DOCUMENT RESUME

ED 031 952 64 EM 007 382

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Readings in Educational Media Theory and Research; Volume I. Final Report.

Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.

Bureau No-BR-236-A-1

Pub Date Aug 68

Contract-OEC-3-16-021

Note-170p.

EDRS Price MF-$0.75 HC-$8.60

Descriptors-Audiovisual Aids, *Audiovisual Instruction, Auditory Perception, Aural Learning, *Film Production Specialists, Information Theory, Instructional Design, Instructional Films, Instructional Improvement, Instructional Materials, *Instructional Media, Instructional Technology, Learning Characteristics, Learning Theories, *Media Research, Models, Multimedia Instruction, *Multisensory Learning, Psycholinguistics, Semiotics, Visual Learning, Visual Perception

This compilation of readings in educational media and research makes accessible published and unpublished documents relevant to designers and users of educational media. Volume I is divided into two parts, "Basic Foundations" and "Media Characteristics." "Basic Foundations" refers to that upon which a science of instructional media design and application may be built. Ten articles discuss the psychophysics of pictorial perception, the semantic and symbolic characteristics of the pictorial image, a model based upon the limited channel theory, an overview of perception theory, learning behavior and aesthetics in the light of relationships of instructional media to learning theory, and applications of research and technology to instructional media design and use. "Media Characteristics" contains 6 papers describing film attributes and psycholinguistics, single and multiple channel perception versus modality, and characteristics of compressed information. These papers describe the characteristics of instructional media and compare their effects. Extensive bibliographies follow these papers. (MM)

FINAL REPORT
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(Volume I)

William H. Allen
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U.S. DEPARTMENT OF
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U.S. DEPARTMENT OF
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ACKNOWLEDGMENTS

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INTRODUCTION

This compilation of readings in educational media and research has been assembled for the purpose of providing students and practitioners in the educational media field with a readily accessible source of published and unpublished documents having implications for the design and use of educational media. Although the editor hopes that the readings are sufficiently comprehensive to serve as a foundation for the development of such a science of instructional media, he is fully aware of the large theoretical and research gaps that appear in the literature.

In assembling this collection of theoretical papers, research summaries, and reports of experimental studies the editor attempted to include papers that would appear to have some lasting value and to have implications across the broad field of education. He had to use his best judgment as to the importance of each paper, and his personal biases undoubtedly resulted in certain selections or omissions that might have been made differently by some other compiler. Because the purpose of this book of readings was to assemble papers that had a specific and direct relationship to instructional media research and theory, the contents were drawn from two sources: the pages of AV Communication Review, the research journal of the National Education Association's Department of Audiovisual Instruction, and the publications in instructional media made by the United States Government. During the past sixteen years AV Communication Review has published an extensive range of papers, the substance of which comprises the main corpus of knowledge about research and theory in the instructional media field. Beginning in 1950 with the publication of Instructional Film Research: 1918-1950 by Charles F. Hoban and Edward B. van Ormer, prepared under the direction of the U.S. Navy's Instructional Film Research Program at Pennsylvania State University, and continuing into the present with the final reports on instructional media research issuing from the U.S. Office of Education's educational research programs, the federal government has supported research that has increased our understanding of instructional media and the role it performs in education. The third major source of theoretical and research information about instructional media--published books--has not been utilized in this compilation of readings because of its magnitude and ready availability.

The readings are organized into seven categories: The Basic Foundations, Media Characteristics, Research on Media Types, Media Design and Production, Media Content and Objectives, Learner Characteristics, and The Conditions of Media Use.

Part One on The Basic Foundations consists of ten fundamental papers encompassing the foundations upon which a science of instructional media design and application may be built. James J. Gibson ("A Theory of Pictorial Perception") and Julian Hochberg ("Psychophysics of Pictorial Perception") present aspects of pictorial perception from the viewpoint of the perceptual psychologist, and James Q. Knowlton ("On the Definition of 'Picture'") considers the semantic and symbolic characteristics of the visual pictorial image. Robert M. W. Travers ("An Information-Processing Model") advances a model based upon the investigations of D. E. Broadbent and stressing the limited channel capacity of the information-processing system. Kenneth Norberg ("Visual Perception Theory") critically analyzes the theories of Gibson, Hochberg, Knowlton, and Travers and considers them in the light of other views on perception and communication. Robert Glaser ("Learning and the Technology of Instruction") looks at the relationships of instructional media to learning theory as an educational psychologist who emphasizes the importance of the responses of the learner and the application of learning principles derived from the discipline of programed instruction. C. R. Carpenter ("Hypotheses of Film Learning") describes several testable hypotheses which may serve as a theoretical orientation for instructional film research. Sol Worth ("Aspects of Visual Communication") deals with the cognitive aspects of sequence in visual communication from the point of view of the aesthetics of the motion picture film. Paul Saettler ("Instructional Technology") and James D. Finn ("Trends in the Technology of Education") look at some of the more recent technological developments as they influence future developments in instructional media design and use, Saettler from the viewpoint of the historical developments and Finn from that of the predictor of the future.

Part Two on Media Characteristics contains six papers describing the characteristics of instructional media and comparing their effects. Gavriel Salomon and Richard E. Snow ("Film Attributes") and Calvin Pryluck and Richard E. Snow ("Psycholinguistics of Cinema") consider the attributes of motion picture films from their structural and functional characteristics. Frank R. Hartman ("Single and Multiple Channel Presentation") and Hower J. Hsia ("On Channel Effectiveness") both make detailed analyses of the research on the effectiveness of the different channels of visual and auditory communication. Jerome Kenneth Conway ("Channel Versus Modality") takes a critical look at the communication channels and modalities and presents a paradigm for consideration of their interactions. Finally, Robert M. W. Travers ("Compression of Information") discusses some characteristics of compressed information.

Part Three presents several summaries of research and selected studies related to Research on Media Types. Leslie P. Greenhill's ("Instructional Television") recent summary review of the research in instructional television and C. David Wood's ("Compressed Speech") review of the research on listening together present a general evaluation of the effectiveness of different media types. Karl U. Smith's ("Textbook Design and Illustration") presentation of principles for the design and illustration of textbooks and Seth Spaulding's ("Pictorial Illustrations") research on the design of pictorial materials for use in under-developed countries present hypotheses and guidelines for the illustration of textual material. The research study by Gloria D. Feliciano, Richard D. Powers, and Bryant E. Kearl ("Graphic Presentation") reports on the effectiveness of various forms of presenting statistical information.

Part Four on Media Design and Production includes papers on various aspects of translating theory and research into an instructional product. The paper by George L. Gropper ("Learning from Visuals") reports on two research studies bearing on the design of instructional media and then incorporates these results into a consideration of the role of visuals in instructional strategies. Robert Glaser ("Psychological Bases for Instructional Design") presents a framework for the translation of scientific knowledge of psychology into instructional practice. Robert M. W. Travers ("Transmission of Information" and "On Channel Switching") applies his theories of information transmission to media design. In an excerpt from their classic review of instructional film research Charles F. Hoban and Edward B. van Ormer ("Variables in Instructional Film Production") summarize the conclusions reached after three decades of research. Some procedures for using preproduction testing techniques for the improvement of instructional materials are given by Nicholas Rose and Charles Van Horn ("Preproduction Testing"). Finally, Stuart M. Cooney and William H. Allen ("Nonlinearity in Filmic Presentation") consider the research on one significant production variable: that of linearity or nonlinearity of the instructional presentation.

Part Five consists of a number of theoretical and research papers relating to Media Content and Objectives. Laurence Siegel and Lila Corkland Siegel ("The Instructional Gestalt") present a methodological framework for studying the variables contributing to media effects and illustrate the application of this framework to a research problem. Leslie J. Briggs ("Selecting Media for Learning Objectives") and William H. Allen ("Media and Types of Learning") suggest guidelines for selecting and developing particular types of media to accomplish specific kinds of instructional objectives. Robert M. W. Travers ("Concept Learning") treats more directly the relationship of media to the learning of concepts. The final three papers by William H. Allen ("Effectiveness of Instructional Films"), Charles F. Hoban and Edward B. van Ormer ("Influencing Motivations, Attitudes and Opinions"), and Mark A. May ("Media Relationships to Learning Tasks") summarize the research pertaining to the accomplishment of different educational objectives.

Part Six deals with the relationships of instructional media to the Learner Characteristics. Richard E. Snow and Gavriel Salomon ("Aptitudes and Instructional Media") concerns itself with the nature of human aptitudes and its relevance for instructional media research and practice. Charles F. Hoban and Edward B. van Ormer ("Factors in Learner Response to Films") and William H. Allen ("Audience-Learner Characteristics") summarize the research pertaining to the characteristics of the learner as these interact with the mode of instructional media employed. Finally, Egon Guba and Others ("Eye Movements and TV Viewing") report on a specific research project wherein the eye movements of the learners during the viewing of television presentations were analyzed and interpreted.

Part Seven on The Conditions of Media Use includes a number of theoretical papers and summaries of research intended to demonstrate some of the applications of instructional media to instructional practice. Charles F. Hoban ("From Theory to Policy Decisions") presents a paper whose purpose it is to bridge the gap between theory and research and the operational decisions inherent in practice. Charles F. Hoban and Edward B. van Ormer ("Principles of Film Influence") summarize into a set of guidelines the generalizations from their comprehensive analysis of instructional film research, and Wesley C. Meierhenry ("Needed Research in Educational Media") presents a number of instructional media problems needing research attention. In William H. Allen's paper ("Research on Film Use: Student Participation") a single dimension of classroom application of instructional media is considered in depth. Leslie J. Briggs ("Choosing Media for Instruction") outlines a procedure for the selection of appropriate media to meet the varied conditions of learning and classroom application. Gerald S. Lesser and Herbert Schueler ("Teacher Education") make a detailed analysis of the instructional media research in teacher education. Finally, Warren E. Seibert and Richard E. Snow ("Cine-Psychometry") consider the use of films in the testing of various human abilities.

PART ONE

THE BASIC FOUNDATIONS

A THEORY OF PICTORIAL PERCEPTION

by James J. Gibson

Cornell University

A distinction is possible between what is commonly called experience at first hand and experience at second hand. In the former one becomes aware of something. In the latter one is made aware of something. The process by which an individual becomes aware of something is called perception, and psychological investigators have been concerned with it for generations. The process by which an individual is made aware of something, however, is a stage higher in complexity, and this has scarcely been touched upon by modern experimental psychology. It involves the action of another individual besides the perceiver. Although a precise terminology is lacking for this two-stage process, it is readily described in ordinary language: we speak of being informed, being told, being taught, being shown, or being given to understand. The principal vehicle for this kind of indirect perception is, of course, language. There is another vehicle for obtaining experience at second hand, however, and this is by way of pictures or models. Although much has been written about language, there is no coherent theory of pictures. The attempt to analyse how a picture conveys information is a necessary but highly ambitious undertaking. The following essay cannot claim to do anything but set up working hypotheses for an important field of investigation.

I. Words, Pictures and Models as Substitutes for Realities

An obvious fact about perception is that it is different for different things, that is, our percepts are specific to the various features of the physical environment surrounding us. We discriminate among these features and we can identify objects, places, and events when we encounter them on another occasion. This discriminating and identifying of things is an important part of what goes on when we say that we learn. Learning requires not only that we make the appropriate reactions but also that we be sensitive to the appropriate stimuli. An important aspect of education, or of any kind of special training, military, industrial, or professional, is an increasing ability to discriminate and identify things.

Reprinted from "A Theory of Pictorial Perception," AV Communication Review, II (Winter, 1954), 3-23. The work on which this paper is based was supported in part by the U.S. Air Force under contract number AF 33 (0380-22804) monitored by the Human Factors Operations Research Laboratories, Air Research and Development Command.

The training situation, however, is not always the same situation as that for which the individual is being trained. This fact holds for the child at home, the student at school, and the military trainee before he sees action. The learner must ordinarily be given an acquaintance with objects, places, and events which he has never physically encountered. The expedient is to train the individual in artificially constructed situations and expect that his learning will transfer to the novel situation, and this is essentially what any teacher does. The artificial construction of these situations is the crux of the matter. They must present adequate substitutes for the objects, places, and events later to be met with, if the latter are to be successfully discriminated and identified. The teacher can use oral and written words to induce this kind of secondhand experience, to "arouse an image," but he has always felt the need for other substitutes in addition. Pictures, films, drawings, models, and displays, along with diagrams, graphs, charts and maps are also, he is convinced, useful. Precisely why they are useful needs to be understood.

What kinds of substitute-stimuli are best for informing or teaching, or which kinds are better for what purposes? What are the advantages of pictures and motion pictures? What are the advantages of words? What are the limitations of both? Should pictures be realistic or schematic? Do pictures reproduce the perception of real three-dimensional space? These are all practical questions, but they involve difficult theoretical problems.

II. Definition of the Term "Surrogate"

In order to understand how pictures convey information it will be necessary to have some general theory of how information is conveyed. Before attempting to specify the difference between pictures and words we should examine them to see how they are alike. The term surrogate is proposed to cover both, and a theory of surrogates will be formulated as a first step toward a theory of pictures.

The traditional or commonsense explanation of how one man conveys information to another is simply that men have ideas, and that ideas are transmitted. The idea is said to be "expressed" in language, the words "carry" the idea, and the idea is then "grasped" or "taken in." An idea may be expressed by a picture as well as by words. It is hardly necessary to point out that this is no explanation at all. The "transmission of ideas" by words and pictures implies, when taken literally, that these vehicles carry their ghostly passengers unaltered from one mind to another. We shall therefore dispense with the term "idea" and state our definitions in terms of behavior.

A surrogate will be defined as a stimulus produced by another individual which is relatively specific to some object, place, or event not at present affecting the sense organs of the perceiving individual. The implications of this definition should be explored both for what it includes and what it does not include. It says, in the first place, that a surrogate is an artificial stimulus constituted or produced by the behavior of another organism. Consequently, a surrogate is not the same thing as a substitute stimulus or a preparatory stimulus or a conditioned stimulus, as these are ordinarily defined in psychology, for these include merely physical conjunctions of events. Clouds are not a surrogate for rain, nor is the smell of food a surrogate for food. These are signs, but not surrogates.

In the second place, the definition says nothing about what the stimulated individual will do in the presence of a surrogate. All it implies is that he may have a kind of mediated or indirect preception of what the surrogate is specific to. It is true, of course, that perception is a form of organic response, but this kind of response probably has the primary function of identifying or discriminating features of the environment; it is implicit rather than overt and it does not in any reliable way tell us what the individual will do.

Thirdly, the definition implies the action of one individual on another, a social influence, or an elementary form of communication, but the emphasis is on one aspect of communication only. The definition is concerned with the mediating of a perception rather than the arousing of an action in one's fellow man. Long ago, De Laguna pointed out that speech had two general functions, that of "proclamation" and that of "command" (3). An act of speech might at one extreme merely proclaim the existence of a certain state of affairs, or at another extreme merely command a certain action. Usually it did both, but the two functions were said to be distinguishable. More recently, Skinner has distinguished between the "tact" and the "mand" in verbal behavior (12). Many social scientists have contrasted the transmitting of knowledge with the effort to control action, or "information" as against "propaganda." Surrogate-making as here considered, then, will apply only to the first kind of communication, not to the second. A general theory of communication including the function of persuasion would require many definitions and assumptions about human motivation and conduct, and is a greater undertaking than the writer here intends. The present theory is admittedly incomplete.

Fourthly, the definition says that a surrogate must be relatively specific to an absent object, place, or event. "Specific" here means a one-to-one relationship between different surrogates and different things; it does not mean that the things specified are necessarily concrete objects or particular places or never-to-be-repeated events. On the contrary, they may be abstract or universal things. Evidently the meaning of specificity is a crucial part of the definition. (Perhaps it is also the part of the theory to follow which most needs criticism and elaboration.) The specificity of surrogates to their referents is analogous to what was called an obvious fact about direct perception--that it is different for different physical things. We assume that direct perceptions correspond to realities, or rather that they come more and more to do so as the perceiver learns. Accordingly we are primarily interested in how perceptions mediated by surrogates also come to correspond to realities. Clearly, this kind of apprehension can only be specific to a referent if the intervening surrogate was itself specific to a referent in the first place. The interesting fact about the specificity of a surrogate is that it depends on the psychological activity of its producer, that is, on the precision of his apprehension. Surrogate-making, whether it be naming, drawing, or modelling in clay, consists largely in what the writer has elsewhere called identifying reactions (5).

The above definition of surrogates may usefully be compared and contrasted with a recent explicit definition of signs by Charles Morris (10). The present formula owes much to his rigorous discussion, but there are fundamental differences between them. Morris distinguishes between iconic signs and non-iconic signs. The former include images and pictures; the latter include words. Morris understands that no sharp line can be drawn between them. But he has very little to say about the former and his theory is applied not to them, but to language. In contrast, the present theory is directed toward pictorial communication and language is slighted. A surrogate as defined here is less inclusive than a sign as defined by Morris, in that the former is always something produced by an organism whereas the latter may be any feature of the stimulating situation. Moreover, surrogates exclude in large part the difficult category of "expressive" or "emotive" signs, that is, reactions which are specific to the state of the organism rather than to the features of his environment. The present emphasis, in short, is cognitive.

III. The Production of Surrogates

Human organisms are chronic makers of surrogates. Some of their reactions yield only temporary stimuli (sounds, gestures, and so-called expressive movements) while others yield permanent stimulus-objects (picture-making, modelling, writing). It would be useful to classify and list, first, the fundamental motor acts which either constitute or produce surrogates and, second, the complex motor acts or technologies which man has learned for producing them. These sources of stimulation are necessarily such as always to be either easily seen or easily heard by normal perceivers.

The fundamental motor acts are (a) the making of vocal sounds, such as cries or speech; (b) the making of movements of the face, hands, arms, or body, which includes gestures, postures, and mimicry; (c) the making of tracings on a surface of some kind, which includes drawing, painting and the special case of writing; (d) the shaping of a substance by moulding it, cutting it, or fitting pieces together, which includes sculptures, toys, and models of all kinds, and finally; (e) the making of mechanical sounds by manipulating an instrument or blowing into it, which includes sound-signalling and above all, music. If this list is exhaustive, it suggests that there are only a limited number of basic reactions appropriate for surrogate-making.

During recent history, to be sure, complex operations have been invented for making all these fundamental surrogates, which enable them to be conveniently reproduced, stored, and transmitted. Secondary surrogates are the result. The earliest technique of this sort, writing, is an instance of making a permanent surrogate to substitute for a simpler but temporary surrogate, i.e., tracings which are a substitute for speech. Writing probably evolved in the history of civilization from drawing, which is a primary surrogate (8). The main technologies for secondary or tertiary surrogates seem to be (a) printing, which substitutes for writing; (b) sound-recording and reproducing, which substitutes for speech and music; (c) photography, which substitutes for drawing, painting, engraving, and other methods of altering a surface by hand, and which, together with photo-engraving, has flooded our environment with pictures; (d) cinematography, which enables a picture to represent time as well as space; (e) vacuum-tube images, both pictorial (television) and symbolic (radar), the end of which is not yet in sight, and finally; (f) various techniques for replicating things in three dimensions and thereby making models, displays, exhibits, panoramas, and simulators intended to produce all kinds of "synthetic" realities.

It should be noted that there is a characteristic of primary surrogates which the secondary or tertiary surrogates tend to lack, namely the personal style of the producer. Speech, gesture, handwriting, drawing and artistic style are notably "expressive" of the person who performs them (1). His reaction is specific, in other words, to himself or to his mood in addition to being specific to an object. The more complex products tend to lack this personal character. A painter is usually identifiable from his pictures but a photographer seldom is.

IV. The Consequences of Surrogate-Making for the Perceiver and the Producer

The most obvious consequence of surrogate-making is that another person can apprehend objects, places, and events perceived only by the first person. This makes possible a sort of vicarious experience for other individuals; the writer of a book, for instance, can produce mediated perceptions in many other people, and they may be people who live in distant places or even will not be living until future times. He can make them see what he has seen and hear what he has heard. A similar power is commanded by the painter, the movie maker, the teacher, and the parent. One person can, as we say figuratively, transmit knowledge to others. What is equally important, however, is the fact that the first person can exchange surrogates with other persons. This makes possible a common body of perceptions among the group; it influences their direct perceptions and it may lead to a sort of consensus of experience, a common world in which mediated percepts and direct percepts are no longer separate.

