have been sufficiently researched to be given the status of a principle.

Proximity. A previous principle has dealt with this factor. It is included here as a reminder of its importance in spatially arranged messages.

Inclusion. A sign or stimulus condition of inclusion is the circle, rectangle, or free form around the assorted things. This gives them in effect the qualities of a good figure. Such a device cuts both ways; it definitely includes some things and equally definitely excludes others. A classic example is the variously overlapping pair of circles called the Venn diagrams which have been so successfully used to teach the vocabulary and concepts of Set Theory, whether to elementary school children or to college students. Pictures in magazines or books are frequently set apart by bounding lines. Paragraphs are set apart by white space.

Directionality. In general, verbal messages are perceived as proceeding in a top-down, left-to-right direction, at least in western cultures. As a consequence, any horizontal linear arrangement of elements will tend to be perceived in a left-to-right sequence. Though obviously a strong tendency for the perception of the printed word, it also holds for pictorial elements, as in the case of the comics. There is evidence that people ascribe cause and effect relations as well as before and after relations to visual elements connected left-to-right by lines, and the effect is strengthened by the use of arrows. (Fleming: 23-31) Time lines in history texts, for example, typically run left-to-right from past toward present. Circles with uni-directional arrows may be perceived as cyclical events such as life cycles or business cycles. Directionality may depict more subtle relationships, as in the case of a curve relating phenomena on ordinate and abscissa. In a decision matrix or contingency table the intersections of rows and columns are the perceived locus of coordinate relationships. Such heuristic devices appear to provide the message designer with powerful perceptual conditions for denoting relationships. However, use of such devices must be contingent on assurances that the audience understands the "code."

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*Guideline principally supported by the subsequent discussion of the five types of arrangements.

Superordination. Visual elements placed at the top of a display may be perceived as related in particular ways to elements below. Even the words used to mean physically higher (such as above, top, superior, superordinate) can also be used to mean better, more important, more general, more inclusive, more valuable as compared to the words meaning physically lower (such as below, bottom, inferior, subordinate).

There is evidence that words placed above others may be perceived as "more or better" rather than "less or worse" as compared to those placed below (De Soto and others). Clearly consistent with such perceived relationships are such message patterns as verbal outlines, where I, II, III, etc. denote superordinate elements and A, 1, a, etc. denote successively subordinate elements, which are not only indented but placed below the element to which they bear a subordinate relationship. Hierarchical tables of organization (such as those used to show the organization of a company or government) have been shown to suggest relationships such as greater-lesser and part-whole. (Fleming: 23-31)

Such stimulus structures have been shown to facilitate learning. For example, it was found that over twice as many words can be learned, in a given number of trials, where the words are arranged in a meaningful hierarchy as where they are randomly arranged. (Bower 1969)

Accentuation. A number of devices for accentuating certain parts of a message have been noted: arrows, underlining, changes in size and type of letters, color. These function mainly by providing perceptual contrast.

The important point here is that the organization of a message can profitably be accentuated. For example, inserted titles and subheadings which accentuate the organizational outline of a film have been shown to increase learning, particularly where the film was not inherently well organized. (Northrop)

Temporal Structures

46. A variety of temporal arrangements, patterns, or structures influence the perception and learning of relationships. (General guideline supported by the specific examples which follow.)

The following kinds of temporal arrangements have been sufficiently studied to justify their being represented as principles.

46a. The first and the last parts of messages tend to be perceived and learned better than the middle. These effects are called primacy and recency, respectively. (Berelson and Steiner: 164)

This principle serves mainly to remind the designer that introductions and summaries are important. Introductions serve to alert an audience as to what to expect, thus directing selective attention to the relevant features. Summaries serve to restate and re-emphasize the key points.

> 46b. The simultaneous presentation of related material may frequently be superior to successive presentation. (De Cecco: 412)

This has been shown to be the case where examples of a concept are being presented. Examples encountered simultaneously will be perceived as proximate and as similar in several ways (presumably relevant ways) and thus should be more readily grouped. They also should be more readily associated or learned. More importantly, because the common attributes are immediately apparent under simultaneous presentation, the memory load is reduced. In contrast, the sequential situation requires that the first instance be remembered in entirety, so that when the second instance is encountered the similarities can be recalled.

However, where simultaneous presentation leads to channel overload, it becomes undesirable.

There is also evidence that simultaneous presentation of name and pictured object or situation will facilitate memorizing or associating the two. (Travers: 107)

Verbal Structures

> 47. A variety of verbal configurations influence the perception and learning of relationships. (General guideline based on the specific ones which follow.)

The amount of evidence in favor of structure as an aid to verbal perception and memory is large and diverse.