The making of a surrogate, we must remember, necessarily involves self-stimulation whether or not it ever stimulates anyone else. Stimulation is fed back into an organism synchronously with its action. A speaker hears his own voice; an actor feels his own gestures; an artist sees his own pencil-movements. As a result, the perceptual process and the surrogate-making process tend each to lead into the other, and the two become inextricably mixed. As Morris and others before him have pointed out (10), this circular response in children, in conjunction with the facts of social stimulation, eventually converts a vocal sound into a symbol. The symbol-process then comes to occur in the absence of another person and even in the absence of the stimulating object to which the original perception was specific. At this stage of development the individual "thinks." Since the same circular operation occurs for other surrogates as well as for vocal ones, it is not unreasonable to suppose that a person can learn to think in terms of drawings or graphs or models (and of the manipulations which produce them) as well as in terms of words. It may even be possible to infer, later on in this essay, that in certain respects such thinking is more easily performed than is verbal thinking.

V. Conventional and Non-Conventional Surrogates

An attempt can now be made to formulate the difference between words and pictures. All surrogates are specific to their referents, but the correspondence between a word and its object is probably not the same as that between a picture and its object. Morris faced the same problem when he considered that a great many signs are, as he put it, "iconic" (10: p. 23 and 191). His formula is very simple: a sign is iconic to the extent that it has itself the properties of what it denotes, or to the extent that it is similar to what it denotes. An image or a portrait of a man has many (but not all) of the properties of the man himself.

This statement is illuminating but it does not go very far, as Morris might be the first to admit. What kinds of properties can a surrogate share with the thing it stands for? In what respects is it similar? Can a surrogate be wholly unlike its object? And what if the object be abstract, so that there is little to be denoted?

Consider two extreme cases of what can be meant by the correspondence of one thing to another, first the correspondence of a license-plate to an automobile and second the correspondence of a shadow to the tree that casts it. The plate is specific to the car because of an arbitrary pairing of the two and because of a rule of social conduct that says plates may not be exchanged or duplicated. The shadow is specific to the tree because it is a geometrical projection of the tree on the surface of the ground by rays of light from the sun.

By analogy with the license-plate and the shadow, one may suggest that surrogates at one extreme are specific to objects, places, and events by convention, while surrogates at the other extreme are specific to the same things by projection. Language and algebraic symbols tend to fall toward the former pole and pictures or motion pictures toward the latter. Diagrame and graphs fall somewhere in the middle. Considering a language as a set of sounds produced by vocal reactions (or an equivalent set of tracings produced by manual reactions) the obvious fact to consider is that some groups of men have one set while other groups have different sets. A given object has different names in different languages. On the other hand the enormous number of photographic snapshots existing all over the world constitute a single set. A given object could be matched with its photograph by any human being without having to learn laboriously a special vocabulary of photographs. The object and its name have an extrinsic relation, whereas the object and its picture have an intrinsic relation.

Non-conventional, projective or replicative surrogates seem to be characterized by a very interesting possibility, which will require closer examination later. It is the theoretical possibility of the surrogate becoming more and more like the original until it is indistinguishable from it. For visual perception, and under certain viewing conditions, a model can be elaborated until the artificial scene is equivalent to the natural one. Under very special viewing conditions a motion picture can probably also be so elaborated that the perceiver is led to suppose that what he sees is an actual situation and an actual sequence of events. This possibility is not characteristic of a conventional surrogate.

Both conventional and non-conventional surrogates may, of course, be relatively unspecific to their referents, and to this extent the resulting perceptions will also be unspecific. Language may be vague or ambiguous (2: ch. 2) and so also may pictures. In the case of pictures the relation will be called one of greater or lesser fidelity; in the case of words the relation will be called one of greater or lesser univocality. Maximum fidelity of a picture or model will be defined later, in terms of geometry and optics. Maximum univocality is very difficult to define; the task will be left to the students of semantics and of information-theory.

A number of propositions about words and pictures seem to follow from the foregoing assumptions, of which four will be stated.

1. In general, children have to learn the correspondence of a surrogate to its object in order to make use of it. The more nearly a surrogate is projective or replicative, the less does associative learning need to occur. The more nearly a surrogate is conventional, the more does associative learning need to occur. Pictures and models are closer approximations to direct perception than words and symbols are.

2. Distinguishing between concrete objects, places, and events on the one hand, and abstract properties, qualities, or variables of them on the other, the more nearly a surrogate is replicative or projective the less is it capable of referring to abstractions and the more must its referent be concrete. Conventional surrogates, however, do not have this limitation. The more arbitrary a surrogate, the more is it free to specify anything, abstract or concrete. Verbal responses, for example,

may be either names which identify objects or adjectives and adverbs which specify their properties. Picture-making can also identify objects and specify properties, but it cannot name an object and describe it separately. Verbal surrogates enable us to separate abstractions from concrete things and respond to them in a special way. With symbolic responses we can make propositions and hance perform logical and mathematical thinking. A realistic picture on the contrary, cannot state a logical proposition.

3. If purely conventional surrogates exist at one extreme and purely replicative surrogates at the other, there are "mixed" surrogates which are intermediate. These are specific to their referents partly by virtue of univocality and partly by virtue of fidelity. This applies particularly to pictures made by hand, which will be called "chirographic." The shift in human pre-history from picture-making (such as cave paintings) to picture-writing (such as Chinese characters) is apparently a development away from fidelity toward univocality. The development of Western painting up until the advent of photography is partly a matter of striving for fidelity, but artists at all times have also sought to specify general or abstract features of the world. Cartoonists, for instance, do so. Mixed surrogates, especially chirographic pictures, specify both concrete objects, places, and events and general or typical objects, places, and events. In other words, graphic conventions or graphic symbols may be incorporated in a picture as distortions of line, shape, proportion, or color. This reduces fidelity, but it may increase univocality. The latter effect, however, depends on the establishment of the convention.

4. A conclusion seems to follow from the forgoing paragraph, which may be controversial. A chirographic picture cannot at the same time possess high fidelity for something concrete and high univocality for something abstract. The introduction of graphic symbolization into a picture necessarily sacrifices its capacity to represent. The effort to gain abstractness entails a loss in concreteness. The sacrificing of fidelity, that is to say distortion, should have the result of making the observer's perception vague and his behavior unspecific, as a general rule. Only when the distortion is such that artist and observer both accept it as a univocal symbol is the sacrifice worth while. The artist's intention may have been to make evident some typical or significant feature of the original, but if his distortion is not established as specifying it, the observer is only puzzled. If his distortion does specify it, the picture can evoke not only a mediated perception of something concrete, but also an apprehension of its general, abstract, or universal features.

VI. The Fidelity of a Model

Certain types of surrogates, it was asserted, are characterized by fidelity (replicative or projective). Models and pictures are examples. Other types of surrogates are characterized by univocality, without fidelity. Words and symbols are examples. "Fidelity" must now be defined. It should be treated as a matter of degree, and the definition should be mathematical. The geometry of fidelity needs to come up for discussion. We will begin with models.

A faithful model can be defined as a physical object whose various surfaces have the same dimensions as the corresponding surfaces of the original object, and hence are geometrically congruent with them, but which is made of a different substance than the original. When the ratios of dimensions are the same, and the surfaces are geometrically similar instead of congruent, it is a scale model, and this is the commonest kind. Color can be reproduced as well as shape and structure. A model as thus defined will produce a retinal image identical with that of the original and, as an object, will be visually indistinguishable from the original. The surroundings of the original are not reproduced, however, and the ground on which the figure appears will then be different.

A model can be fabricated for a place as well as for an object in it, with the same definition as above. An example is a stage-setting, or the simulated cockpit of an airplane. A working model can be constructed in which movements and the course of events are replicated, although this begins to be difficult. Theoretically, this simulation of a total situation could be elaborated indefinitely, but if the purpose is a visual surrogate, it will soon become more economical to utilize a picture or a motion picture instead of a model if the observer's viewing position can be confined to one spot.

A model has several dimensions of fidelity: shape and proportion, motion, size, color, texture, and the like. Since a learner does not need to become familiar with all the properties of an absent situation in order to learn how to deal with it, there is theoretically no need to simulate all its properties in a model. The properties which are relevant or significant for his future behavior are the important ones.

The most obvious kind of non-fidelity of a model is any distortion of shape. Consider, for instance, a set of scale-models of different military aircraft used for the purpose of learning to identify and name the originals. As a general rule, distortion on the models would lead to confusion and poor aircraft recognition. There is evidence to suggest, however, that a distortion which exaggerates some unique or characteristic feature of an airplane relative to all the others may lead to improved identification of it (4: ch. 7). The phenomenon may be related to the caricaturing of faces by drawing, and it is consistent with the fourth proposition of Section V. This prediction can be tested experimentally.

VII. The Fidelity and Scope of a Picture

The fidelity of a picture, like that of a model, has to be defined geometrically, and only as an extreme case. A faithful picture is a delimited physical surface processed in such a way that it reflects (or transmits) a sheaf of light-rays to a given point which is the same as would be the sheaf of rays from the original to that point. This definition is intended to apply to paintings, drawings, color prints, photographic prints, transparencies, projected slides, movies, television pictures, and the like, when taken as cases of pure representation. The definition is equivalent to saying that a picture may be considered as a geometrical projection, and that the relation of a picture to its original is given by a polar projection of a three-dimensional solid on a plane. If the center of projection is taken as infinity distant from the solid, the polar projection becomes a parallel projection, and the picture correspondingly becomes a map, or a plan view, such as is employed in engineering drawing. This unique point for every picture is what makes the viewing position for a picture important, as will be later evident.

In the above definition a sheaf of rays is "the same as" another when the adjacent order of the points of color in the cross-section of one is the same as the adjacent order in the cross-section of the other. As the light-energy varies along any cross-sectional axis of one, so must it vary along the corresponding axis of the other. To the extent that this condition is fulfilled, the picture will be said to have fidelity.

All the above applies to a "still" picture, and the fidelity defined is momentary only. If in addition to the same adjacent order of color points, there exists the same successive order of color instants the picture will be said to have temporal fidelity. If the temporal pattern in the picture is that of the original, complex qualities like the motion, sequence, change, growth, and pace of the original can be reproduced. The motion picture and the television image are techniques for approximating this state of affairs. It should be noted that the points and instants referred to above do not have to be the theoretical points and instants of mathematics, but may be finite units of area and finite intervals of time. The unit areas of the half-tone photograph exemplify the former, and the 1/24 second intervals of the standard motion picture exemplify the latter.

Along with fidelity, another important property of a picture is its scope. A picture was defined as a delimited surface, which is to say a picture has edges, commonly rectangular. If the surface is flat, the sheaf of rays projected by it to the "given point" is necessarily less than 180° in solid angle, and usually much less. Some pictures, such as murals, intercept a wide angle; other pictures, such as portraits, intercept a narrow angle. The scope of a picture is the angular sector of the original environment intercepted by it. One picture, in other words, may be a surrogate for a wide piece of the absent scene and another may be a surrogate for only a narrow piece of the absent scene, or perhaps only for a single object in it. When an environment needs to be represented, or when the background of or relations between objects, people, or events is important, a picture of wide scope is called for. When only a single object, person, or event needs to be represented, a picture of narrow scope may be sufficient. The scope of a photographic picture, for instance, is the angular amount of light intercepted by the lens of the camera. Scope should not be confused with degree of enlargement of a photograph. It is determined wholly by the lens used. A picture taken with a telephoto lens has a narrow scope and one taken with a wide-angle lens has a wide scope no matter what the size of the print in either case may be. The scope of a picture may be reduced by masking or cropping it, but it cannot be increased by photographically enlarging it. Neither can it be increased by holding the picture close to the eye or coming toward it for a close look. The retinal image of the observer is thereby magnified but the scope of the picture remains unaltered.

The fact that a picture is a surface with a boundary means that a picture can never, practically speaking, fill the entire field of view of its observer, which at any one moment occupies nearly a solid angular hemisphere. It is always surrounded by something else not the picture (the room for instance); it is a figure on a ground in psychological terminology. An effort to overcome this limitation can be made by increasing the scope of the picture and employing a curved instead of a flat surface. Panoramic still pictures have long existed, and semi-panoramic motion pictures are now being exploited. The psychological effect of this increased scope is very striking. Even a completely circular panorama, however, cannot surround the observer below his feet as well as to his right and left, since there has to be a physical floor to stand on. Only a full-scale model of a situation can do that.

VIII. Space in Pictures

A serious misunderstanding has existed for a long time about the physical fact that a picture is a two-dimensional surface. The misunderstanding takes the form of asserting that one cannot see three dimensions or depth in a picture. What one "sees" is a patchwork of flat surface-colors which serve as clues, and then one "infers" depth in the scene. This account of the matter is mixed up with a second more basic misunderstanding which assumes that the retinal image itself is a picture (this assumption being false) and then goes on to assert that we can only see flat sensations of color in the world around us and must infer its depth. There is at least a germ of truth in the first misunderstanding, for anyone who looks at a picture can see a flat surface, if he attends to it as such. (The second misunderstanding is less excusable, for very few people who look at the world can see a flat surface in front of their eyes.) If, however, the man who looks at a picture does not give special attention to the surface as such, he perceives a three-dimensional scene. How is it possible to assert that he can see a flat surface and can also see a three-dimensional scene?

The misunderstanding about pictures arises because it is only half of the fact to say that a picture is a two-dimensional surface. It is a surface and it is also a peculiar sheaf of rays. The sheaf of rays is an essential part of the total fact of a picture. The fact of physical optics (the sheaf) and the fact of physical chemistry (the processed surface) must be combined. The surface as such is flat, but the surface as the source of a sheaf of rays may be equivalent to that of the original scene, and the latter is not flat. The hypothesis to be proposed is that a picture can ordinarily be perceived in two different ways, as a surface and as a three-dimensional scene, and that this is so because the sheaf of rays ordinarily contains within it elements which are specific to a flat surface and also elements which are specific to a three-dimensional scene.

There can be no doubt whatever that a picture is capable of yielding a perception of depth and distance. It is, no doubt, the kind of depth and distance obtained when we close one eye, but this is not so different from the kind obtained with two eyes as the traditional theory asserts. The supplementary stimulation for depth-perception obtained from the second eye is not, on the one hand, negligible, but neither is it, on the other hand, basic or essential for depth-perception (5: ch. 6; 4: ch. 9).

When, under very special circumstances, a picture cannot be seen as a flat surface--when an observer who compares a photograph with the original scene cannot say which is which--it is because the elements in the sheaf of rays which are specific to a surface have been carefully eliminated. This involves (a) arranging for the picture to be viewed through an aperture, and for the original scene to be viewed through a similar aperture; (b) making the physical texture of the surface very fine; and (c) processing the surface so that the ray-bundle has high fidelity. A good deal of informal evidence for the success of this experiment exists, but it needs to be systematically performed.

It should be noted that our definition of a faithful picture implies not only a surface and a sheaf of light rays, but a unique viewing point. A picture is unlike a model in that theoretically it should be viewed with a single eye placed at its center of projection and kept motionless. Actually, and in practice, people do not satisfy these conditions very well when they look at a picture. They use two eyes, move about, and look from positions farther or nearer, above or below, and to the right or left of the center of projection (although they do, at least, always keep the picture nearly upright). These circumstances make the sheaf of rays at the retina (actually a pair of them at two retinas) rather different from the ideal sheaf of the theoretical picture, and plenty of stimulation is thus ordinarily provided for seeing the picture as a delimited flat surface.

Several propositions can now be formulated about space perception relative to picture-perception.

1. Since two distinct systems of stimuli operate when a picture is viewed in the ordinary way, two kinds of perception ought simultaneously to occur: first, that of a three-dimensional scene (the situation represented) and, second, that of a delimited flat surface which is part of a

different scene (the room, say, in which the picture is shown). There is evidence for this proposition, and more should be obtained.

2. The mediated perception evoked by a picture is a space-perception, that is to say, it is three-dimensional. There is already evidence that the size of distant objects can be accurately judged in a photographic scene (4: ch. 9), or in other words, that size-constancy holds for this kind of perception. There is need for more evidence of this kind. We need to know whether accuracy of spatial judgments is increased when the fidelity of the photograph approaches a maximum, and also what happens to the perception when the fidelity is much reduced.

3. If two distinct spaces are capable of being seen when viewing a picture, two correspondingly different sets of spatial judgments should be obtainable from the observer. One set would consist of judgments of the distance from the eye to the picture. Another set would consist of judgments of the distance from the point of view of the picture to a specified object in the picture. Phenomenally, the first distance would be in the space of the room and the second would be in the space of the picture. These two spaces should prove to be incommensurable. A similar experiment might require judgments of the size of the picture in contrast with judgments of the size of an object represented in the picture.

IX. The Unique Viewing-Point for a Picture

Insofar as any picture is a geometrical projection, it must have a unique center of projection. Although this point lies in the air on a theoretical perpendicular to the plane of the picture, it is just as important for the picture as the deposits of pigment (or silver halide or dye) on its surface. In the case of a chirographic picture, constructed with some regard to the laws of perspective, it is the "station-point" for the "picture-plane" (12). In the case of a photographic picture it is at the perpendicular distance given by multiplying the focal length of the lens of the camera by the degree of enlargement of the picture (7). This is the point at which an eye must be stationed if the eye is to be stimulated by the same sheaf of light rays which was included in the angular scope of the picture. In other words the visual solid angle of the picture at the eye should equal the scope of the picture, or, in still other words, the eye should be so stationed relative to the picture that it takes in the same light that the camera did when the picture was taken (or that the painter's eye did when he made the picture).

The point has already been made that this ideal viewing position is departed from rather widely in looking at paintings, snapshots, projected slides, movies, and especially television pictures. The question which naturally arises is <u>what happens to the phenomenal space of the picture when a departure is made from the unique viewing-point?</u>

Compare the sheaf of rays to the center of projection and the sheaf of rays to the eye, when these are not the same. The latter is magnified when the eye is nearer the picture. It is diminished when the eye is farther from the picture. (It is also compressed horizontally when the eye is to the right or left of the center of projection, and is compressed vertically when the eye is above or below the center of projection, but these deformations will not be considered at present.) We may now put this question: How is the three-dimensional object corresponding to a given sheaf of rays related to the three-dimensional object corresponding to a magnified (or diminished) but otherwise similar sheaf of rays? Would the latter object be simply enlarged (or reduced), or would it also be deformed? Geometrical analysis demonstrates that the object would have to be deformed as well as altered in size. The deformation consists in a relative shortening of its depth dimension in the case of magnification, and a relative elongation of its depth dimension in the case of diminishment. The implication is that depth in the space of a picture viewed from "too near" is shortened, whereas depth in the space of a picture viewed from "too far" is elongated. Whether this geometrical analysis will predict what happens to the phenomenal space of a picture is an empirical question which ought to be put to the test.

There is good evidence, obtained with groups of aviation cadets during the last war, that various types of abstract perceptual discrimination not involving any discriminations of depth, when tested by the projecting of motion pictures in a classroom, are not affected by the distance of the eyes from the screen, that is, by the angular magnitude of the picture (4: ch. 4). This fact seems to suggest that the importance of the unique viewing-point for a picture depends on the kind of perception the picture is intended to produce. Perhaps the chief consideration is whether the perception needs to be correct with respect to depth or distance.

The issues involved in picture-viewing are highly complex, including as they do problems of spatial perception and perceptual constancy. The main puzzle for a general theory of perception can be put in this way: there is evidence to show that a retinal image which is magnified, diminished, or laterally compressed is in some respects equivalent to the unaltered image as a stimulus for perception. There is also evidence to show that a retinal image which undergoes such an elastic deformation is in other respects not equivalent as a stimulus for perception. What are the viewing-conditions under which the first statement holds and what are the conditions under which the second statement holds?

The perception of pictures viewed obliquely, i.e., at an angle to the surface, presents a similar set of problems regarding phenomenal distortion and phenomenal constancy. A method of investigating them has been described by the writer (4: 170 ff.).

X. The Approximation of Pictorial Perception to Direct Perception

References have already been made to the experiment of arranging that a picture and the original scene represented be viewed successively, under aperture conditions, and the possibility that the observer will be unable to distinguish one from the other. The picture most likely to yield success in this experiment is probably a large photographic color-transparency; if the original scene involved movement, it would have to be a motion picture. Indistinguishability from the original has long been attained with models of certain things, for example, wax flowers, and there seems to be no reason why it could not be realized in pictures.

The experiment is theoretically important since it constitutes a test of the validity of the definition of a picture with fidelity given in Section VII. It exemplifies the limiting case in which an object and the surrogate for it can have precisely the same effect on an organism, and in which the pictorial quality of a picture-perception vanishes. But its greatest importance, perhaps, is in demonstrating negatively the visual factors which, under ordinary viewing-conditions rather than aperture-conditions, make a picture seem what it is, namely, a surface, a substitute, or a mediating object (6). These factors constitute a second system of optical stimulation, we postulated, which makes possible two kinds of spatial impressions and two kinds of judgments for the observer.