The following kinds of semantic and grammatical structures have been sufficiently studied to justify their being stated as principles.

> 47a. The more nearly a string of words approximates English word order, the more readily it is perceived and learner. (Neisser: 263)

Although novel word orders may be useful in attracting attention, they are not perceived and recoded as readily as normal word orders.

> 47b. The active form of sentence structure (good figure) is easier to perceive and learn and use in solving problems than is the passive form (poor figure). (Neisser: 270)

47c. Words imbedded in a sentence or paragraph are more readily associated than those encountered in isolation. (Rohwer) (Bower 1967: 2-4)

For example, it is easier to learn to associate the noun pair, "Fork" and "Cake," when they are imbedded in the context or pattern of a sentence, "The fork cuts the cake." (Rohwer) In these and other cases it is somewhat of a puzzle as to why it is easier to memorize elements and a structure, such as a five-word sentence, than it is to simply memorize the elements, the two words. A string of digits presented orally is more readily learned if a rhythmic pattern is introduced. Again, it would seem that the pattern would introduce an additional load on memory instead of effectually decreasing the memory load. (Neisser: 233)

Also, memory for an unrelated list of words is facilitated where the learner is instructed to create a story which incorporates them. This is remindful of the imagery studies mentioned in Chapter 4, wherein memory for words is facilitated by instructions to imagine a visual scene in which the objects represented by the words are engaged in some kind of interaction.* (Bower 1967)

These studies give further weight to the general proposition that perception and learning are facilitated by perceived or imagined relationships. However, it is still an open question as to whether the designer should provide a relationship in his message or encourage the learner to imagine his own. It seems probable that where a meaningful structure exists or can be provided for the verbal or pictorial elements, it should be employed by the designer along with specific instructions to notice and use it. Otherwise, where there is no meaningful structure, i.e., where the relationships are arbitrary and rote memory is needed, the designer should encourage the learner to imagine his own verbal, numerical, or pictorial structure.

It may well be that structures that have wide utility should be taught early and reused wherever possible. For example, it is probably efficient for some purposes for a student to learn $E = I \times R$, i.e., EMF (voltage) = Current x Resistance. The other combinations would also need to be learned: $R = E/I$ and $I = E/R$. However, in other cases it would be

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*For example, to associate "cow" and "shop" the learner might imagine a scene in which a cow is standing at a cash register making a purchase in a shop. Typical results from such studies show twice as many pairs learned by subjects given imagery instructions as compared to those given instructions to associate the two words. Further, there is some evidence that the success of imagery for any pair of words is proportional to the learner's rating of the vividness of his image for that pair. (Bower 1967: 5-8) an advantage to teach the general formulation: A = B x C as well as the algebra of its permutations. Once this structure or pattern was learned, any example of it, whenever subsequently encountered, would be more easily learned: Force = Mass x Acceleration. Photographic Exposure = Intensity x Time, etc.

The same principle of teaching the structures that have wide utility would apply to such commonly used graphic patterns as pie graphs, time and number lines, and hierarchical outlines and tables. Learning the pattern of the alphabet obviously yields a comparable payoff by greatly simplifying access to a dictionary, to a textbook through its index, and to a library through its card catalog.

Summary

This chapter took off from the proposition that man's perceptions are organized and that consequently the designer can facilitate and control the perceptual process by the way he organizes his messages.

The three key perceptual principles considered were similarity, difference, proximity. Quite simply, man groups similar things and separates different things. And the process is influenced by the spatial or temporal proximity of these things. Concepts are based on similarities, but learning to use them may depend heavily on the differences that distinguish one concept from another.

These are very broad principles, which makes them widely useful but never sure-fire. A design problem might employ all three. For example, the concept of "proper noun" could be taught in part by an array of perhaps twelve examples arranged in close proximity, perhaps three columns of four. They would be labelled as proper nouns and attention would be called to their similarities: all are capitalized and all are names for specific individual persons, places or things. Then, perhaps after some practice identifying proper nouns in a paragraph, a two-column array might be presented which placed in proximity some proper nouns and related common nouns, such as Chicago and city, Time and magazine. The relevant differences would be pointed out and practice given in applying the distinction.

A number of more specific principles for the organizing or structuring or patterning of messages were given and discussed under the headings: spatial structures, temporal structures, verbal structures. These varied widely in the amount of research behind them but yielded guidelines for the designer such as:

a. Making the organizational outline of a message apparent (subtitles in a film or transitional statements in a speech) should improve perception and learning of its essential features.

b. Simultaneous presentation of several examples of a concept, such as drawings of various fungi, should be superior to one-at-a-time successive presentations.

c. Words imbedded in meaningful sentences should be more readily related and associated in memory than words presented outside of sentence contexts.

It seems plausible that stimulus structures that have wide utility across subject matters, such as hierarchical outlines, pie charts, and time lines, should be taught early in the curriculum.

CHAPTER 7

PERCEPTION OF SIZE, DEPTH, SPACE, TIME, AND MOTION

The preceding chapter dealt at a general level with the perception of regularities such as similarity, difference, and relationship, i.e., with some of the basic conditions for learning concepts. This chapter extends that discussion to some of the specific relationships and concepts which have been investigated by perception researchers.

Size and Depth

The perception of size and depth are essentially the perception of relationship.

> 48. Perceived size is reciprocally related to perceived distance, and vice versa, i.e., the greater the size the less the distance and the greater the distance the less the size, aotbe.* (Forgus: 80)

Note that perceived size may not always vary with actual distance, only with perceived distance, and vice versa. Thus, the designer has the opportunity to arrange stimulus conditions such that the apparent (perceived) sizes and distances in his messages are as desired. For example, where the designer wishes to compare the size of two animals, he must control the distance cues so that the animals appear equidistant from the observer. And where he wishes to show distances he must control the apparent size, usually by showing the same object or person at both the near and far points.**

> 49. The sizes of unfamiliar objects are perceived as relative to that of familiar objects. (Vernon 1962: 69)

Where cues for distance are lacking, the size of an unfamiliar object can be judged relative to familiar objects. In the case of an unfamiliar rock specimen, for example, the designer would include in the picture a familiar standard such as a ruler or a hand.

Size comparisons can be done verbally as well: your heart is as big as your doubled fists, a mile is as long as 1,760 yardsticks. Texas is larger than Michigan, Wisconsin, Iowa, Illinois, and Indiana all together.

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*That is, all other things being equal. This qualifier should follow every principle statement in this report. However, it is given mainly at the beginning of each chapter as a reminder to the designer that none of these principles act in isolation, all are relative to other factors.

**More accurate depictions of distance can be done by equalizing distance from the observer. Distances on a map, for example, are about equidistant from the observer.

50. The perception of depth in two-dimensional displays is influenced by the following: Relative size (especially of familiar objects), linear perspective, texture gradient, upward angular location of grounded objects, superimposition. (Forgus: 207-212)

Ordinary depth perception is influenced as well by several physiological factors.* However, for most message materials such depth cues are irrelevant, for the materials have no intrinsic depth. The TV or motion picture image, textbook page, etc., are all two-dimensional, though we often experience them as three-dimensional.

In what follows, the above factors which influence depth perception in two-dimensional displays will be discussed and examples given. Picture an outdoor scene looking down a highway with fields on one side, occasional houses on the other, and mountains in the distance. In general the relative sizes of cars on the highway and of houses along it should vary inversely with the distance, i.e., the frontal dimensions of a truck that is half a mile away would be twice the frontal dimensions of one that is a mile away. (Forgus: 208)

Linear perspective refers to the longitudinal, near to far, dimension of objects and is illustrated by the lines which mark the edge of the road stretching off into the distance. This longitudinal dimension of objects varies inversely with the square of the distance. (Forgus: 208) Thus, if the distance from the near to the far end of a bridge 200 yards away were represented in a drawing by a one inch line, the same bridge 400 yards away would be represented by a 1/4 inch line.

The concept of texture gradient combines those just discussed for the edges of objects (relative size and linear perspective) and extends them to the texture of surfaces. (Forgus: 208) For example, if the highway were concrete the joints would form a texture pattern or gradient which would be a very good cue for distance. The longitudinal distances between successive joints would decrease at an accelerated rate (following the dictates of linear perspective), while the horizontal or frontal length of each joint would decrease at a constant rate (following the principle of relative size). Similarly, gravel along the edge, clods in a plowed field, and shrubs along the fencerow would form a texture gradient of decreasing size with distance.

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*Probably the most studied are the effects of accommodation, convergence, and binocular disparity. As the eye muscles change the shape of the lens to bring an image into focus (accommodation) they give some cues as to the distance to the object being imaged, cues that appear to be of some help up to about 25 feet. As the eyes "toe inward," so to speak, to fixate a near object (convergence) they also produce some cues as to the distance to the object that are reliable up to perhaps 50 to 80 feet. Binocular disparity, the difference between the retinal images of the two eyes, is more marked as the fixated object moves closer, and hence provides another cue for distance. (Forgus: 199-203)

The idea of "upward angular location of grounded objects" is simply that near objects are usually grounded (touch the ground) at the bottom of a picture while the successively more distant are grounded nearer the top or nearer the horizon. (Forgus: 207) In the process, some objects may overlap others, which is called superimposition. (Forgus: 209) Thus, a tree which overlaps and blocks out the view of part of a house is perceived as nearer than the house. (This would not apply to superimposition in the TV sense of a blend of images.) The latter two factors, upper angular location and superimposition, function essentially independently of image size, while the first three factors, texture gradient, etc., are dependent on image size. (Figure 16)

The perceived three-dimensionality of an object involves a degree of distance or depth perception, and some of the above factors apply.