It is possible to add "realism" to a still picture in various different ways besides the aperture-method described. The semi-panoramic picture, and the circular panoramic picture constitute one way. The motion picture is another way. It is possible to combine these effects in semi-panoramic motion pictures, as Waller has done in the "Cinerama." The stereoscopic picture and the stereoscopic motion picture is still another way. Color, sound, "stereophonic sound," the "subjective camera" method of shooting motion pictures, and perhaps others, are all techniques for increasing realism. It is the writer's opinion, however, that there are basic discrepancies among these lines of effort, at least between the stereoscopic and the panoramic, which will make it impossible to use them simultaneously in one grand effort to achieve "complete realism."

The graphic method of constructing a surrogate for a situation is fundamentally different from the method of building a model for it, or a full-scale replica. The replica for a situation has a ground on which one can stand. Any graphic method (including photography, cinematography and stereophotography) presupposes the use of either a room or a viewing-device, and this limits the ultimate illusion of reality. A viewing-device eliminates the sight of one's nose, hands, body, and one's feet on the floor, which is an important component of direct visual perception. A panoramic picture includes this component but necessarily introduces some kind of a junction between the room one stands in and the picture itself. The dilemma might be expressed by saying that it is intrinsically impossible to get the ego of the observer completely into the space of the picture. There will probably always be some tendency to experience two spaces, one incompatible and incommensurable with the other.

XI. The Fidelity of Chirographic Pictures

Little has been said so far about hand-made pictures as distinguished from lens-made pictures. Hand-made or chirographic pictures include paintings, drawings, cartoons, caricatures, animated drawings, and a host of others. Their fidelity, as defined, is generally lower than that of photographic pictures, although this is not true of necessity. As early as the 17th Century, some paintings of still-life achieved a level of fidelity barely reached by modern color photography. The reason for chirographic lack of fidelity, perhaps, is this. A picture, like a model, has many dimensions of fidelity to the object, rather than a single dimension. The object has many visual properties, but the most important ones (for most human purposes) are the form, shape, and proportion of its edges and surfaces. These can be rendered by outlines, which are very easy to trace on a surface by hand. If we assume that a perceiver does not need to be given all the properties of an absent object in order to know how to deal with it, but only those which are relevant or significant, it is a waste of effort to simulate them all. The photograph reproduces them all indifferently. The chirograph reproduces them selectively. It can be (and has been) argued by artists that such selective emphasis may clarify the observer's perception of the object in a way that no photograph can do. The truth of this assertion is a problem in perception and cognition for which there is no present solution, but at least the assertion is not unreasonable. The danger of low fidelity is vagueness or nonspecificity. When the artist either omits some dimensions of fidelity or departs from fidelity by distorting form, he takes the risk, but he may achieve a picture which clarifies and specifies instead.

XII. The Advantages and Disadvantages of Realism in Pictures

Why, one might ask, do picture-makers strive for increased realism or, more exactly, why does a certain class of them do so? Why do children like realistic toys? Why the appeal of photography? of the movies? of television? of color-movies? of stereoscopic color movies? Only an intuitive kind of answer can be given until a workable theory of surrogates is more fully developed, but it might be of this sort: that human beings have a need for first-hand experience; that an increasing proportion of experience comes at second-hand in the modern world; and that they therefore need the closest thing they can get to first-hand experience.

A realistic picture, notably a movie, makes the observer "forget himself," or "lose himself in the scene," or "takes him out of himself." So also, of course, does the reading of history, or a novel, or a book on how to do carpentry, but the realistic picture does so with less effort on the part of the observer. And there are good reasons for the greater simplicity and directness of this kind of perception, as we have seen. Pictures and models are better than words and symbols for learning about concrete things, tools, mechanisms, or organisms, about particular places, scenes, and environments, and about existing events, processes, and sequences. If this is what needs to be learned, the surrogates for them should be "realistic."

On the other hand, proponents of the spoken and written word have argued that this kind of learning makes no demands on the "imagination" of the learner. No one knows what the imagination is, precisely, but it does seem likely that men need to apprehend abstract things and general rules, as well as to perceive concrete objects. Words and symbols (including graphic symbols and geometrical drawings) are essential for learning about properties, variables, groups, classes, and universals. Men can make propositions with symbols, and discover new ones by manipulating old ones. They can mutually exchange propositions, and formulate general laws. If this is what needs to be learned, the surrogates for them should be arbitrary and conventional. Both kinds of surrogates have their value.

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PSYCHOPHYSICS OF PICTORIAL PERCEPTION

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The study of pictures, and psychology as a scientific inquiry, have been intertwined since Leonardo da Vinci's analysis of the techniques for portraying space. As we learn more about perception and learning, we must revise our interpretation of how pictorial communication takes place. Reciprocally, what we have learned about pictorial communication has altered some of our conceptions about the underlying sensory structures and perceptual processes.

This paper presents a brief review of the interaction between systematic psychology and the study of pictorial communication; some hypotheses about the perceptual function of pictures; and some current attempts at psychological treatment of pictorial communication. Since an object or shape must first be perceived before it can function in the processes of communication and education, the conditions which determine pictorial shape and object-perception will be our main concern.

Theory of Depth Clues

In the 1580's, Leonardo da Vinci investigated the techniques by which "pictures" could be made: ". . . place a sheet of glass firmly in front of you, keep the eye fixed in location, and trace the outline of a tree on the glass. . . . Follow the same procedure in painting . . . trees situated at the greater distances. Preserve these paintings on glass as aids and teachers in your work (11)."

A picture is a flat object with a pigmented surface whose reflectance varies from place to place and which in some sense (which we will examine later) acts not as a dappled surface, but as a substitute or surrogate for spatial arrangements of other entirely different objects (19 and 20).

Why does Leonardo's method produce a surrogate for the scene being traced on glass? Because such a pane of glass, if perfectly prepared, would provide the eye much the same distribution of light, or optic

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Reprinted from "The Psychophysics of Pictorial Perception," AV Communication Review, Supplement 5, X (September-October, 1962), 22-54. This paper is part of an investigation of pictorial psychophysics supported by the National Science Foundation, NSF-G9601.

array (21), as would have reached that eye from the scene itself.[1] If a painting had to be perfect in this optical sense to portray an object or scene, this process would hold little interest for the psychologist. However, the optic array produced by a painting must be quite different in a number of ways from that produced by the portrayed object. The picture needs to share only certain aspects of the optic array produced by the real scene, and the question of what these features are and why they are so is what makes pictures important to the psychologist.

The "Laws" of Representational Painting

For many years, pictorial surrogates could be prepared only by some variation of Leonardo's prescription--a large part of the artist's task. (See Figure 1.) With the advent of photography, the preparation of such high-fidelity surrogates became a more precise and less laborious task. However, to da Vinci, the glass tracings were not to be pictures in themselves, but "aids and teachers" to the artist. If the artist sets a tracing to some other distance and slant from his eye than that at which he painted it, and views the glass plate as an object with patterns of pigment on it, he will discover certain regularities in the tracing, correlated with aspects of the scene he traced: the tracing of the near man and that of the far one are different sizes; the parallel roadsides converge to a "vanishing point"; the nearer object yields a completed outline while the farther one is "interrupted"; the density of detail of texture becomes progressively greater as the surface being traced recedes in space; the shadows which model the objects in the environment appear as areas of different reflectance or albedo. If the artist studies a number of such tracings and compares them with the scenes which they portray, he will discover a set of laws--for example, perspective--or rules by which he can achieve approximately what he would have traced on a glass pane with any real or imaginary scene. Here there are two alternative technical procedures whereby one can prepare pictorial surrogates: we can actually trace the scene with a glass plate or photographic film, or we can employ pictorial rules--perspective, interposition, etc.--in preparing pictures of any given scene.

There is a third method which is most curious: with some training, we can--almost at will--view the real world as though it were a painting and examine it for its pictorial qualities (aided in this attempt, perhaps, by framing the scene with our hands, sighting with the thumb, squinting, etc.) These properties--mainly the rules of linear perspective--have been extracted as the "visual depth clues" or "cues," and have been used by artist and psychologist alike for almost 400 years. Let us see why they became embedded at the heart of perceptual theorizing.

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[1] This is true only if the painting is presented to the eye of the observer from the same distance and in the same orientation as that at which it was painted by the artist.

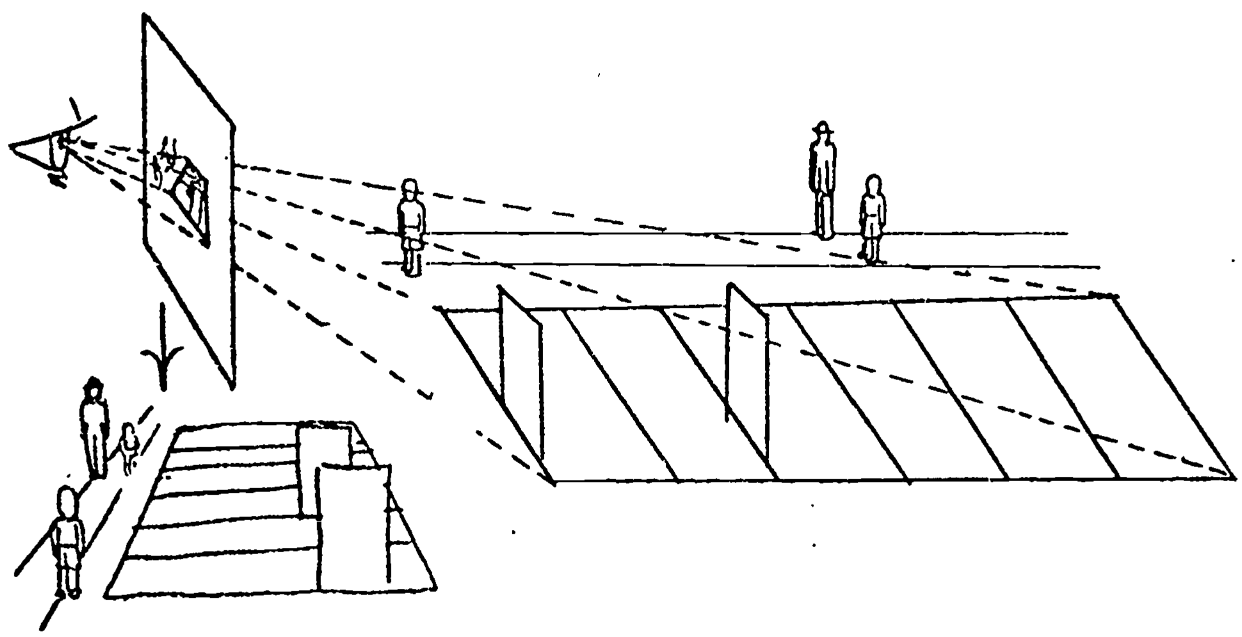

Figure 1. Scene, picture plane, and the tracing (or surrogate) which will portray the scene.

1. These depth cues seem to compel our observation of space where in fact there is no space. Might not our normal space perceptions depend upon the use of these same cues? Since the retina of the eye is flat, just as is an artist's canvas or a photographer's plate, how else could we possibly perceive space?

2. As noted above, these cues can actually be observed in a peculiar way. That is, if we look at railroad tracks (as shown in Figure 1) with the right attitude, we can see the convergence readily enough. Less easily, we can see that the boy at 20 feet looks smaller than the boy at ten feet.[2] That is, we seem to be able to see the individual pieces of which the optic array is composed. This is what the early psychologists attempted. By careful study of our observations of the world, they sought to break them down into their elementary components or <u>sensations</u>--a very serious effort which made a lot of sense. (It still does even though we now know that it can no longer be undertaken with such simple intentions.)

However, let us note one very important point about these depth cues which have been thought about for centuries and were deeply involved in the most widespread of the psychological analyses of man, starting with what is usually called British Empiricism or Association-

[2] Some training is necessary to observe this difference, and some aid--either the use of mathematical perspective or special viewing devices--is always necessary to see that the farther boy is only "half the size."

ism and culminating with Brunswik and the Princeton School today. Nevertheless, the depth clues were not discovered by psychologists, nor even studied much by them; herein lies both a lesson and a warning concerning their use.

In 1585, Leonardo systematically investigated them (11). In 1946, Ames constructed demonstrations to separate them (2). Both men were artists, seeking how best to represent the world. For representational purposes, the depth cues are probably functioning tools. As cues--as stimulus-variables by means of which we see the world, itself--they have never been shown to be anything of the sort. Despite a great deal of literature in psychology "explaining" depth perception in terms of these cues, and despite their inclusion and assertion in every textbook on psychology, they have not, in general, been shown to be responsible for the perception of space other than in pictures. Even more to our present point, we don't know too much about their importance in pictures.

Empiristic Theory of Space and Picture-perception

Self-observation of the visual depth cues fitted most neatly into what has been the only serious, systematic attempt in common Western thought to set up a scientific study of the mind and its processes. This was the attempt (which we may trace from Locke and Berkeley to Helmholtz and Titchener) to find the "elements" of which mental events are composed. It was an immensely bold and exciting attempt. All present approaches to perceptual problems are marked both by its failures and by the continuing attempt to find an adequate substitute (21 and 31). The task was as follows:

First, it was assumed that all thoughts come originally through our senses so that every idea must consist either of sensations--elementary sensory experiences--or of these combined with the memories of previous sensations (called images). Thus, it was thought that out of a finite list of sensations one can explain all the infinite variety of things we perceive and know. The task of psychology, like that of chemistry, was to find the elements and the rules governing their combination into the various objects of the world which we can perceive or conceive.

Second, it was assumed that with effort and training we can dissect our own perceptual and conceptual experiences so as to observe the elementary sensations and images of which they are composed. The procedure employed was known as analytic introspection. This act of the introspective psychologist is almost identical with that of the artist when he "sees" the depth cues, which we discussed above. Let us consider a concrete example:

1. Painters' Observations and Psychologists' Introspections: To casual observation, Figure 2 portrays a light-colored cube. Its corners are right angles, its surface is fairly uniformly light. As soon as the point is mentioned, however, one notices that i is nothing of the sort; with more careful analysis, one sees that, as at ii, the angles are very

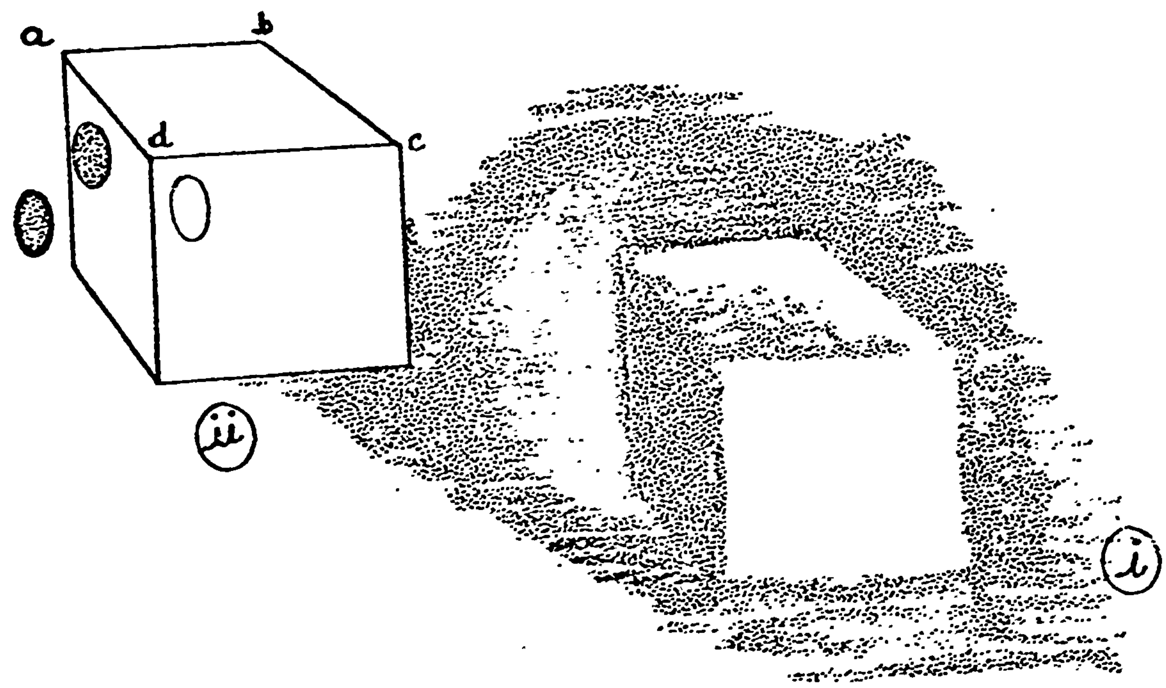

Figure 2. A light cube (i) and its parts (ii).

far from being rectangular and equal, and the local color grades markedly from dark to light. This is a particularly easy kind of introspection to undertake since, after all, angle d-a-b really is an acute angle drawn on paper, and the gradation of pigment from one point to the next is quite evident.

The task is much more difficult when you look at a real object such as a box or table. There, to approximate the conditions of Figure 2, ii, you will need to look at the various parts through a tube or a hole in a piece of cardboard--that is, if you wish to detect the actual changes in local color from one region to the next as they would be seen if each patch of color had been presented separately. It was believed that with suitable training, one could in fact observe the pure sensations by means of analytic introspection. Thus, if one could divorce meaning and past experience from his observations, he would in fact see railroad tracks converge (as in Figure 1), the smallness of the man further off, the texture-density gradient, and not the spatial qualities at all. (We now know that this accomplishment is simply not possible in the sense attempted.)

Let us now see what this assumption meant with respect to the pictorial cues as such.

2. Necessary Ambiguity of the Pictorial Depth Cues: One essential property of Leonardo's depth cues is that they must be ambiguous and unreliable indications of spatial arrangements. The very fact that a picture--a pattern of pigment on a flat plane surface--can be prepared which can produce at the eye the same cues as would be produced by a tridimensional object means that these aspects of light are not determi-

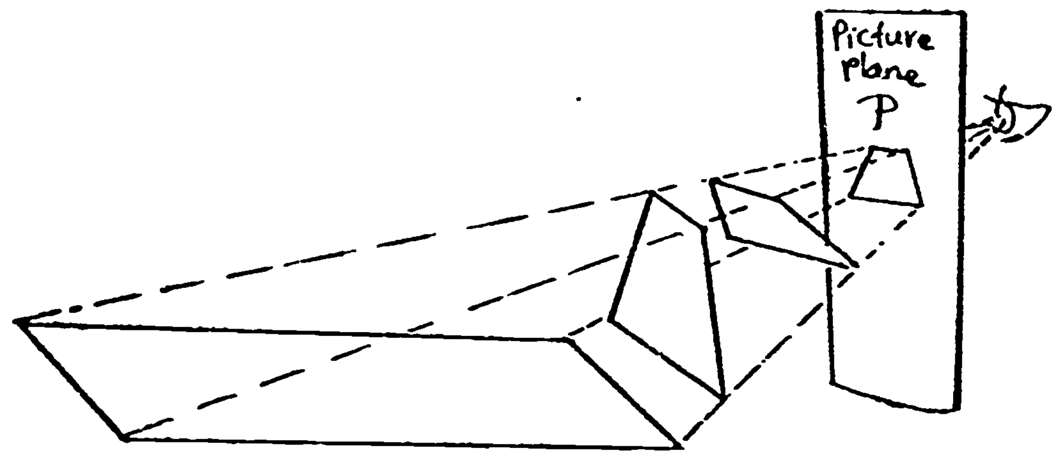

Figure 3. The necessary ambiguity of pictorial representation: the trapezoid on the picture-plane could be projected by any one of an infinite number of quadrilaterals.

native; that is, they can be produced by at least two spatial arrangements. Indeed, as Figure 3 indicates, there is an infinite number of different spatial arrangements which will provide the same pictorial depth cues.[3] This point concerning the ambiguity of pictorial communication led, via an irrelevant metaphysical issue, down a false but still popular path of psychological theory.

Since the pictorial depth cues cannot suffice to reveal depth to our minds unambiguously, how can we learn about the real world of three dimensions? One response is that there is no such tridimensional real world--the solipsistic vein running strongly through Western thought. Others held that there must be other sources of information from which we learn about the true state of spatial arrangements. For example, the convergence of our eyes which changes as we look from one distance to another might serve to convey, by sensations of different degrees of muscular tension, the distance of the object at which we are looking; so might the sensations from the muscles which focus the optic lens (accommodation). Similarly, the memory of the greater number of steps which we must take in order to touch the smaller boy in Figure 1 would be recalled when we receive the visual sensations of his size.