51. The perception of depth in an object is markedly influenced by the illumination and the sharpness of image features. (Forgus: 210, 215)

Flat lighting (lighting from the direction of the observer) or diffuse lighting serve to reduce the perceived three-dimensionality of an object (hence the name "flat"), while lighting that is from the side or more directional tends to accentuate three-dimensionality.

Both the gradual brightness gradients and the abrupt ones (shadows which are adjacent to lighter areas) are cues to form or depth or relief. For example, though human eyes may appear darker than nose even under flat lighting, the two can be "separated" even more by side lighting which puts the eyes in shadow and thus makes them appear deeper in their sockets. Such lighting might also accentuate the shape and size of the nose. Also the sharpness of the focus (or the lens) serves to accentuate perceived depth. A sharply focused figure appears distant from an out of focus or softly focused background.

The above factors facilitate the perception of depth in flat instructional materials. The effect is presumably reduced because of the absence of the physiological cues mentioned earlier, but the illusion of depth can be very convincing. Surface features, such as reflections on the TV tube and texture of the photographic paper, serve to diminish the depth illusion, though skillful use of surface texture in painting can accentuate depth.

Space, Time, Motion

The previous three chapters have considered at length the spatial and temporal aspects of signs, of modalities, of environmental regularities, of message structures and patterns. Hence, the perception of space and time will not be belabored here. There will be only brief reviews and a few more principles.