In short, it was proposed that we do not see space at all and that what we always see is directly analogous to a picture, with neither

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[3] This is not the only point at which ambiguity is a useful property. It is a valuable research tool for the investigation of psychological laws. Furthermore, the entire psychological testing area of projective techniques--Rorschach ink blots, etc.--rests upon the ambiguity of the pictures employed. Of course, the very existence of non-representational as well as representational art depends upon such ambiguity.

solidity to the parts nor distance separating the near and far objects. Space, it was contended, is a non-visual idea, a tactual-kinesthetic idea (composed of sensations of touch and of muscle-action), which past experiences have taught us to associate with the visual depth cues. By such analysis, the world we see becomes an assemblage of patches of color-sensation, differing only in their hue, brightness, and saturation, and occupying areas of different extent at different positions in a two-dimensional arrangement.[4] Ideas of tridimensionality derive from the muscular sensations of convergence, accommodation, and locomotion. Even ideas of form--e.g., circle versus square--were thought to consist of the muscular sensations which arise from their "tracing out" by the moving eye of the observer (23 and 51). An object has apparent spatial form because of the cues by which such form is indicated to the observer, and the cues themselves suggest muscular motions in space simply because of the frequency with which those cues have been paired or associated with the appropriate motions in the past experiences of the observer. A picture, then, is simply the putting together of a set of symbols in a learned and arbitrary visual language of tactual-kinesthetic spatial suggestions.

This was an attractive idea. We can--at least in some circumstances--"see" the depth cues, rather than the space itself; these depth cues do appear to suggest space rather than to comprise it. Artists, indeed, have seemed quite willing to accept the depth cues as learned conventions--as arbitrary assemblages of pigment on paper or canvas by which we learn to (or agree to) assign spatial meaning (1 and 2).

3. Demise of Structuralist Empiricism: This theory of space perception is now untenable. We know now that at least some animals can make spatial discriminations though they have been reared in darkness and prevented from having any associated visual and tactual-kinesthetic experiences since birth (15 and 30).

More important, we simply cannot consider "sensations" of color and position to be the observable and fundamental elements out of which our perceptions of the world are in fact built and, therefore, out of which pictures are composed. One cannot, in fact, observe the elements as though they were presented in isolation. For example, no matter how strongly you try, you cannot see the horizontal lengths in Figure 4 as equal--which they are--without covering up the diagonal lines. The number of such examples is immense. Over a very wide spectrum of psychological orientation, no one I know of seriously proposes this ana-

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[4] In a purely physical sense, this analysis is bound to work. If we make our patches small enough, we know that we can duplicate any scene by an appropriate set of colored dots--cf. TV, half-tones, stippling, and pointillism.

lytical task today, although rarely are the consequences of its abandonment followed through.

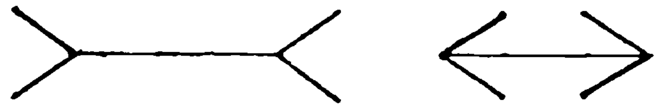

Figure 4

We shall have to re-inquire what a picture is, and how it is that the pictorial cues are at all observable.

What, Then, Are Pictures?

A picture so perfect that it would produce at the eye exactly what the eye would receive if confronted with a real scene (as in Figure 1), would have perfect fidelity (19 and 20). However, even with the most perfect photograph or motion picture, there are profound differences between picture and reality. Do these departures from fidelity impair the pictorial communication? Not at all. Photographs have higher fidelity than outline drawings and still more than caricatures, yet the characteristics of a given object may be communicated better as the representational fidelity of the surrogate deteriorates (41). Perfect physical fidelity is impossible and would not be of phychological interest if it were achieved, but perfect functional fidelity--"the degree to which the variables to which the eye is sensitive are the same in one array as another (20, p. 233)"--is completely achievable and is of considerable phychological interest. Indeed, findings as to functional fidelity raise a vast area of inquiry. The nature of exaggeration, caricature, distinctive features, etc. in pictorial communication can tell us a lot about the normal perceptual process and its development. We must, however, first ask explicitly what possible essential feature is being retained when an outline drawing is substituted for a high-fidelity photograph.

What Are Outline Drawings?

How can the lines of linear perspective represent what we normally confront when we look at a real scene? How can a circle, scribed by a compass on paper, claim functional fidelity to the edge of a dinner plate and the solid form (or margin) of a ball (16, p. 405)?

The first answer which might occur to us is that such pictures are a form of visual language learned much as we learn a foreign language at school. In the typical "paired-associates" procedure, we rehearse "manger--to eat, avoir--to have" or, instead, we point to the chaise, the fenetre, the porte. Is this how pictures come to communicate? Are outlines drawn on paper learned symbols for the edges of things in the world? Persistent anecdotes concerning the inability of primitive people to comprehend pictures suggest some support for such doctrine.

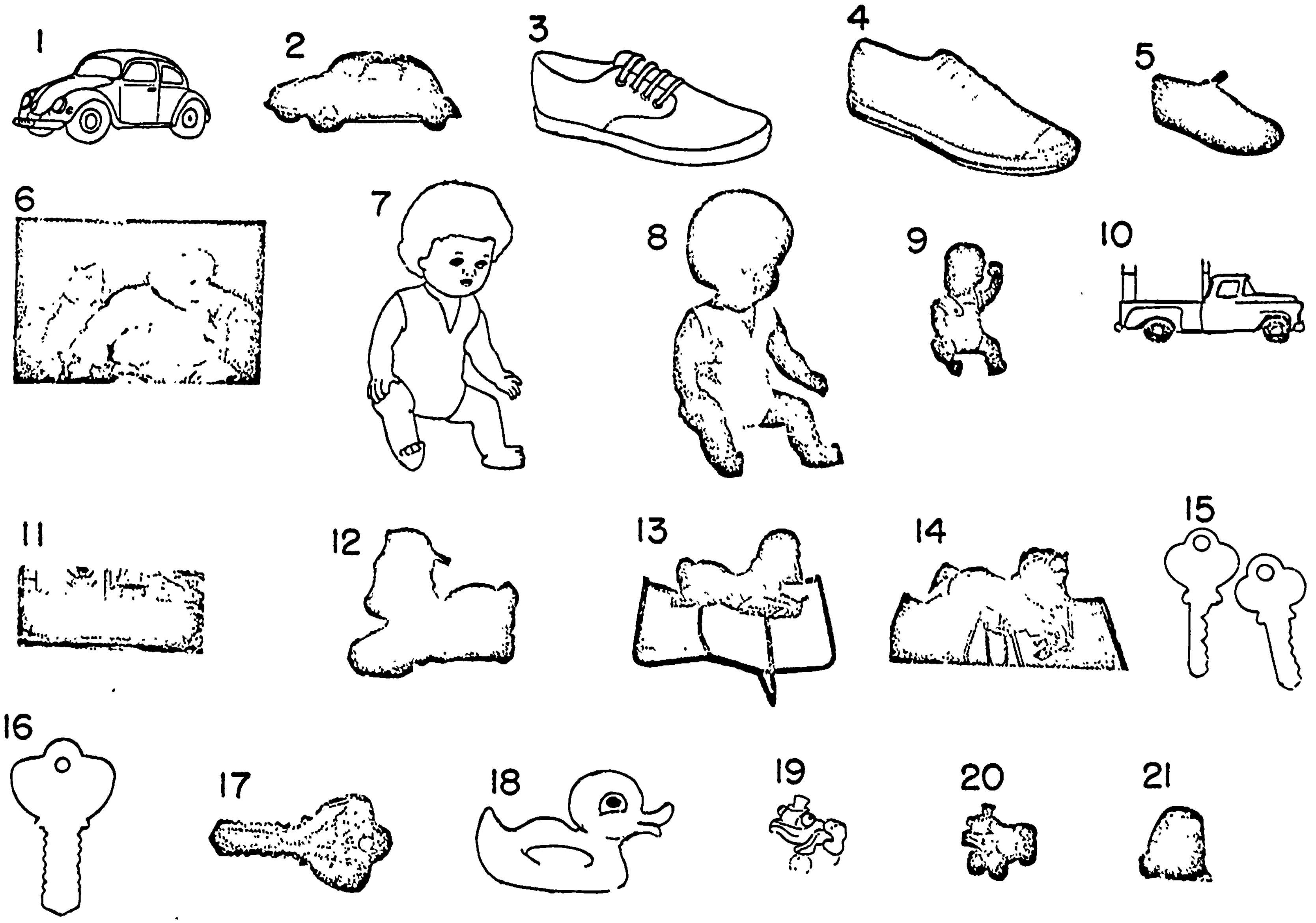

Figure 5. OUTLINE drawings are not merely symbols. Drawings and photographs shown here were correctly named by a young child who had no previous opportunity to associate pictures with objects or with their names.

1. That outline pictures are not a learned language is now clear. It has been established that an individual without any formal training of the paired-associates variety, can recognize pictures. A recent study of a 19-months old child provides confirmation (36). The child had been taught his vocabulary solely by use of solid objects and had received no instruction or training whatever concerning pictorial meaning or content; indeed, he had seen practically no pictures close at hand. Yet he recognized objects portrayed by two-dimensional outline drawings as well as by photographs. The pictures are shown in Figure 5 in the order in which they were presented and recognized.

Thus, if the understanding of outline drawings is learned at all, this must occur not as a separate process but in the normal course of whatever learning may be involved in seeing the edges of objects in the world. In what way can a line on paper be inherently equivalent to the edge of an object?

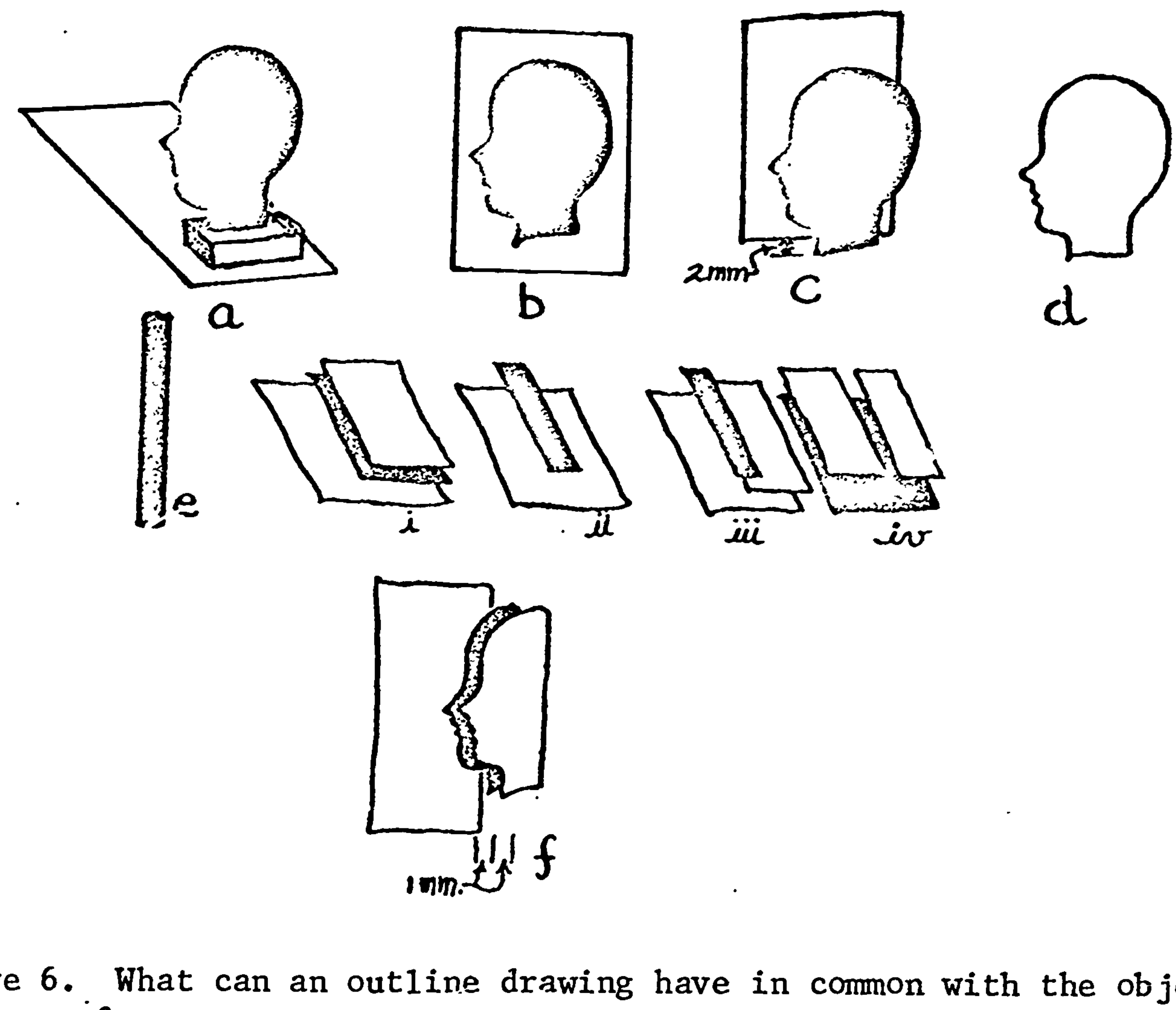

Figure 6. What can an outline drawing have in common with the object it represents?

2. Lines, ribbons, and edges--the psychophysics of "flats": What are the characteristics of an edge? At an object's edge, there is an abrupt cessation of surface at that distance from the eye, and some increase in the distance through empty air (or other medium) which must be traversed before we hit another surface. In Figure 6a, the cut-out silhouette does not have both a convex nose and a concave expanse of back-

ground nesting together at the boundary between the two. Instead, the nose is flesh up to its very edge which is convex; past that, we have nothing in the same plane, and the material to the left (if there is any) is at a greater distance and extends indeterminately behind the convex edge. Note that this is a description of physical properties, of physical objects. We shall see later that this relationship is faithfully reflected in the perceptual qualities of figure-ground contours.

Thus, a printed silhouette on paper, as in Figure 6b, provides the eye the same optic array as would an arrangement of two surfaces, one in front of the other, as in Figure 6c. There are, of course, some slight differences between the two--in accommodation and binocular disparity, and in relative motion, interposition, etc. for a moving observer--but these differences are negligible. In fact, if we prepare both an actual cut-out object, such as Figure 6c, and a picture of it as in the inked silhouette of Figure 6b, subjects who are asked to compare the picture and the object from a normal viewing distance of about two feet do not spontaneously recognize that one is a spatial array and one is a picture of it (33). In short, a silhouette is a reasonably high-fidelity surrogate for the edge of a planar object.

The same profile appears again in Figure 6d, this time in outline. In what ways are this outline and the silhouette of 6a the same? Again, let us examine the kinds of physical objects which could provide the same optic array as this picture: In Figure 6e, we see that there are six arrangements of surfaces which produce substantially the same optic array as does the ribbon of pigment on the printed page--those shown, plus the mirror images of i and iii. In three of these--i, ii, and iii--the same surface edge appears as formed the silhouette in 6a. This is a description of the ways in which a number of different physical surfaces will produce optic arrays similar to that produced by an outline drawing.

We now have to inquire as to what, in fact, people see when confronted by such optic arrays. If we now prepare a multiple-level cutout object such as Figure 6f, and ask subjects to compare that object with the outline picture of Figure 6d, again we find that they do not spontaneously recognize one as a spatial array and the other as a picture.

Let us assume that--either as a result of a great deal of extremely early experience with the world of things and objects,[5] or as the result of being born with appropriately evolved structures of eye and brain--we enter early childhood with the tendency to see an edge of a surface each time a sufficiently large luminous discontinuity (or other stimulus for "contour") confronts our eyes. Even the untrained child would see the margins of deposit of pigment on paper as surface-edges.

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[5]Repeated exposures in early life might build up neural structures

What kinds of surface-edges are in fact seen when outline drawings are being viewed? Naive subjects asked to describe a line of some specific width using any words other than "line," overwhelmingly use a small number of categories--those in Figure 6e; that is, either the edges of overlapping surfaces, or in rare cases, rods (or wires) and their edges (16, p. 409 f). As the width of the line decreases, the tendency to see a ribbon or wire, with two edges bounding the pigmented region, first increases, then decreases. That is, we pass from a silhouette to a wire or bar, back to some form of silhouette again. And as we increase the angle formed by a line or contour, the preference of one over the other alternative silhouette increases (33).

Subjects' use of words like edge, surface, etc., are remarkably subject to suggestion by the questioner. Is all this merely a matter of language, of terms derived from objects, simply because the observer knows no other words which our questions permit him to use?

3. Edges as elements of shape: There are several ways in which it appears that for an object's shape to be perceived at all, it must have an edge which can function in only one direction at a time, and which operates only over a limited span or distance. As far as shape is concerned, what isn't edged is not perceived, and what is perceived is edged. Three different measures, in addition to the purely verbal descriptions of Figure 6, support this assertion.

a. Retinal rivalry between opposing contours: If the views to the two eyes are in marked conflict as in Figure 7a, the information coming from the left eye, i, and from the right eye, ii, does not consist of independent points which can fuse to form one single image. Instead, it consists of edges, each of which carries a "halo" of its appropriate field along with it; that is, we see iii or iv instead of a complete black cross.[6] Edges must originate at some pretty primitive levels in the nervous system.

b. Successive contour-appropriation (Metacontrast): If stimuli are presented in the same position, but for the durations and order indicated in Figure 7b, the disk in b, i, simply is not perceived at all (although there are some secondary effects due to its presentation). The formation of an edge facing in one direction preempts the edge which had just begun to form in the opposite direction, thereby preventing the first shape from being seen (50).

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in the brain--that is, "cell assemblies" (23)--which would respond in a unitary fashion.

[6] Moreover, the descriptive observations given in Figure 6 appear to be duplicated, at least in gross outline, in the fusion-products of retinal rivalry.

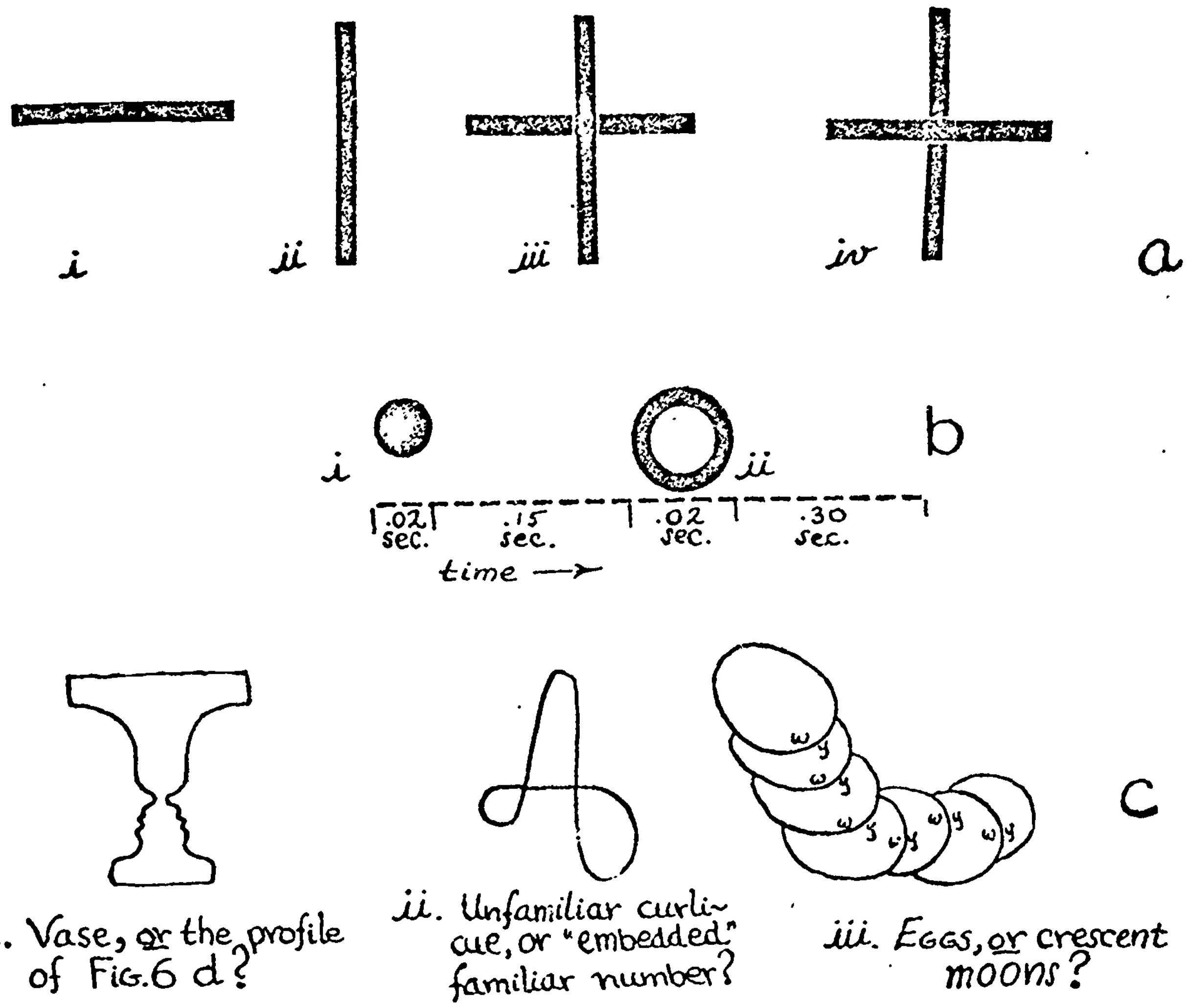

Figure 7. EDGE as a prerequisite for shape: In group a, if the left eye is shown i, and the right eye is shown ii, we see iii or iv instead of a solid, complete cross. In group b, the sequence of disk, i, and annulus, ii, will render i invisible; in the reverse order, this does not occur. In group c are figure-ground alternatives.

c. Concealment of forms in camouflage and "puzzle-pictures"; figure-ground phenomena: The previous two sets of phenomena are far removed from normal visual communication. Not so the following: Any and every region of color on a painted or printed surface is, in a very strict sense, shaped in only one direction at a time; if one of the two adjoining regions has a recognizable shape, the shape of the other is lost. Grossly speaking, what is figure has recognizable shape; what is ground is formless and extends behind the picture. See Figure 7c for some classical examples of figure-ground alternatives.

As a general description, the figure-ground distinction is convenient, but it is not really accurate. A given closed region may be figure in one part, ground in another. For example, in Figure 7c, iii, each region is figure at w, ground at y. Similarly, it is incorrect to treat the contour which separates a figure from its surrounding regions as a monolithic phenomenon. Again note Figure 7c, iii. There, contours are shown to comprise an edge facing in one direction; yet at some distance away, they form an edge facing in another direction.

What is true is that a *perceived* edge, like a physical edge itself, can belong to only *one* surface at a time, but a given surface may extend in front of another surface at one edge, and yet, elsewhere, can itself have another surface extend in front of it. A perceived edge appears to have a limited sphere of influence within which it maintains a direction of surface. Within this critical functional distance range, edges opposite in sign will conflict, forming the famous "reversible figures" which provide research tools to perception psychologists, curiosae for laymen, and interesting exercises for graphic artists (13). Past this critical distance, however, the effects of such conflict disappear, and quite inconsistent and "impossible" physical surfaces can be perceived side by side in apparently peaceful continuity as in Figure 8*a*. Very little is known about the perception of pictures of "impossible objects" (40). They are probably very rewarding subjects for study, since the problems of relationship between thing and picture, concept and percept, *unity of structure* and local *psychophysical* determination would all appear to focus here. In an important sense, moreover, all pictures are surrogates of impossible objects. The rigidity and consistency of the objects we see in the world are, then, not predetermined by our prior associations, by our mental categories, nor by over-all organizational factors. When we see rigidity and self-consistency between the parts of an object and between the objects in a scene, these are *imposed* by the relationships between the parts of the stimulus array. If they are missing, an inconsistent and non-invariant world is acceptable to the perceptual system and is communicated to the observer.

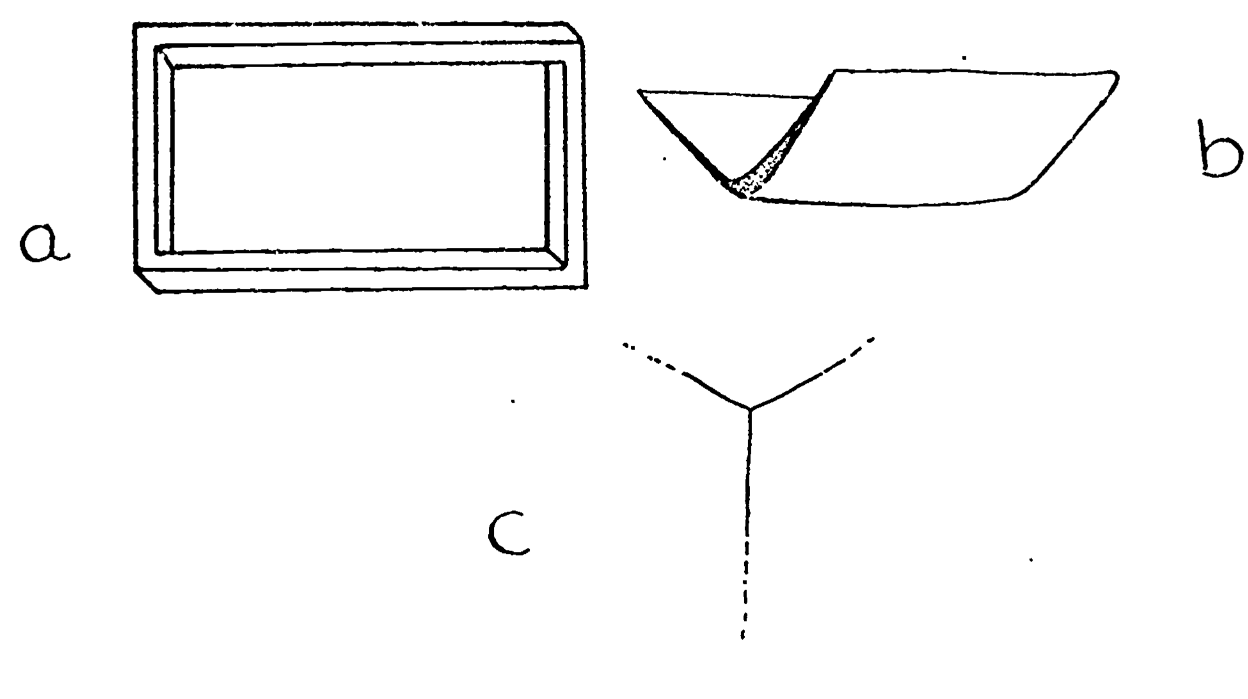

Figure 8. *a* is a picture of an impossible object patterned after Penrose (40). *b* shows a bent surface defined by its edge. *c* outlines a corner.

In short, outline-drawings are surrogates for edges, as are silhouettes.[7] Since any contour can be a surrogate for either of two edges, there is always the possibility that what we want to communicate pictorially will not be seen at all, or will not be seen as we want it to be seen. How can we determine which way an edge will be seen? We shall consider this essential problem in outlining the next school of perceptual psychology, Gestalt theory. First, however, we must complete our consideration of what pictures are.

What Are Pictures of Solid Forms and Volumes?

We have considered outline drawings as surrogates for overlapping plane surfaces like stage "flats." Most pictures, of course, portray much more solid forms (16, p. 405), and spatial features such as slant, curvature, and a dihedral angle can certainly be represented without the use of outlines at all. How can a picture act as a surrogate for such objects and real scenes?

1. The phychophysics of "models": What essential features of the optic arrays produced by scenes of solid objects also can be produced by the dappled surface of a shaded or half-tone picture? Three classes of such common features have been separately studied so far:

a. Textural distributions: Most common surfaces have inhomogeneities which are more or less uniformly distributed over their substance, and these produce optic arrays whose texture density gradients --*i.e.*, the rates of change of the texture distributions--characterize the spatial arrangement of the surfaces, and, therefore, might provide information about spatial arrangements of the surfaces and about the relative sizes of objects resting on them (19, 20, and 21). These gradients can be produced with great fidelity by a pictorial surrogate, particularly a photograph.

b. Modelling by shade and shadows: By virtue of their different orientations to the source of illumination, and because of "cast shad-

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[7]Why this should be so, is as yet unknown. It may be a physiological accident (*e.g.*, by-product of some edge-responding or contour-enhancing properties of the optical nervous system). It may serve some evolutionary function in its own right. Or it may be an adventitious product of the general learning process. In any case, we can vary the physical and geometrical nature of the stimulus pattern to which subjects are exposed and determine experimentally the correlated changes in appearance which result (26). This is desirable not only because this technical information is applicable in pictorial communication, but because it tells us something about the machinery of perception as a psychological and physiological process--and we must know what the machinery does and how it acts, before it is meaningful or reasonable to investigate what the machinery is like.

ows," the optic array produced by objects of uniform surface-color will usually contain distributions of shading and shadow. These characteristics of the array are readily produced--within a limited range of illumination ratios--by the pigment density in a painting, photograph, or print.

c. Corners and bends: To the traditional cue of linear perspective (Figure 1), and the edge-interposition of stage "flats" (Figure 6), we can add at least two other ways in which outline drawings can produce optic arrays equivalent to those produced by curved and angular surfaces. The edge of a bent or curved surface will produce a correspondingly inflected contour in the optic array, and a suitably drawn line (preferably of unequal width) can form a surrogate for these (Figure 8b). Most important: a corner, which in a sense is an edge facing in two directions simultaneously, can be replaced by lines (Figure 8c). In these respects a drawing can be a surrogate for a solid form or volume, as well as for silhouettes or "flats."

2. Pictorial ambiguity: All these features of the optic array are, of course, ambiguous; the very fact that we can produce them both by real scenes and by flat pictures is proof. The information contained in pictorial surrogates must necessarily be equivocal, and pictures must always be open to alternative interpretations, at least in theory. This inherent ambiguity raises two critical questions about pictorial communication: First, to what extent can pictures actually be optical surrogates for what they represent, rather than being merely interpreted as signs or symbols? Second, since pictorial information is ambiguous, what determines which of the alternative sets of surfaces and edges will be perceived? The answer to this first question will finally tell us what a picture is; the answer to the second will tell us how to make and use pictures, and this finding will return us to Gestalt theory which first followed structuralism, and to the mainstream of psychological inquiry.

a. "Fooling the eye": Mistaking the picture for its object--and *vice versa*. If we consider a picture to be a surrogate for a scene, we should recognize that it must be an imperfect surrogate. As we have noted before, there are many ways in which the array produced by a picture is different from that produced by the scene being portrayed. The most important of these would seem to be the cues which identify the picture as an object--as a plane surface, itself, at some specific distance and slant with respect to the viewer, and with variable reflectance due to uneven pigment deposits. To the extent that a picture is seen as a dappled surface, it cannot be a surrogate and must be acting merely as a symbol (16, p. 410). Regardless of how realistically a *trompe l'oeil* painter reproduces his scene, no matter how high the fidelity of a photograph, neither the painting nor the photograph can be mistaken for the scene itself if the plane of the picture is effectively localized over its entire surface. A number of cues can, in principle, accomplish this destructive localization of the picture's surface.[8] As we remove or reduce the cues, the effectiveness of the picture--the solidity or plasticity of the represented objects--appears to increase remarkably Thus, everyone knows that the use of a stereoscope to introduce binocular disparity appropriate to the objects in the scene rather than to the surface of the picture will provide an impression of "relief" or plasticity; that is, one sees the scene, not the picture. However, the appearance of plastic solidity can be obtained with a single picture, also, if it is viewed monocularly through a lens or aperture which hides the edges of the picture (1, 42, and 48). Indeed, the apparent space in a photographic scene can be made so convincing that observers could throw a ball at a point in it (46). Sonoda reports that such strong "plastic space" was suggested even by extremely simple outline drawings that relative pictorial distances were measured in a comparison with distances in real, freely-seen space (47). These experiments provide some reason to believe that the conditions which produce strong plastic effects also mediate more accurate judgments about the characteristics of the represented object--for example, size. Certainly we would expect an increased speed and consistency of spatial comprehension. Equally important is the strong esthetic value which seems to inhere in pictorial plasticity--a value to which the expensive paraphernalia of both stereoscope and "cineramic" viewing may be largely superfluous. The study of the conditions for, and consequences of, the perception of solidity is still in its infancy despite its obvious importance. We shall survey some closely related problems in the next section. Here, however, let us consider the other side of this point.

After all, pictures are normally viewed binocularly, with clear edges, and with a certain amount of head-movement. How important are these cues to the flatness of a picture?

We have seen that it is possible under restricted monocular-viewing conditions to "fool the eye" into taking a flat picture for relief or plastic space. We can also reverse this process and under normal-viewing conditions, we can equally well "fool the eye" into accepting a real scene as a picture. F-- example, see Figure 9.

This tolerance of the optical system for discrepancies between the depth cues may depend upon an ability to attend to some cues and ignore the others. Thus, since we have seen that the effects of an edge (and the unity or rigidity of a surface) extend only over a limited space, perhaps one sees a picture as a tridimensional scene merely by keeping

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[8]The traditional cues which would specify the locale of the picture's surface are, of course, those which do the same for any surface: binocular disparity, motion parallax, interposition, accommodation, and convergence, *etc*. However, the effective use of these cues for this purpose has not been studied. We do not know the actual efficacy of such localization.

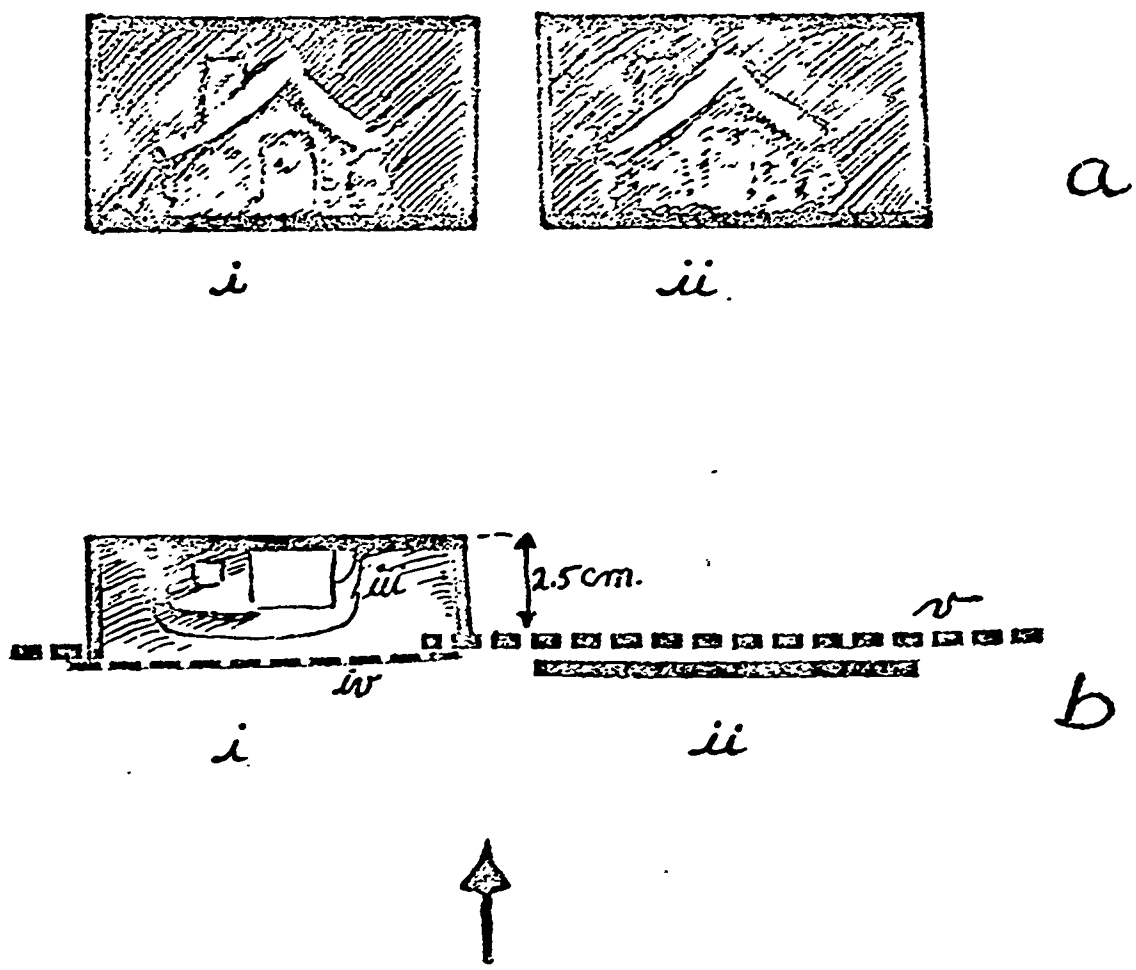

Figure 9. PICTURE AND OBJECT

From a viewing distance of about 10 feet with unrestricted binocular viewing, observers of the pair, a, do not spontaneously notice a difference between i and ii, despite the cues which must be present to indicate that i is a model house--shown from above as iii in the top view of the arrangement, b. The model was sprayed with paint from an angle which stimulated a direction of illumination at strong variance to that of the room, and was then covered by a sheet of textured cellophane, iv. In b at ii, next to the model house, a picture of the set-up is placed on a common cardboard background, a: both are given heavy black borders. The purpose of the textured cellophane is to eliminate the surface-cue differences between i and ii, but such texture merely makes the surface uneven and does not affect the operation of binocular disparity, accommodation, convergence, or motion parallax. With monocular vision, it becomes extremely difficult to detect with is picture, which is object.

his gaze away from the edges of a picture. This specialized restriction of gaze--and perhaps a decreased attention to the binocular localization through suppression of the contribution of one edge--may well comprise all or most of the "learning" to use pictures of objects or scenes. The traditional primary cues of accommodation and convergence, as well as binocular disparity, would oppose the pictorial depth, of course, but as Smith and Smith point out in discussing their ball-throwing experiment:

> Accommodations and convergence were necessary for the perceptions (i.e., to form clear retinal images), but the latter were otherwise independent of these ocular functions . . . (which) are probably of no effect as cues for the perceived depths and absolute distances over surfaces which are characteristics of everyday life. (46, p. 231)

Research here awaits a good means of measuring "plasticity."

What is implied concerning the problem of scale is another matter. Except in rare cases, the picture is a surrogate not for the original scene but for a reduced and distorted model of that scene; that is, if it is true that savages have difficulty in identifying pictures of their family and friends, it may simply be that they would have evidenced exactly the same difficulty with the miniature simulacrae of their friends to which the normally-viewed photograph is in fact a surrogate.

b. Potential pictures: Because naturally unhomogeneous pigmented surfaces--such as grainy woods, dappled fur, clouded skies--surround us, potential pictures are abundant. These, however, only become surrogates when viewing conditions permit their surfaces to be divorced from their own determinate positions in space. Several factors contribute to this "pictorialization" of a surface, some of which we will consider below. The point is that without ever attempting to make a picture as such, we could, by judicious selection from among all of the dappled surfaces which nature produces, select a surrogate for almost any conceivable object or scene which we might desire to portray. This is what is meant by the "suggestion" inherent in the veining of a particular block of marble, the picture which grows by itself, or the cloud-pictures and Rorschach ink-blots which have been used in the so-called projective techniques.[9] Thus, a picture is defined not by the activity of its creator, but by the intention of the viewer (and partly by the introduction he receives). The artist may construct the picture on bare canvas, on the other hand, he may, as with scratch-board, simply remove what he doesn't want from the pigment on a surface.[10] Similarly,

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[9] We should note a firm difference in kind between the various projective techniques. The Rorschach technique is not ambiguous in the same sense as is the TAT (25). The Rorschach ink blot does, indeed, contain a number of surrogates for different, alternative objects (18 and 28). These surrogates are not consistent with each other nor necessarily good surrogates. They are, however, just as reasonably interpretable as objects as are the markings on any other picture. Against this, such tests as the TAT ask questions about situation, social intent, life history--sets of responses for which some stimulus determinants may or may not be present.

[10] Against this, cf. Gibson (16, p. 404).

the photographer who seeks out a formation of clouds whose photograph, when suitably presented, can represent a castle or a unicorn, merely puts a frame around the photographically-presented surface produced by a light-sensitive film at the rear of a camera.

c. Multiplicity of scenes portrayed by any picture: Although a single picture may appear in "plastic" relief, it still lacks the information contained either in a pair of stereoscopic pictures of the same scene, or in the view of a real scene obtained by a moving observer. The scene being portrayed and the dappled picture-surface, itself, are only two of many alternative arrangements which will fit the same optic array. An infinite number of slant-shape pairs will fit the "tennis court" of Figure 1, and the pair of rectangles might just as well be an L-shaped flat in front of an eight-sided one. The corner in Figure 8c might be two rhomboid flats butted together at one side. In preparing any picture, fidelity alone will not explain nor predict what object or scene will be perceived. Figure 10a shows three projections of the same object, all equally faithful, yet extremely unequal in their portrayal of the original object.

We do not start with two-dimensional perception and build up, by learned associations, to tridimensionality. The problem is not why we see depth in pictures. Instead, we must ask why we see more or less depth in some pictures, and what conditions improve communication in pictures considered as surrogates for real, tridimensional objects in the world around us.

To offer a good surrogate is simply not enough to insure that the tridimensional object will be adequately communicated. High fidelity may not prevent misperceptions, as every amateur photographer has discovered. For example, an unexpected coincidence of a telephone pole and a prize subject may weld the two into some inexplicable new object. Mechanical measures of representational fidelity are inadequate. The artist and photographer must still "compose" their pictures if scenes and objects are to be recognizable (and also to lead the eye where it should go--a point we shall consider separately, below). One way they do so is by trying out or visualizing an arrangement, then changing their roles to that of the naive observer in order to discover whether such an observer would see what is intended. Assuming that most people respond in much the same way, and to the extent that they do so respond, it must be possible to discover general rules or laws governing perceptual selection. The discovery of these rules comprised the main goal of Gestalt theory. In recent years, as we shall see, some progress has been made toward reaching it.