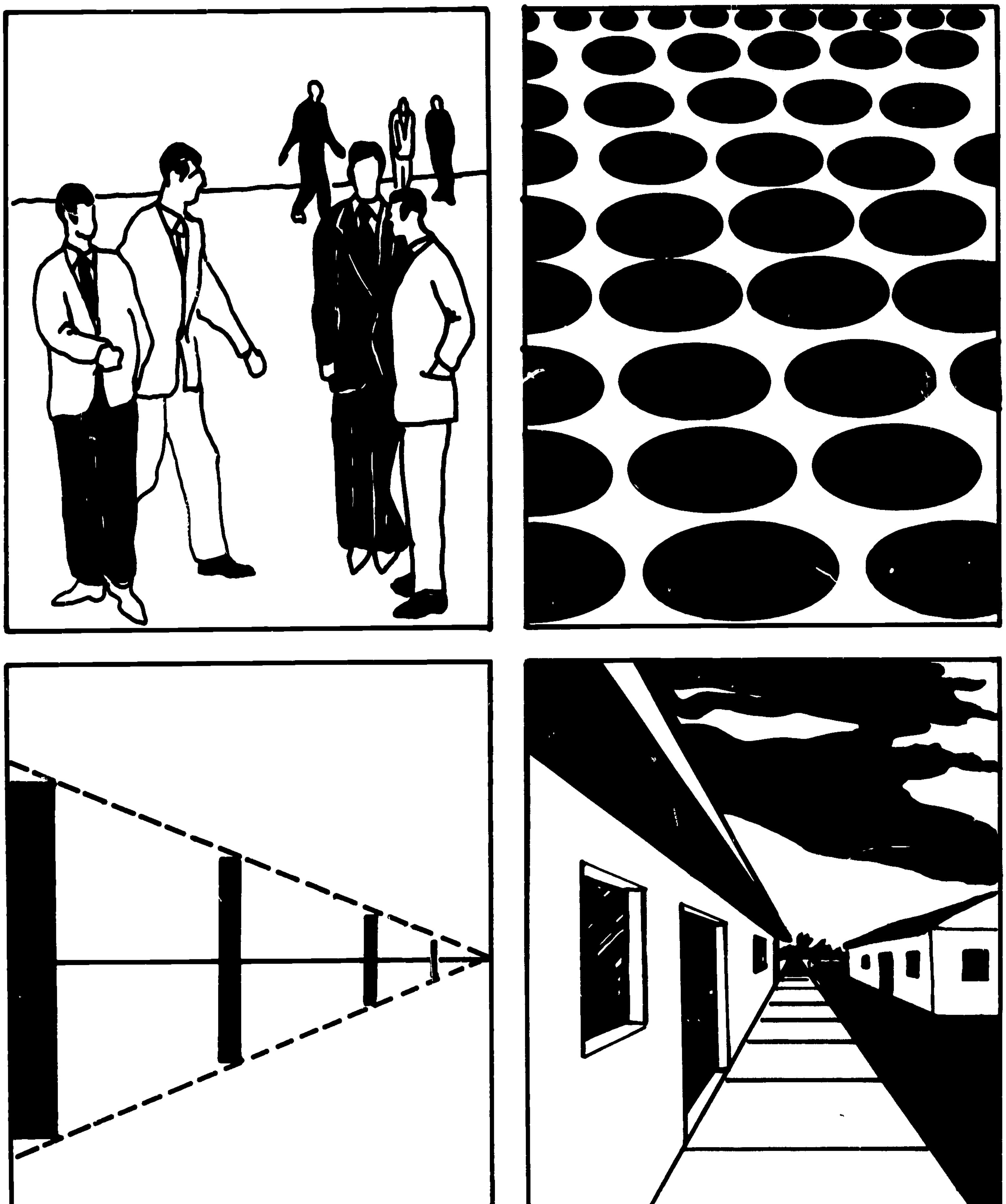

Figure 16. Identify examples in the above of the five factors influencing depth perception in two dimensional displays.

The importance of the perception of spatial relations has been frequently noted in this paper. The spatial proximity of people, for example, influences whether we see them as strangers or lovers. The spatial directions in which people are moving (motions toward, away from, or with each other) are also important in perceiving relationship. And, as previously noted, the deployment of objects in space from foreground to horizon markedly influences our perception of their nearness. (Forgus: 207) Objects placed to the left may under some circumstances be perceived as occurring before or as being the cause of those placed to the right. (Fleming: 25, 29) Also, under some circumstances, words placed above are perceived as more or better in relation to those placed below. (DeSoto and others)

> 52. Spatial perception is strongly oriented relative to the vertical and horizontal. (Vernon 1962: 120, 121)

Our perception of the vertical and horizontal accounts for much of our sense of stability and orientation. Our static and dynamic sense,* our muscle sense, and our perception of upright objects keep us upright oriented and provide a frame of reference for judging the spatial location and form of perceived objects.

In a sense, the frame of a picture or a TV screen provides a substitute anchor point for spatial perception. A tree parallel with the side of the frame is perceived as upright, and one at an angle to the frame is about to fall. A person that fills the frame is close, one that does not is distant.

> 53. Ordinarily, the perception of time durations and time intervals is relatively inaccurate without a standard or frame of reference. (Forgus: 233)

Temporal structuring or ordering of events is very important to perception. Events are perceived relatively, i.e., as before, after, or during other events. In fact we usually speak of time with reference to something: time for a cup of coffee, time for the bus, faster than you can count to three, slower than molasses. Accurate time estimation requires some external frame of reference such as counting seconds or observing some change such as the position of the shadow on a sundial. For this reason, time is typically portrayed in messages by means of change: the change in position of clock hands, changes from youthful to wrinkled faces, change from summer to winter.

> 54. Time that is filled with activity appears to move more rapidly than time that is not. (Forgus: 234-237)

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*Located in the labyrinth in the inner ear.

The lesson for the designer is clear. He should fill the message time slot available. Of course, there is more to it than this, for what the time is filled with makes a major difference. Pleasant, changing, interesting events appear to shorten time durations and intervals, while repetitive and boring events lengthen them.

Time duration in film and TV is a much manipulated dimension. Where an ongoing event has been documented, as in a Presidential address, an hour may be reduced to five minutes of highly selected segments. In depicting a lengthy process, the passage of time may be implied by dissolves and fades or by leaving the process for a while and then returning at a later stage. An extension of this is the dramatic device of cutting back and forth between two concurrent events (typically chaser and chased) and thus either stretching or shortening real time. The perceived tempo of an event can be modified by changing the length of each scene.

Also, time relations can be depicted linearly as in the case of a time line or perhaps the ordinate of a curve. For events that recur, the time line is formed into a circle, and the successive events, such as the stages in the reproductive cycle of a plant, are arranged around it.

> 55. The perception of motion is highly related to both temporal and spatial factors. (Forgus: 226)

As noted earlier, our perceptual apparatus is very sensitive to movement, even in peripheral vision. Motion attracts attention. So powerful a perceptual phenomenon is it that even minimal cues can suggest it. Motion can be suggested in static figures by blurring or streaking them, and by depicting them in active positions (arms and legs at dynamic angles). (Figure 17) An asterisk moving appropriately in a film can be perceived as walking, jumping, or running.* And the film medium itself gives an illusion of motion achieved through a succession of static views of objects in different spatial positions, the succession being so rapid that the views cannot be separately distinguished--- a clear case of the proper arrangement of spatial and temporal factors.

More basically, time and space are reciprocal with reference to motion: speed = distance/time. An increase in speed is effected by either an increase in distance covered or a decrease in time taken, and the designer frequently has control of both factors.

> 56. The relation of figure to ground is particularly determinative of motion perception. (Vernon 1962: 144)

*Experiments in which one square moves variously in relation to another have, in darkened rooms, been perceived causally, i.e., "A" is seen to pursue, bump, join, push, repell "B." (Forgus: 240-242)

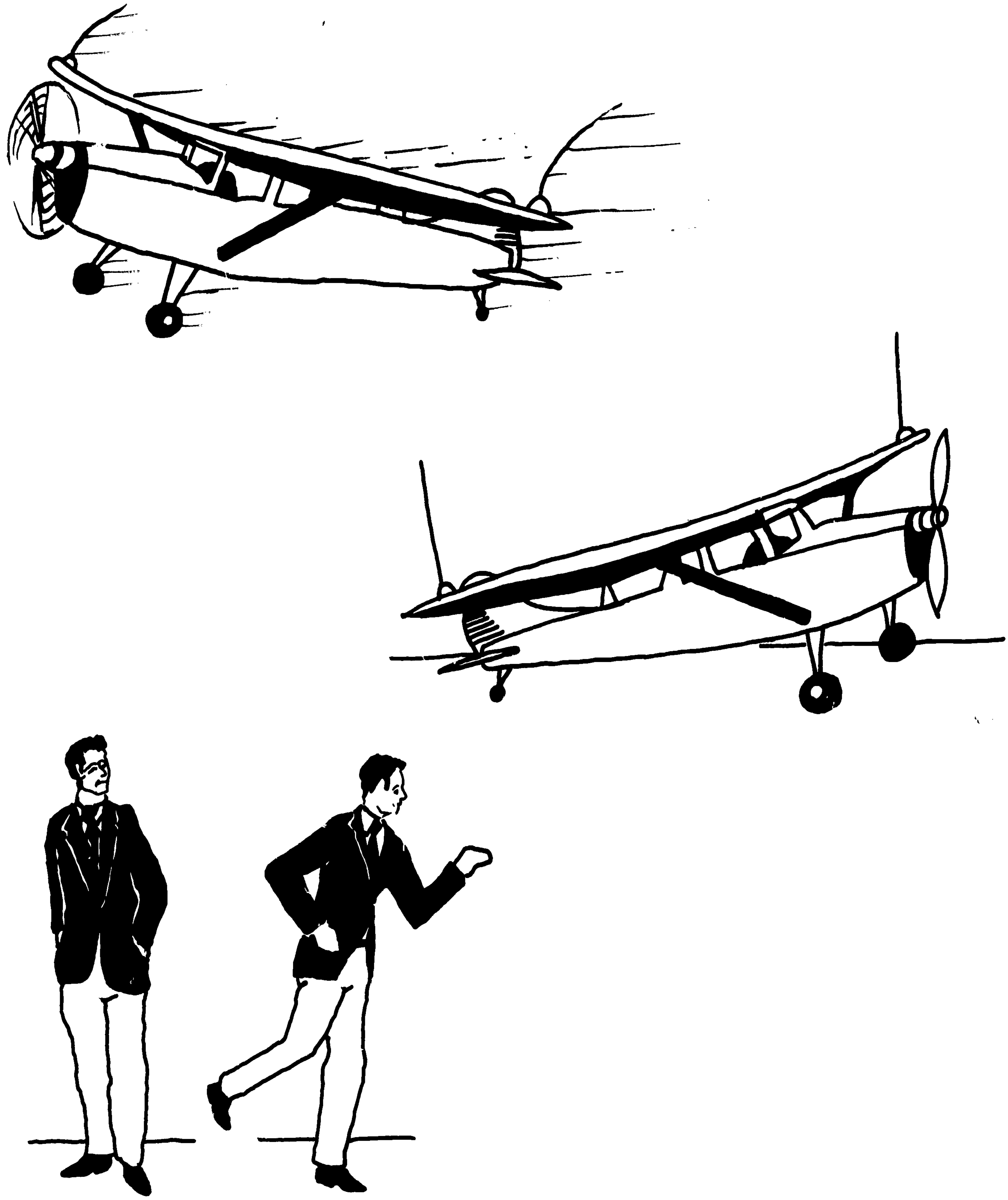

Figure 17. Examples of contrasting still and "moving" figures.

The sun appears faster-moving at the horizon than it does overhead partly because in the one case it is relative to a static horizon while in the other there is no reference point.