Psychophysics of Represented Form

The search for new units by which to analyze both the world we perceive and the processes of our nervous system (27)--the "laws of or-

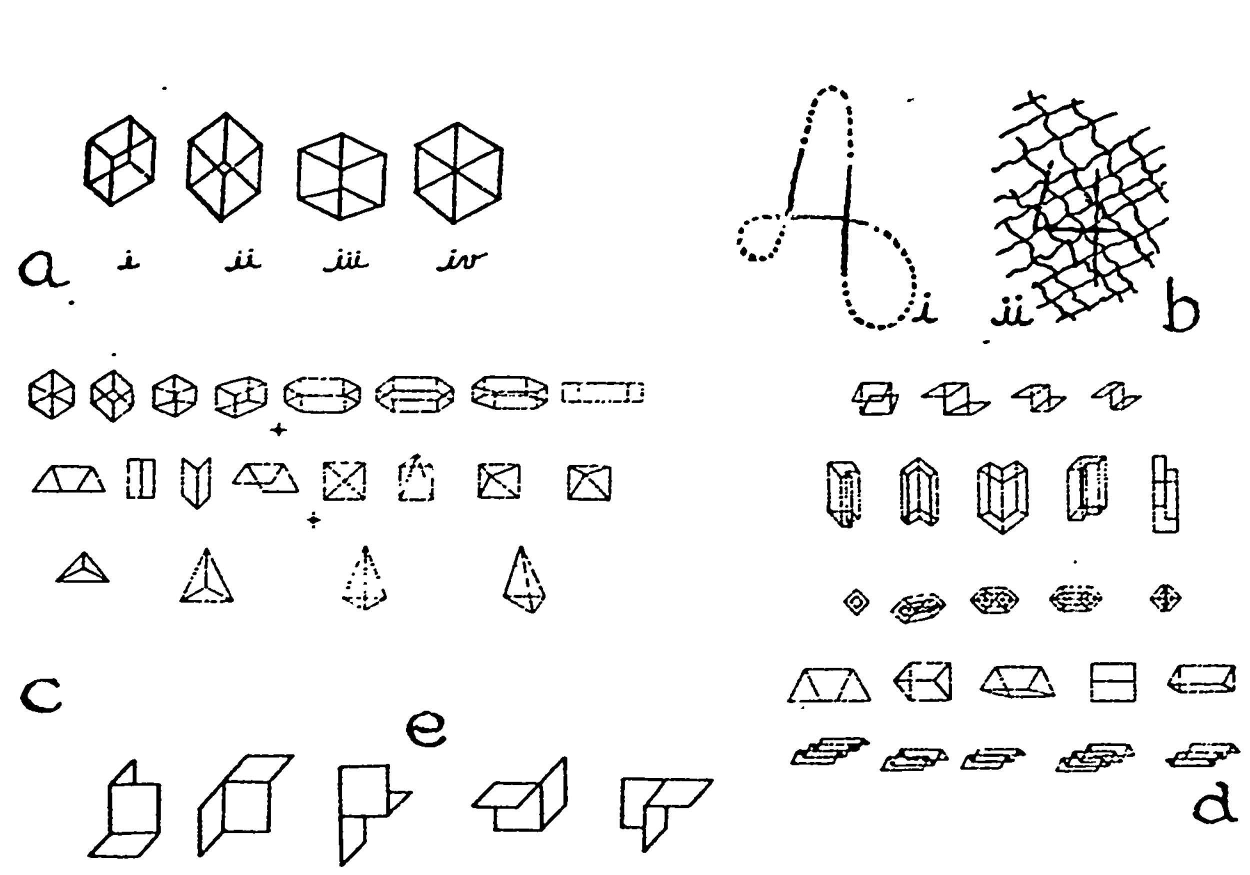

Figure 10. Reversible figures: tools for the study of organization.

ganization"--brought the Gestalt psychologists into the very set of pictorial problems we now have to consider.

The "Laws of Organization"

To know where, in a picture, an edge will be seen and which way it will face is essential in the preparation of pictorial stimuli. Remembering the empiricist tradition, we might as a start hypothesize that we will see what is familiar to us. However, although this assumption may be true in some complex sense, it is certainly not true in any way which we can use, in practice, to make predictions. For example, in Figure 7c, ii a very familiar shape is in sight yet is difficult to detect. It cannot be the lack of familiarity which conceals it since it is more familiar than the pattern in which it is embedded.

Is it, then, a question of confusion? Is the number invisible because it is presented amidst cluttering lines? No, for despite an equal or greater number of lines in Figure 10b, ii, the number remains clearly in view. It is a matter of arrangement of additional lines, not their mere presence. The configuration (Gestalt) decides what will be figure, what will be ground. The point of Gestalt psychology in opposition to structuralism is that there are lawful ways in which the over-all configuration determines the action of any part we may consider--for example, which way an edge will face--and that these laws are not to be explained simply in terms of associative learning to assemble the individual local sensations--the patches of color and brightness--as the empiricist structuralists would have it.

This concept providing some means of anticipating and predicting which way edges will face is pretty much what we have been looking for. Unfortunately, the mainstream of Gestalt theory did not go much further than three undertakings: (a) to demonstrate that individual sensations could not in fact be observed when embodied in contexts (i.e., demonstrations that the whole is more than the sum of its parts); (b) to speculate about the underlying kinds of physiological mechanisms which might be responsible for such organization; and (c) to find examples of the laws of organization.

The first two of these undertakings have little purpose today. The last provides an intuitive set of explanations about where contours or edges will form--the "laws of grouping"--and a set of rules which tell us which way they will face--the "laws of figure-ground organization." The Gestalt laws may or may not be convincing to the reader, but they certainly suffer from one major defect: they appeal to intuition to decide what will occur in each case. The reader must decide which alternative has better continuation, which arrangement is more symmetrical, which is simplest. Of the laws listed, that of proximity appears to be most objectively statable, but the least impressive as a predictor. Good "continuation" appears to be subject to measurement and objective statement, as we shall see. "Simplicity," which appears to be the most powerful--at least as an intuitive statement--also appears to be the least easy to state objectively. The next steps, then, are to try to discover the measurable aspects of the physical stimulus-distributions which correspond to these intuitive laws of organization; to subject them to psychophysical research, and to ascertain their relative strengths and efficacies in predicting what will indeed be seen.

Quantitative Statements of Gestalt Laws

A number of attempts have been made to state and measure several Gestalt laws, but since it is difficult to devise pictures in which only one of the laws of organization is operative at any time, these are in general unsuited for the problems normally faced in pictorial representation (*cf.* 26 and 31). A more inclusive formulation is needed and, fortunately is available.

1. *Simplicity and informational redundancy* as the bases of pictorial depth cues: Kopferman (39) explored a number of reversible-perspective figures like the series in Figure 10*a*. These portray either one cube in parallel projection viewed from a number of different vantage points, or a group of different two-dimensional patterns. Figure 10*a*, *iv* appears most readily as a flat pattern; it is only with some effort that we can recognize it as a cube. Figure 10*a*, *i*, appears most

readily as a cube. What changes from i to iv to cause a corresponding decrease in tridimensionality?

What the Gestaltists proposed here is a deceptively similar formula: Where more than one organization may be perceived, we will see the simplest alternative. This generalization does seem to fit a great many cases. Figure 10a, iv is simpler as a two-dimensional pattern than as a tridimensional object, and we see it accordingly. Similarly, Figure 10a, i is simpler as a tridimensional object than as a two-dimensional pattern, and so we see the former. If we review the pictorial depth cues in Figures 1 and 8, we find that in each case the three-dimensional arrangement is simpler than the two-dimensional alternatives--it is simpler to see one square in front of another than an abutting "L" and square, simpler to see two boys at different distances than a giant and a midget side by side, etc.[11]

The only defect in this "law" is that the measurement of "simplicity" remains to be made explicit. As it stands, an intuitive judgment permits us to explain only after we have constructed a figure and have observed how people react to it. It does not enable us to predict in advance, as any useful law or rule must.

However, "simplicity" need not remain purely intuitive. Several closely related attempts to define it as a physical measure have been made in order to being the Gestalt hypothesis into usable form (3, 4, 14, 32, and 38). Of these, it suffices to cite two:

> Gestalt psychologists have been vigorously attacked in the past for . . . these concepts, on the grounds that they are subjective, unquantifiable. . . . Such arguments no longer have much weight since organization is demonstrably measurable in informational terms: roughly speaking, organization and redundancy are the same. . . . Perception might be conceived as a set of preliminary "data-reduction" operations, whereby sensory information is described . . . in a form more economical than that in which it impinges on the receptors. (4)

Specifically, we might hypothesize "that the probability of a given perceptual response to a stimulus is an inverse function of the amount of information required to define that pattern" (38).

To use such an hypothesis, we must discover the specific physical variables by which to measure "complexity." A first attempt in this

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[11]Only one traditional cue--that of familiar size--cannot be expressed in terms of "simplicity." It was thought that the known size of an object could affect the distance at which it appears to be located. This cue depends for its very definition on past experiences, not upon anything one can say about the stimulus itself. It now appears, however, to be largely or wholly ineffectual (12, 22, and 24).

direction has proved extremely promising thus far, using only the following three-factor equation:

$$Y_1 = t_1 + t_2 + 2(t_3)$$

where: Y_1 is the predicted relative apparent solidity of each of the different viewpoints from which a particular object can be represented (e.g., i through iv Figure 10a).

t_1 = the number of angles enclosed within each figure;

t_2 = the number of different angles divided by the total number of angles;

t_3 = the number of continuous lines.

This prediction is based on the previous assumptions: The degree to which each of the different drawings of an object appears in its solid rather than its flat alternative is proportional to its complexity as a flat pattern.[12] Study of several "families" of different views (as in Figure 10c and d) suggested that the important factors were the three measures given above (32). In each case, these measures refer to flat patterns and are scored on a scale running from 0 for the lowest in each "family" to 10 for the highest. This formula has been tested over a fair range of pictured objects with some success. Correlations between predicted and observed apparent solidities vary between 0.6 to 0.9 for the various categories of pictures which have been sampled by a variety of "random" procedures.[13] There are, however, at least three distinct limitations to the use of this formula at present:

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[12]There are branches of physical science--notably thermodynamics--which also have to deal with problems of configuration. The measures which have most frequently borrowed for this purpose are closely related to entropy; e.g., the measures of "information theory." As the quotations above suggest, a number of attempts are currently being made to devise and use informational substitutes for the intuitive Gestalt terms.

[13]Thus, a correlation coefficient of 1.0 would represent perfect prediction of what observers say they see, while one of 0.0 would represent a complete failure to predict; that is, no relationship was found between the prediction and the reported appearance. Some amendments of the formula are needed for special kinds of pictures. For example, in generating randomly-assembled 45° oblique projections of the sort shown in Figure 10e, right angles are produced which remain unchanged regardless of whether the flat or solid alternative is perceived; they should not be counted in either t_1 or in the numerator t_2. To make this change improves prediction from $r = 0.3$ to $r = 0.8$ for the tested sample of this class of pictures.

First, it applies only to the different representations of one single object and does not as yet permit direct comparisons between the pictures of different objects.

Second, it was designed to fit only relatively simple, unshaded drawings consisting of straight lines.

Third, there are undoubtedly relevant factors which we have not included and some which we do not as yet even know (35 and 37).

Research here is still very much in progress. We need to test this formula and other quantitative restatements of the Gestalt laws with much wider samples of pictures before we can evaluate their validity and usefulness. Also, the selection of pictures for use in research is itself a problem in need of study since it is all too easy for the artist acting as a psychologist or for the psychologist acting as an artist to select sets of pictures to "prove" his laws. This sampling problem is extremely serious (5), but we can, of course, produce pictures in arbitrary ways, not subject to the experimenter's own choice.

Procedures for generating flat "nonsense shapes" (5) have been used to study the stimulus-bases for the apparent complexity and connotative meaning of silhouette forms. By means of three-dimensional gridworks and tables of random numbers, arbitrary shapes like those of Figure 10e can be obtained. Samples taken "randomly" from the objects surrounding us can be made just as arbitrary, yet are not so unrelated to stimuli we are likely to encounter in the normal run of events (29).

It is evident that the range of arbitrarily-produced pictures providing the experimental bases for any rules or theories which can be enunciated today is still dangerously restricted. As long as the perception psychologist finds it necessary to employ only constrained and simplified pictures in this research, it would be very unwise to employ his generalizations with more confidence than these constraints display.

Even with the restricted selection of pictures so far investigated, one major omission has appeared. Observers do not look at an entire picture, but at selected portions (especially those with larger and more complex patterns). This factor of selective attention may set the most important limits of the entire enterprise of attempting to deal with pictorial communication on a scientific basis.

Prediction of Attention

Early psychology was particularly concerned with the origin of spatial ideas of form or tridimensionality. Gestalt thought and inquiry were similarly invested. However, with such complex stimuli as normal pictures, other variables became more interesting. Research on the pictorial communication of metric spatial information--that is, judgments about relative distances, sizes, etc.--is still exploratory, but appears promising (6, 44, 45, 47, and 49). The experiences in which we may be interested may not even be spatial or "physical" at all. They may fit more naturally with the interests of the advertiser, the cartoonist, the pin-up artist, or the aesthetician than with the communication needs of the engineer or draftsman.

Communicating "Non-Physical" Qualities

Just as some believed that the optic array--and, by the same token, any pictorial display--can contain no information about tri-dimensional space, Berkeley argued:

> As we see distance . . . in the same way . . . we see shame or anger in the looks of a man. . . . Without . . . experience we should no more have taken blushing for a sign of shame than of gladness. (7, p. 202 f.)

We have seen, however, that we can find bases--whether it is a learned process or not--in pictures for our perceptions of portrayed size and distance. Can we similarly hope to find bases for the communication of shame and anger?

A number of such phenomena as facially-expressed emotions (43) seem to be reliable in that subjects agree with others in their responses to pictures. Consequently, we know that observers must be responding to some physical aspects of the stimulus, and psychophysical study is at least possible in principle. Scattered attempts have been made to measure stimulus bases for such experiences as "cuteness" (38).

It does, indeed, appear that we can discover psychophysical formulas with which to predict observers' non-physical experiences with some consistency (and we would expect--from the successes of type-casting, the cosmetic industry, pin-up sales--even greater consistency outside the laboratory). It is not difficulty of measurement which slows our progress in this area of inquiry, but rather the absence of systematic theories, counterparts of the structuralist and Gestalt theories which motivated inquiry into spatial form. At present, we can expect such research to be directed by specific needs, as these appear in other areas of theoretical or practical interest. Of particular interest here is the quality of visual attractiveness because, as we have seen, it may influence profoundly our attempts to predict what people will see in pictures, by determining where they will look.

The Psychophysics of "Attensity"

No matter how successful we might otherwise be in our attempts to determine a particular experience on the part of the observer, unless we have some way of knowing (either statistically or individually) where and when an observer will look, we have no way of knowing what his response will be. Upon the success of this last point depends the

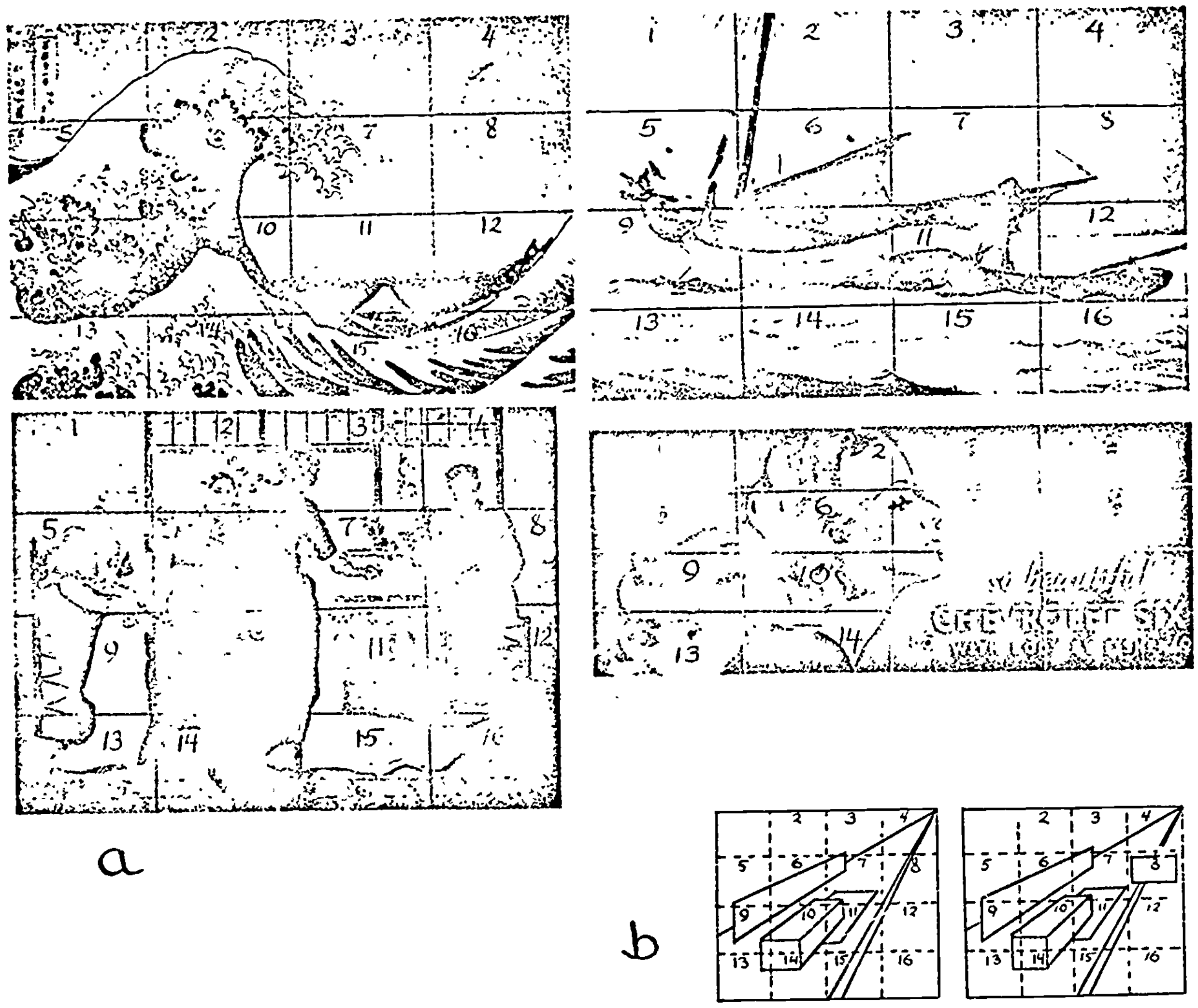

Figure 11. PREDICTION of attention: Group a shows pictures used to compare photographic records of where people look (10) with other observers' judgments of prominence (34). Group b shows examples of the class of pictures for which the psychological prediction of attention is being attempted.

entire attempt at a psychophysics of pictorial perception. Artists, layout men, and advertisers believe that linear composition and other aspects of the stimulus decide where the gaze of the average observer will be directed. Although a great deal of research has been done over the years on the study of eye movements, very little scientific study has been made of the "laws of composition."

Intuitive prescriptions may turn out to be correct. At least grossly, observers do seem to know where they are in fact being "forced" to look. Figure 11a shows paintings and photographs for which Buswell recorded observers' eye movements photographically (10). The pictures are each divided into 16 sections to show the relative duration of fixation spent within each section. They were not so divided, of course, when they were presented to the subjects.

When other observers are requested to indicate the most prominent regions in Figure 11a--those which attract their eyes the most strongly or the most frequently--we find general agreement from one set of observers to the next (34). That is, observers are consistent in their judgment of where they are looking, and we can predict what one observer will say from what others have said. In fact, the distributions of judged attention--what we here call *attensity*--are in fair agreement with the photographic records. It is not premature to make two conclusions about the control of fixation and attention:

a. Even the *untrained* observer has some idea as to what attracts his eye. It therefore seems a good bet that the student of composition can do better than chance in guessing where people will look in a given arrangement. Such judgments are probably not merely empty expertise.

b. The fact that observers' judgments are consistent and agree both with each other and with eye-movement records indicates that a psychophysics of attensity must be possible in principle. Is it possible in practice? Preliminary attempts have been made to predict points of greater and lesser attensity in simple pictures (34) such as those in Figure 11*b*. In these attempts, several different tentative formulas have succeeded better than chance. The preliminary formulas were obtained with restricted samples of stimuli and with a relatively restricted sample of motivating conditions. The effects of different motives on a freely-moving observer beset by varied visual displays--all competing for his active and passive attention--may offer an entirely different set of problems from those being studied.