In film animation, a car may be perceived as moving either where it changes position relative to a static background or where it remains still relative to a background which changes position behind it.

As noted earlier with reference to size, the frame of a picture or screen provides a reference point. The less time required for a person to move from one side of the screen to the other the faster he is apparently going.

The perception of motion is highly related to aspects of depth perception discussed in the preceding section. For example, because the retinal image of a car varies in size with its distance, the rate at which the retinal image changes in size is a clue to the speed of an approaching car. Also, a texture gradient perceived when we are still becomes very dynamic when we move, giving many clues for size, distance, and motion. For example, when we walk down a corridor it appears to open ahead of us and close behind us, this being simply the consequence of a changing gradient of size, perspective, and texture. The gradient of expansion of the landing strip gives the approaching pilot critical cues for altitude, speed, distance. (Hochberg: 96, 97)

Summary

This chapter has dealt with some of the relationships or concepts which have been investigated by perception researchers.

Considered first were the interrelationships of size and distance perception. A change in the size of an object can be perceived as either a larger object or the same one moved closer to the observer. Consequently, the designer must reduce this uncertainty. He can do this in several ways.

a. Where the perception of a change or difference in size of two objects is desired the designer must control for distance, i.e., make sure that distance cues indicate the objects are equidistant from the observer.

b. Where the perception of a change or difference in distance is desired the designer must control for size. He can do this by placing an identical appearing object at both distances. He can also do this by using as many distance cues as possible.

Distance or depth perception in 2-D instructional materials depends on a number of factors such as: relative size, linear perspective, texture gradient (change in texture of surfaces), location of grounded objects (in foreground or near horizon), superimposition, lighting contrast, and sharpness of focus.

Considered last were space and time factors and their relationship to the perception of motion.

Spatial perception is strongly oriented relative to the vertical and horizontal. Time perception is relatively inaccurate except as related to some standard or frame of reference. Filled time appears to move more rapidly than empty. The design implications of these perceptual principles were discussed.

While motion may not often be a criterial cue in the sense that it is required for the understanding of a relationship, it is markedly attention getting and directing. Further, people perceived as moving (TV or film) frequently appear more alive and 3-dimensional than they do when perceived as still. (Vernon 1962: 148) Such added effects may at times justify media of motion where they otherwise could not be justified on the basis of achievement tests.

Motion is perceived primarily in the relation of figure to ground. An appropriately paced change in position of either with reference to the other is interpreted as motion. Animation designers make use of both figure changes and ground changes.

CHAPTER 8

PERCEPTION AND COGNITION

While this report has been written with particular reference to perception, it should be clear by now that the behaviors labelled perception have consequences that extend far beyond themselves to learning, concept formation, and problem solving. These terms refer to ill-defined points on a presumed continuum that begins with perception and continues to high order behaviors such as problem solving. While the research literature continues to employ such terms, it also notes increasingly that the distinctions are more indicative of the particularities of behavior theory and of research procedure than they are of the dynamics of human cognition. Nevertheless, it is at this point that books on perception typically end or taper off rapidly.

What follows are a few principles relating perception to some of the other cognitive processes. The principles are general and are heavily dependent on previous chapters for their implications.

> 57. The better an object or event is perceived, according to the principles of perception, the better it will be remembered,* aotbe.** (Berelson and Steiner: 181)***

Contrarywise, the quality of particular learning will markedly influence subsequent perception related to it. What we have learned about our environment and what we consequently come to want and expect from it determine to an important degree what we give attention to, what we selectively perceive, and how we choose to interpret it. Thus, learning and thinking can be seen as facilitating the perceptual process of information extraction from the environment. (Forgus: 3) It is on such grounds that a case is sometimes made for improving, training, educating the perceptual skills. Teachers of reading and of science have been particularly supportive of such training. The message designer may find himself designing materials to train and sharpen the very perceptual

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*Interestingly, the process of recall itself seems to operate somewhat analogously to perception. Recall involves search, selection, organization, and interpretation. It, too, is a construction process. The product of recall tends to be, in a way, a "better figure," one that is simpler and more internally consistent. (Berelson and Steiner: 183; Neisser: 285)

**Aotbe means all other things being equal and is intended as a continual reminder to the reader that all these principles are relative.

***Principles in this report are based on references given but are not quotations.

tendencies discussed in earlier chapters, such as perceptual discrimination and perceptual grouping.

Suffice it to say, if the perceptual conditions described throughout this report are met, learning will be facilitated.

> 58. Stimulus conditions are important determiners of the efficiency of concept formation. (Forgus: 295-296)

The perception of similarities, regularities, invariances amid pervasive differences is an integral part of school learning because such perceptions are the progenitors of concepts. This was the position presented in Chapter 6. The stimulus conditions (verbal and pictorial, auditory and visual, concrete and abstract) that can facilitate such perceptions, such progenitors of concepts, have been the focus of this entire report.

In sum, concept formation will be facilitated where stimulus conditions make more likely the perception of the relevant attributes, the invariances, in contrast to the irrelevant attributes.

Generally speaking, the message designer faces a quite different kind of task in arranging the perceptual conditions for problem solution as compared to the conditions for concept formation. For concept formation, the designer is trying to maximize stimulus support, whereas for problem solution he is intending to minimize such support.* Also, a concept will usually be defined by a small and prescribed number of attributes, whereas there may be multiple solutions to problems, each involving different approaches and different attributes.

> 59. Problem solution can be facilitated by instructions which develop a relevant set toward the problem and by situational support which emphasizes or groups the crucial elements or reveals the crucial relations in the situation. (Forgus: 335)

Frequently, in problem solving situations, it is the case that familiar objects and concepts must be used in an unfamiliar way. Unusual perceptions and responses may be required. (Berelson and Steiner: 203) We say that the problem solver must "look at the situation in a new way."

For such problems, perceptual set may be the major deterrent. The usual way of looking at things is ineffective. In a way, it can be said that there is more information available in the situation than the

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*These latter distinctions do not characterize concept formation as typically thought of by either the psychologist studying concept formation or the teacher employing the inquiry approach to concept discovery. Both tend to approach concept formation as a problem for the learner to solve.

problem solver at first perceives. (Forgus: 339) The designer can arrange to make crucial elements or relations in the display more evident, or he can simply arrange elements in an unusual way so as to upset stereotyped perception and thought. Whether or not any such help is given is another issue, and may depend on the purposes of instruction and the stage in the process.

It is no doubt possible to control the difficulty of a problem by the instructions given and by the various kinds of contextual cues provided. (Forgus: 277) Also, it is probably desirable to exercise such control so as to provide the learner with a graduated series of problems, such that the situational support is initially high and then gradually removed as the learner finds effective strategies for problem solution.

Language is importantly related to both concept formation and problem solving. Words represent the world view of those who use them, in that words stand for or label the concepts which a particular language community have found necessary to their style of life. In a sense then, language tends to stereotype or channel our thinking. This can be a constraint to problem solving where new concepts and new ways of thinking are required. (Forgus: 309-313) Consequently, the words used by the designer to describe the problem or to label its constituents may either facilitate or inhibit solution. Perhaps problems "stated" nonverbally would induce or permit less restricted and more creative solutions.

60. Provision of situational support for problem solving can take the form not only of relevant information but also of opportunity to record, test, and manipulate various alternatives. (Forgus: 280)

Pencil and paper, chalk and chalkboard, charts and models, feltboards and magnetic boards, audio and video recorders, calculators and computers, and manipulanda of various other sorts may facilitate problem solution.

Creative behavior is even further distinguishable from concept formation; it is like problem solving only more so. Stimulus support is necessary but quite different. Whereas stimuli for concept formation were chosen so as to direct, control, and converge perception and response, stimuli for creative behavior should be chosen so as to allow or cause perception to diverge or to escape from restrictive sets.

61. The development of creative behavior is facilitated by materials which increase sensitivity to the attributes or features of the environment (objects, events, relations, people), and which encourage and give practice with alternative ways of dealing with that environment under low risk conditions. (Forgus: 357-359)

Various kinds of materials have been used: some, like clay or construction paper, move the student to create something from nothing; others, like a tin can or brick, provide familiar simple forms, but ones with minimal constraints where the student is encouraged to perceive or conceive of as many uses for them as possible. More structured are games which provide certain constraints but allow many possible moves. These are particularly useful in the study and development of strategies for creative problem solving.

Thus, materials for creative behavior will tend to be such as will permit and encourage adapting, rearranging, substituting, modifying, reversing, combining, removing.

Summary

This brief chapter has served mainly to reiterate that perception is a part of the cognitive process. As the first step in the process, perception can facilitate or inhibit the learning, concept formation, and problem solving which follow.

Because earlier chapters had related perception to learning and concept formation, the emphasis of this chapter was on problem solving. Materials should be much less restrictive and controlling of perception for problem solving as compared to concept formation. Such materials should allow perception to diverge and to escape restrictive sets. Thus, iconic materials may frequently be more suitable than digital.

And in conclusion, it is hoped that this report has been important in a variety of ways to the designer's understanding of his own perceptions, the perceptions of his audiences, and the design processes that mediate between them.

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