Further studies, however, should be relevant to tasks in which the observer is set to look at some particular communicative display. Most reading, TV-viewing, and instrument-searching would be included in this category--one that is not too narrow a field in which to achieve a measure of psychophysical control of visual attention. That measure of control will, in turn, permit the application of whatever other psychophysical knowledge we have obtained.

Summary

Pictorial communication of shape anf form is not simply a learned visual language. Whatever processes of learning, if any, underlie our ability to perceive represented surfaces' edges--without which the communication of shape is impossible--in response to outline drawings, probably occurs very early in life in consequence of our normal commerce with spatial objects. Although this probability makes the problems of "learning to see pictures" relatively inaccessible, it simplifies the study of the rules which govern edge- and surface-perception in pictures. The applicability of such rules depends, eventually, on knowing where people will look in a pictorial display. The study of such selective attention and of its stimulus-control and educability--although it appears promising--has barely been started.

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and shadow and angle and distance. Thus, there are a very large number of "versions" of a single, presumably unvarying, stone. All these would comprise a referent category, even though one assumes the stone to be a single, unchanging entity.

One could photograph a stone from an infinite number of different distances and angles and lighting conditions, and many of these pictures would be judged to be photos of "the same stone." All pictures so judged would be classified as members of the same sign category.

D. Sign and Sign Vehicle

Written words and their spoken counterparts differ physically even to the extent of involving different media--the visual and the auditory--and yet they typically evoke similar dispositions to respond in literate members of a speech community. The written and spoken versions of "man," "homme," "uomo" comprise six physically distinctive categories of stimuli, but any member of any one of these six categories will produce essentially the same response disposition as will any other member, provided the interpreter is a literate English/French/Italian polyglot. Moreover, each of these six categories of stimuli have a very large number of discriminably different members. Thus, "man" (or "homme" or "uomo") can be presented in any of many styles of writing or printing, in any of many colors and shades of ink or lead, or in any of many loud to soft soprano, bass, etc., voices, without noticeably changing the nature of the concept signified.

Students of signs have long recognized this distinction between a sign conceived, on the one hand, as a physical stimulus object and, on the other, as something upon which meaning is conferred by an interpreter of the physical stimulus. To aid in maintaining this distinction, we shall follow Morris (13) in referring to the physically embodied word or picture as a sign vehicle, and to the disposition to respond that is regularly evoked by a sign vehicle as, simply, a sign. Thus, the spoken and written versions of "man" involve a single sign; but also involved, and simultaneously, are two highly distinctive types of vehicle. When it is not especially important to distinguish between sign and sign vehicle, cumbersomeness of exposition can be reduced by employing the term "sign" to refer to both.

To conclude the above example, the written and spoken versions of "man," "homme," "uomo" are all different sign vehicles. However, if these different vehicles arouse very nearly the same signification-response (i.e., meaning) in a literate polyglot, these different vehicles would classify as members of one and the same sign category for that polyglot. Moreover, if it were possible to create a stick figure that would arouse the concept man (as generally does appear possible), such a stick figure would also have to be included in the just-described sign (but not sign vehicle) category.

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ON THE DEFINITION OF "PICTURE"

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The scientist and philosopher of science are today stressing that a study of the language of a science is an integral part of the study of that science. Antoine Lavoisier (in his preface to his Elements of Chemistry, 1789) put it this way: ". . . we cannot improve the language of any science without at the same time improving the science itself; neither can we, on the other hand, improve a science without improving the language or nomenclature which belongs to it." The point is therefore not a new one, although the modern-day development of symbolic logic has facilitated this sort of examination.

Knowlton (11) has reported a beginning attempt to do something along this line for the language of pictorial communication; that is, he has attempted to develop a metalanguage for talking about pictures. A working assumption underlying this development is that pictures and other visual-iconic displays can for some purposes usefully be conceived of as signs (or symbols).

The writer's intention in the section following is to define this relatively superordinate concept, sign, and to use it in place of the vernacular concept of picture as the fundamental working unit for analysis. Certain subcategories of the concept of sign are then examined, as are some interrelationships among these that are of consequence to the student of pictorial communication. In the second of two major sections, the writer proposes a logical taxonomy of pictures and suggests a way to test it empirically.

In order to better highlight certain things, the first section of this paper follows the rather artificial stratagem of analyzing pictures in isolation from words. The second section stresses that the verbal context in which a picture is embedded is highly determinative of what it shall signify.

Reprinted from "On the Definition of 'Picture,'" AV Communication Review, XIV (Summer, 1966), 157-183. The paper was based on a study, "A Socio- and Psycho-Linguistic Theory of Pictorial Communication," supported by a grant from the U.S. Department of Health, Education, and Welfare, Office of Education, under the provisions of Title VII-B of the National Defense Education Act of 1958 (Contract Number OE-3-16-019).

Sign and Referent Categories

A. The Concept of Sign

According to Morris (13), a sign is "something that directs behavior with respect to something that is not at the moment a stimulus" (p. 354). Thus, a sign is a type of substitute stimulus. For Morris, signs are of two broadly different sorts, labeled "signal" and "symbol." This distinction is subtle. For present purposes it will be sufficient to note that signs that are produced by someone with the (purposeful) intent to communicate are signs that classify as symbols. In what follows, the reference is generally to signs that classify as symbols.

Signs may be stimuli of any sort that can stimulate an external receptor. But, in man, these are (essentially) limited to the audio and visual receptors. In the central meaning of the modifier "audiovisual," we can say that for most intents all communication is either "audio" or "visual" or "audiovisual." As illustrated in Figure 1, this is because only the eyes and ears are capable of receiving stimuli originating at some distance from the receiving organism and of making discriminations on the basis of tiny differences between stimuli.

The substitute character of signs is illustrated in Figure 2. If there were no person present to alert the motorist depicted in this illustration, his behavior with respect to stopping his car would be guided by his perception of the washed-out bridge. But a warning person could secure this same "stopping behavior" at an earlier and safer point in time through the production of signs. In the illustration, the word "STOP" and, probably, the posture and arm position of the warning person are signs.

It was just stated that signs direct behavior in a way something else would--were this something else present to the senses. This "something else" is the referent of the sign. Signs probably never direct behavior in precisely the same way as would their referents, if present. The driver depicted in Figure 2 would not know, for example, what was the state of affairs that prompted the sign producer to signal him to stop; whereas, should the driver proceed to the bridge, he would know this. The sign producer could, of course, have added the phrase "bridge out" under the word "STOP." And better yet, he might have supplemented the verbal message with a picture. But, even here, signs would probably not direct behavior in just the same way as would the referent of the sign.

B. Sign and Referent Categories

As Brown (2) has commented, one should always speak of sign categories and referent categories. While the writer will often speak simply of "signs" and "referents," it is to be understood that the reference is always to categories of these.

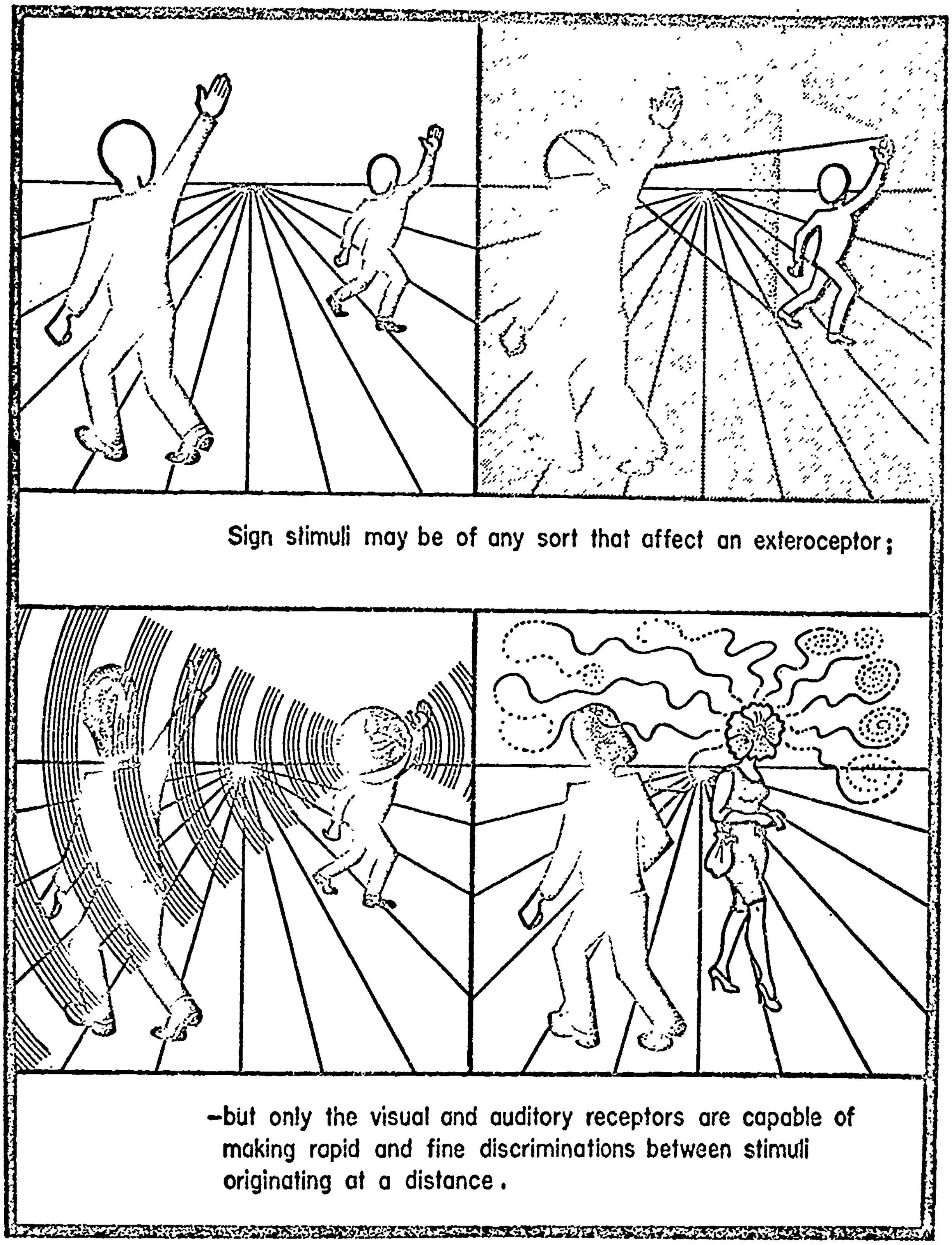
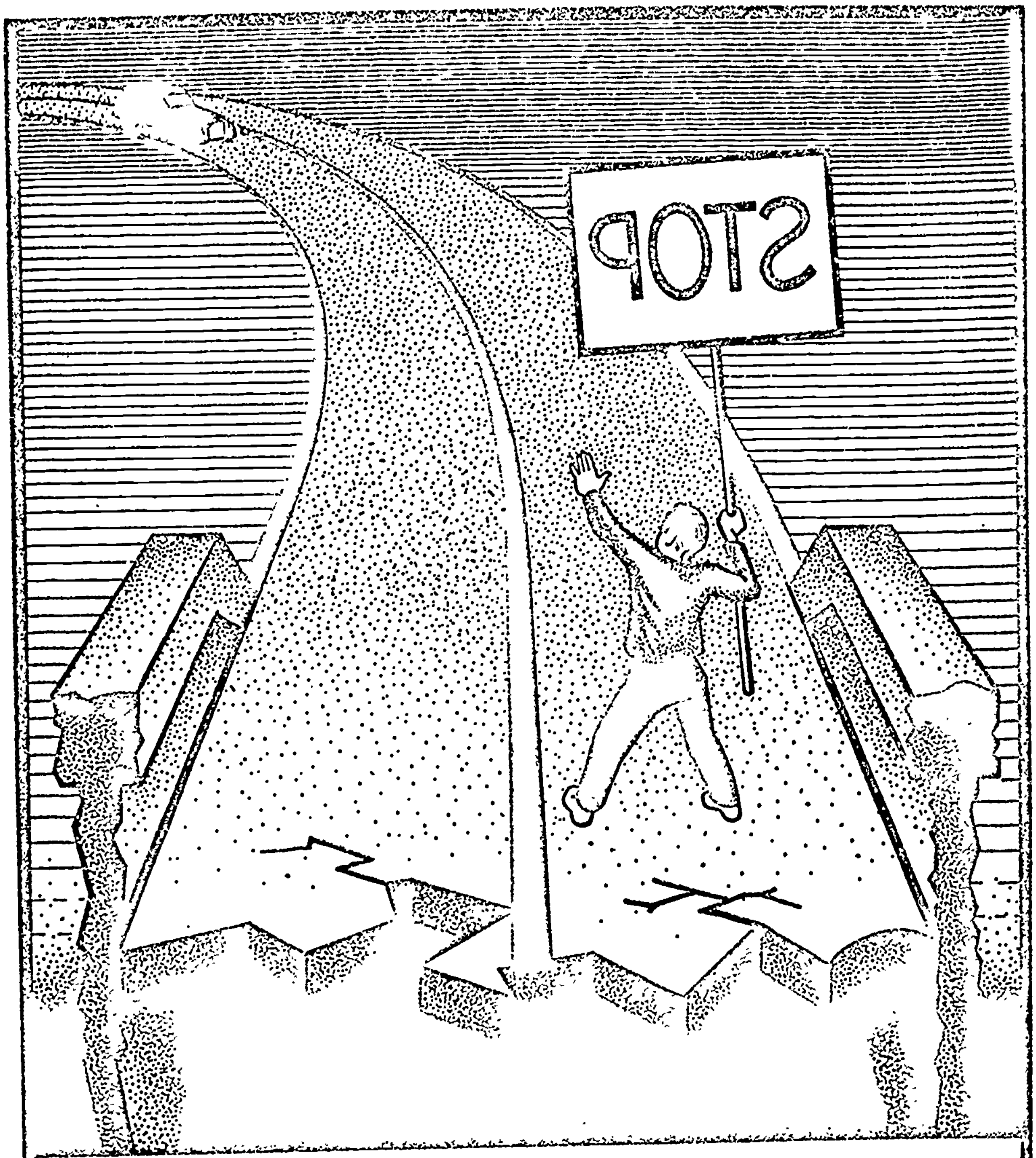


Figure 1

A referent category relates to a collection of different "things" in the nonsign world that are taken as equivalent for some purpose. Thus, "animal" names a large such collection while "man" names a smaller subset of this collection. Whether or not man is really an animal is not a useful question, for the answer depends upon the categorizer's purposes. Hence, it may be useful for the zoologist to include man in the category labeled "animal" and to treat man, fish, and flea as equiva-



Sign stimuli as "substitute" stimuli.

Figure 2

lent for some purposes. For the lawyer or moralist, it may be important to categorize man separately from all other animals.

Thus it is that categories are human contrivances, not relentless divisions of nature. And thus it is that any collection of "things" can be sorted in very nearly as many different ways as there are different purposes motivating the sorting task. The collection of adult humans can be sorted in terms of sex, number of dental caries, brain weight, attitude toward the John Birch Society, and so on indefinitely.

A category refers to a collection of "things." But "thing implies a concrete, bounded entity, like a stocking or a daisy, for example.

The world, of course, is also comprised of unbounded "things" (like air and water), processes (like muscle contraction, the movements of tide, growth), ideas and feelings. Thus, the term "thing," enquoted, must be given this extended meaning. The term "thing" (enquoted) is that which is to be understood by the notion of referent: the most general of all notions.

To describe a category requires that one be able to describe certain of the attributes (relevant cues) of the members of the category. Of several types of attributes, we here speak only of the formal type. Formal attributes refer to the perceptual qualities of objects, such as color, size, weight, sound, texture, etc. Attributes that have the potential to act as discriminanda for sorting and resorting the objects in the perceptual world are here called criterial (i.e., diacritical) attributes. Thus, ripe apples and ripe tomatoes can generally be separated from their unripe counterparts by color; and, if so, color is a criterial attribute for this purpose. (Of course, most categories are defined by more than one attribute--by combinations and relationships among several attributes.) Whether or not an attribute is criterial or noncriterial depends upon the sorting task. Hence, color would ordinarily be highly criterial for separating limes and lemons, but less criterial, even noncriterial, for separating lemons and grapefruits. On the other hand, the relative criteriality of the attribute of size, for these two purposes, would be just the opposite: low or zero for separating limes and lemons, high for separating lemons and grapefruits.

C. Equivalence and Identity Categories

Equivalence categories are named by such terms as "animal," "house," "mountain." Identity categories are named by such phrases as "Sam Smith's pet goat," "my house," "Mount Fuji." The elements comprising an equivalence category are recognized as being different and distinct entities, but as entities that are equivalent for some purpose. The elements comprising an identity category, on the other hand, are not regarded as distinct entities, but as varying forms (different versions) of a single entity.

Single words (except proper names) refer to equivalence categories, while proper names refer to identity categories. It is important to stress that identity categories are categories, nevertheless. A single individual person, for example, displays discriminably different moods, physiognomies, senses of humor, etc. Thus, Sam Smith at church with his wife, and Sam Smith out on the town with the boys are discriminably different Sam Smiths, though these different "versions" of Sam Smith are taken as different forms of the same entity.

A single, presumably unvarying, block of stone is also usefully to be conceived of as a category; again, as an identity category. Thus, however many times one observed a given stone, it is not improbable that one would never observe it under precisely the same conditions of light and shadow and angle and distance. Thus, there are a very large number of "versions" of a single, presumably unvarying, stone. All these would comprise a referent category, even though one assumes the stone to be a single, unchanging entity.

One could photograph a stone from an infinite number of different distances and angles and lighting conditions, and many of these pictures would be judged to be photos of "the same stone." All pictures so judged would be classified as members of the same sign category.

D. Sign and Sign Vehicle

Written words and their spoken counterparts differ physically even to the extent of involving different media--the visual and the auditory--and yet they typically evoke similar dispositions to respond in literate members of a speech community. The written and spoken versions of "man," "homme," "uomo" comprise six physically distinctive categories of stimuli, but any member of any one of these six categories will produce essentially the same response disposition as will any other member, provided the interpreter is a literate English/French/Italian polyglot. Moreover, each of these six categories of stimuli have a very large number of discriminably different members. Thus, "man" (or "homme" or "uomo") can be presented in any of many styles of writing or printing, in any of many colors and shades of ink or lead, or in any of many loud to soft soprano, bass, etc., voices, without noticeably changing the nature of the concept signified.

Students of signs have long recognized this distinction between a sign conceived, on the one hand, as a physical stimulus object and, on the other, as something upon which meaning is conferred by an interpreter of the physical stimulus. To aid in maintaining this distinction, we shall follow Morris (13) in referring to the physically embodied word or picture as a sign vehicle, and to the disposition to respond that is regularly evoked by a sign vehicle as, simply, a sign. Thus, the spoken and written versions of "man" involve a single sign; but also involved, and simultaneously, are two highly distinctive types of vehicle. When it is not especially important to distinguish between sign and sign vehicle, cumbersomeness of exposition can be reduced by employing the term "sign" to refer to both.

To conclude the above example, the written and spoken versions of "man," "homme," "uomo" are all different sign vehicles. However, if these different vehicles arouse very nearly the same signification-response (i.e., meaning) in a literate polyglot, these different vehicles would classify as members of one and the same sign category for that polyglot. Moreover, if it were possible to create a stick figure that would arouse the concept man (as generally does appear possible), such a stick figure would also have to be included in the just-described sign (but not sign vehicle) category.

E. The Iconic Sign

A central distinction is that between the digital and iconic sign. An iconic sign vehicle is usually (though inadequately) defined as one that resembles that for which it stands. Drawings, paintings, photographs, statues, and such, are examples. A digital sign vehicle, on the other hand, is said to bear no resemblance to its referent. It is arbitrary. (Onomatopoeia provides a trivial exception.) Words, numbers, flag signals, the sign language of the deaf, etc., are examples of digital signs.

While a picture is not totally arbitrary, it does involve a good deal of conventionalization in its production, and learning is involved in its interpretation. However, the learning that is involved is often rapid and "instantly generalized."[1] In this paper, a sign will not be called arbitrary unless it is totally so. By definition, then, digital signs are arbitrary; iconic signs are not (because never totally so).

As implied in the preceding paragraph, the definitions of iconic sign (iconic symbol, analogical sign, or other essentially synonymous phrase) that have commonly been given are inadequate. Thus, Morris's definition, which is typical, states that "a sign is iconic to the extent to which it itself has the properties of its denotata [or referent]; otherwise non-iconic" (13, p. 349). But, by this definition, a squashed banana smeared on a piece of paper should be more highly iconic of banana than would a clear photograph of an intact banana. And yet, even a simple schematized line drawing would ordinarily be more likely to call to mind the notion of a banana than would the smeared paper. Thus, the definitions of Morris and others (e.g., Gibson [5], Ruesch and Kees [18]) have not been sufficiently explicit in recognizing (a) that the iconicity of a sign must be determined with reference to the <u>criterial</u> attributes that are common to sign vehicle and an exemplar of the sign's referent category, and (b) that the degree of criteriality of attributes is partly dependent on the interpreter of the vehicle. Thus, of all the potentially criterial attributes that might be shared by a sign vehicle and an exemplar of its referent, only a part might be used by the producer of a sign vehicle, and only a part of this part, by the interpreter of it. Vis-a-vis the example of the smeared banana, it is

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[1]Persons living in cultures where pictures are nonexistent sometimes fail to recognize pictures of familiar objects when pictures are first encountered (15). But the ability to read pictures is rapidly generalized, once the "hang" of seeing objects in pictures is grasped. Thus, Hochberg and Brooks (9) report the case of a 19-month-old who had been raised in a pictureless environment. This child could appropriately name pictures of all the familiar objects whose names he had previously learned, and he could do this upon his first exposure to these pictures.

evident that the most important, most highly criterial type of visual attribute is visual contour. There must be an isomorphicity of visual contour between the sign vehicle and a "good" exemplar[2] of the vehicle's referent category.

F. The Post-conceptual Status of Iconic Signs

Success in pictorial communication requires that the iconic signs that are used have "postconceptual" status. To say a sign is postconceptual is to say that the fact of its ability to signify a concept is dependent upon that concept's having already been attained by the interpreter of the sign. This should be only slightly less obvious in the iconic than in the digital realm, for, indeed, this idea is true by definition. And yet, the postconceptual status of iconic signs seems rather regularly to have escaped the notice of students of pictorial communication.

As an illustration, consider a situation wherein the concept of interest has yet to be invented. For example, assume that Mars has Martians with sensory equipment like our own, but that Mars has no gravitational field. Martians, therefore, would have had no need to have invented furniture; hence, no need for the concept furniture. (A Martian in a gravity-free environment, it is here assumed, would require no furniture because his dishes and clothes and he himself would remain wherever placed until again moved.) An Earthman who has just landed and is ready to teach the Martian about the earth might use pictures--and with success--but not for communicating the concept furniture or the subcategories thereof. Pictures of tables and chairs and actual tables and chairs would all be exactly as meaningless as would the letters of the Earthman's alphabet.

Or, to take a more likely example, consider that a picture of an old-fashioned coal-burning kitchen stove would likely signify the concept old-fashioned kitchen stove to a 40-year-old mother, though not to her 10-year-old daughter; and this would be true even though both mother and daughter would ordinarily be said to have attained the concept kitchen stove.

1. That There Are No Iconic Signs. Bierman defends the thesis "that there are no iconic signs." (He uses this as the title of his article [1].) To this thesis he adds one critical qualification: "There are no signs whose denotation and signification depend solely

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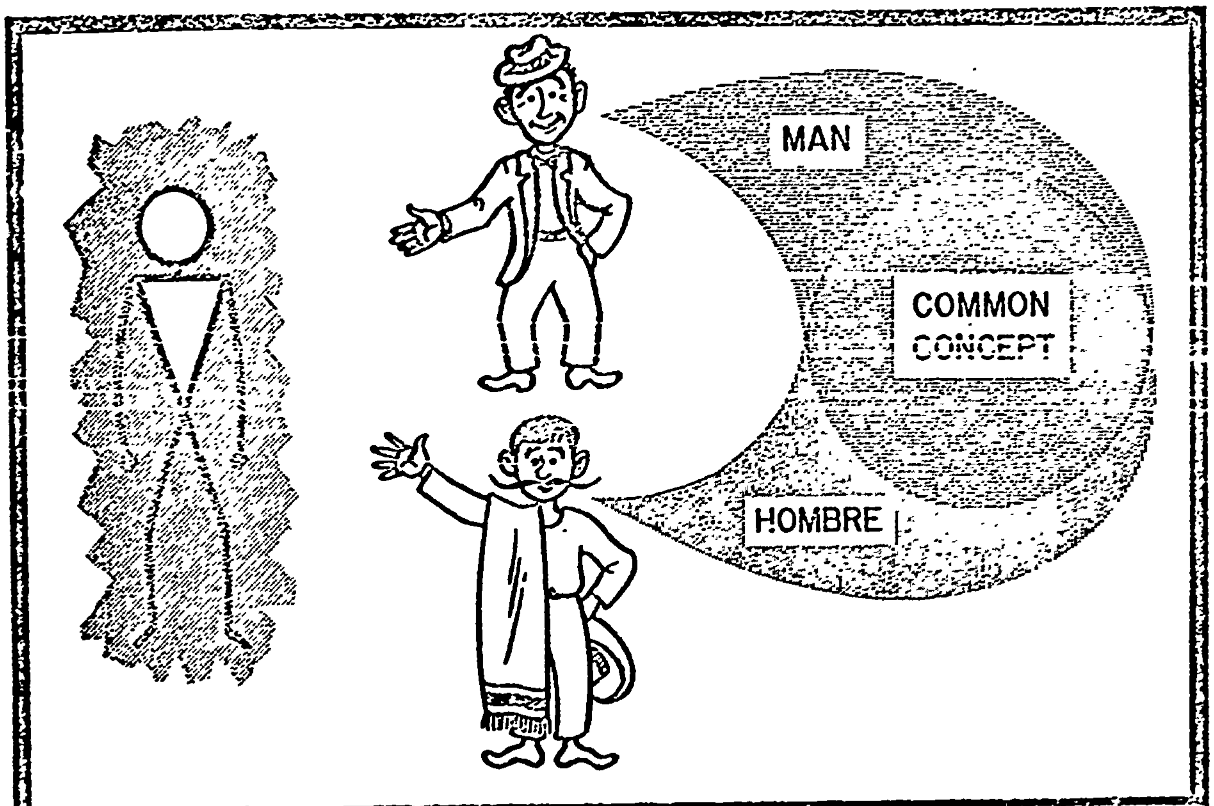
2 The question "What is a good exemplar of a concept?" is of the greatest importance to the pictorial communicator. It is also a most difficult question--one that will have to be answered in several ways, one for each of many widely varying categories of circumstances.



A schematized pictorial symbol with "post-linguistic" status can signify an equivalence category, even across language boundaries. Pictorials cannot be assumed to signify equivalence categories if they lack "post-linguistic" status.

Figure 3

on their resemblance to that which they denote" (p. 245; italics mine). This writer believes that Bierman's position is valid if (as implied, to be iconic) a sign's denotation and signification must depend solely upon the sign's resemblance to its referent. But if signification depends also upon prior mastery of the concept signified by the icon--which is the argument developed in the preceding paragraphs--then the icon, if schematized and thereby made barren of detail, may evoke the verbal name of the concept, thence the concept. This is illustrated in Figure 3 in a way designed to suggest an important use of iconic signs in communicating across language boundaries.

G. The Subordinate/Superordinate Continuum

The labels "salmon," "fish," "animal," "thing" name a hierarchy of categories. Fish labels a category that is superordinate to salmon, for fish includes all salmon and something more. However, fish is subordinate to animal, for animal includes all fish, and something more; and so on. This sort of continuum has also been referred to as a concrete-abstract continuum.

A picture or other highly iconic sign cannot, in isolation, signify a concept. A photograph of Sam Smith's pet salmon may be taken as just that, or as a salmon (any salmon), or even a fish. It is also a picture of an exemplar of the animal and thing categories, etc. The point is--and it is widely recognized--that it is not possible to signify a concept (equivalence category) iconically. However, it may be possible to suggest a concept with an iconic sign, provided the concept has been attained and provided the iconic vehicle is a representation of a "good" exemplar of the concept. Werner and Kaplan (19) use the phrase "exemplificatory representation" to describe such a possibility. This seems an apt phrase because, strictly speaking, the concept is not signified but exemplified: it is exemplified by a concrete object (or its picture) that has membership in the equivalence category of interest.

Thus, sign vehicles high in iconicity will generally represent only identity categories. On the other hand, single words (except proper names) signify equivalence categories. For most instructional purposes, the broadness of signification of single words is typically too great, that of single pictures, too narrow. However, the signification of a single word is readily narrowed by adding modifiers. Thus, the category labeled "pencil" is greatly narrowed by the modifier "mechanical" and, further yet, by the modifiers "red mechanical," etc.

A common problem in the use of single pictures is just the opposite of this; i.e., to broaden the range of what is signified. This is commonly done with words: by the verbal manipulation of context or set. But this can also be done nonverbally. Hence, a detailed picture of a particular person would not ordinarily signify the concept man. Rather, it would more likely signify some particular man--or primitive African, Eskimo, etc., as suggested by Figure 4. But if this picture were made barren of detail to the point where a stick figure emerged (see Figure 4), this barren icon would be more likely to signify man (in general) than would the more detailed portrayal. (Also illustrated in Figure 4 is the evolution of a pictographic/ideographic writing system such as Chinese. In Chinese, "man" was very early written as in "B" in the figure; then, later, as in "C"; and today it is written, roughly, as in "D.")

H. Nonsign Visual Displays

There is a frequent need to refer to such things as simple geometric forms: circles, squares, triangles. Generally, this is efficiently handled verbally. But there are statistically infrequent shapes or forms which, if encoded by language, would place a large burden on the language learner. But these need not be verbally encoded, for they are readily displayed visually with drawings, photographs, and such.

An analogous circumstance involves the use of common color names. Thus, as Bruner, Goodnow, and Austin (4) have noted, it would take more words than exist in the English language simply to name the colors that

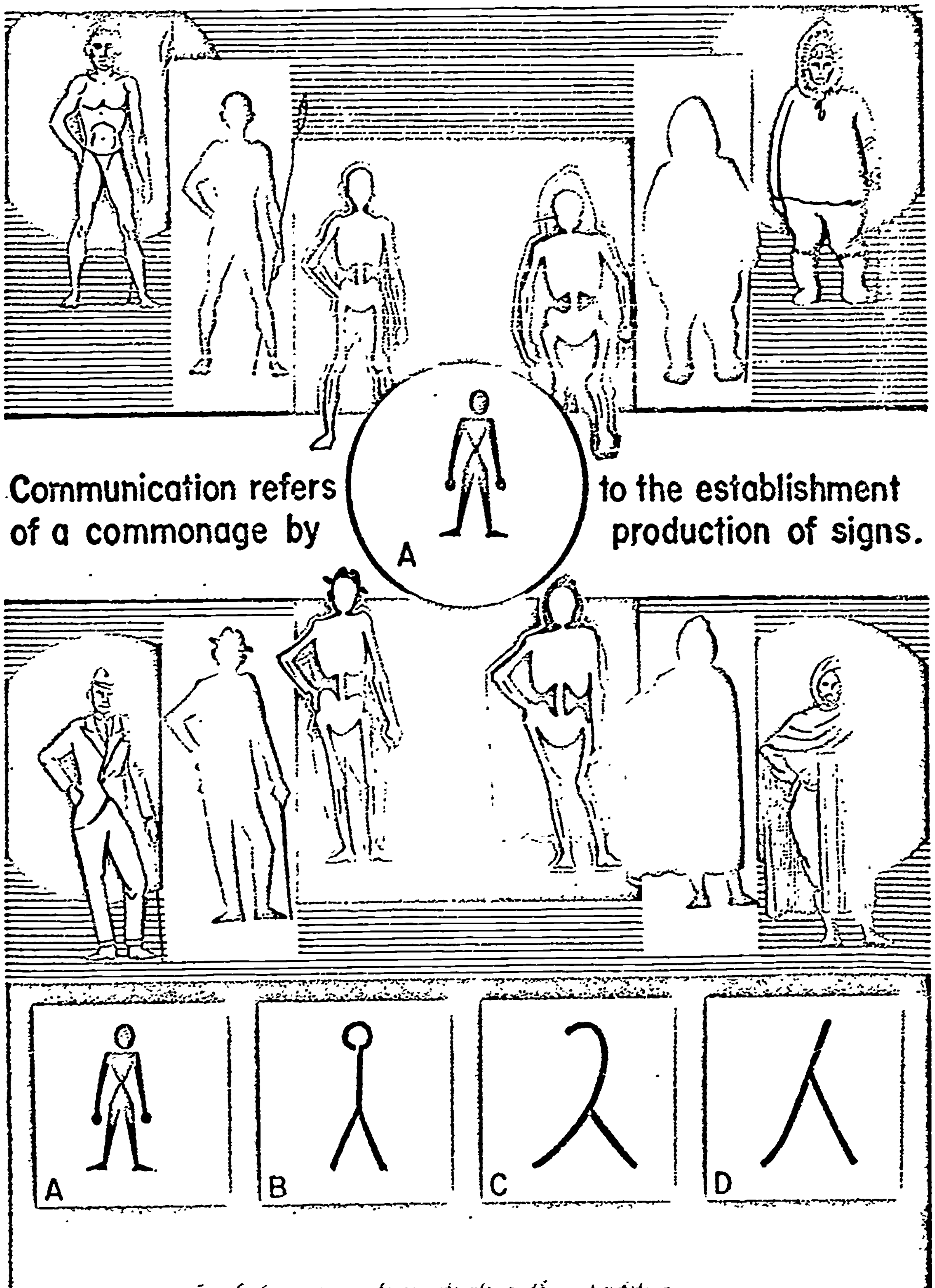

Communication refers of a commonage by
to the establishment production of signs.
A
A
B
C
D
A pictorial verbal abstraction ladder

Figure 4

can be distinguished by the average-sighted person. English has about five million words, but man can discriminate about seven million different colors. We ordinarily get along with a few dozen color names; but when fine distinctions must be made, it will usually be necessary for us to base these on matchings of actual color samples.

The above-described uses of visual displays are of borderline status as concerns the decision whether to classify these displays as sign vehicles or, simply, as nonsign visual displays.

The distinction here under development is one that all students of signs have recognized as fundamental. And we shall label this difference in the way followed by most of these students, thus referring to the sign use of vehicles as referential, and to their nonsign use as emotive. (The term "emotive" seems an unfortunate choice in some contexts as, for example, in the sort of case just illustrated.)

A referential vehicle directs attention to something in the nonsign world, therefore to something other than itself. A vehicle that is interesting in its own right--and, therefore, one that "calls attention" to itself--is an emotive vehicle and not properly to be regarded as a sign.

For example, paintings frequently have an interest in their own right as esthetic objects. Such pictures have primarily an emotive function (at least, they are nonreferential), and they therefore function quite differently than, say, the instructional photos in an automobile repair manual, where the pictures that are used are used to direct behavior relative to the parts and functions of actual automobiles.

That which is involved here was early described by Ogden and Richards (14) in their analysis of the "triangle of reference." The three corners of this triangle correspond to the three-part character of all sign processes: (a) the conceptions of the interpreter of a sign, (b) the sign vehicle, and (c) the referent of the sign. The referent is not directly present to the senses but is "called to mind" by the sign vehicle. As it is sometimes put, the sign vehicle is "transparent." One "sees through" the vehicle to the referent. Thus, on a conscious level, one may scarcely be aware of printing as the patterns-of-mounds-of-ink-on-paper that it is. The meaning "behind the print" is what "comes through." However, if one stares fixedly at a word, or repeats it over and over again, this will sometimes "drive the meaning away," and one suddenly finds one's self paying attention to the sign vehicle, as vehicle. "Transparency" is lost. The vehicle becomes opaque.

Represented in Figure 5 is an extension of the Ogden-Richards' triangle. This illustration is intended to suggest that the similarities and differences between visual-iconic signs and nonsign visual displays can be ranged along a continuum. The left-hand triangle (labeled I) is

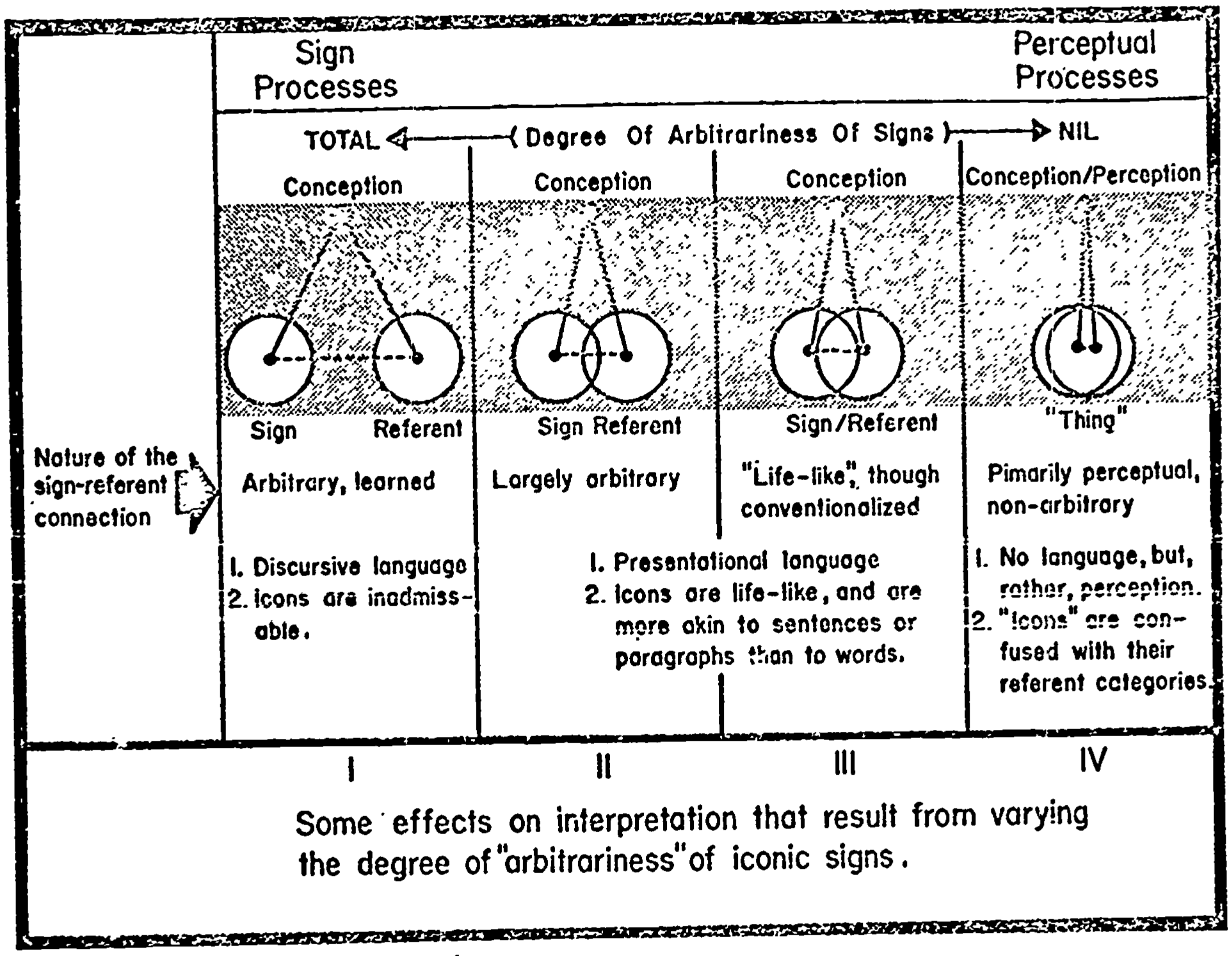


Figure 5

similar to the Ogden-Richards' triangle. The dotted base line indicates that sign and referent have no necessary (intrinsic, natural) connection; rather, that the connection is inside the interpreter in the form of a concept or referent--involving, presumably, some kind of language-related change in the functioning of the nervous system. The connection referred to is arbitrary and learned.

The white circles around the base corners of each triangle (those standing for "sign" and "referent") are intended to suggest that a sign is to be regarded as a sign category, and a referent, as a referent category. Thus, these circles represent category boundary lines. In the No. I case, there is no overlap of the sign/referent categories. This indicates a total lack of commonality of any criterial attributes as between sign and referent; hence, the relationship depicted is non-iconic.

In No. II, there is a slight overlapping of the sign/referent boundary lines. This pictures the state of affairs that exist when highly schematized iconic signs are employed. Examples would be such as those found in the language-through-pictures texts authored by I. A. Richards and his group (e.g., Spanish Through Pictures by Richards, Metcalf, and Gibson [17]). The status, as signs, of representations suggested by the No. II case would not ordinarily be in doubt unless they were employed by an interpreter family whose members had rather heterogeneous linguistic histories.

No. III is intended to suggest the case in which the iconic signs are "lifelike." There would sometimes be doubt in such cases as to whether the representations involved could validly be thought of as signs, or whether it would be more justifiable to regard them as nonsign visual displays.

No. IV depicts the state of affairs wherein the sign/referent distinction begins to vanish, or vanishes. When this distinction vanishes, no signs at all are involved; hence, the conceptual language of semiotic (i.e., the "science" of signs) is no longer useful. Rather, the area of interest is perception per se, and the conceptual language of perception would be most useful. One of the very best examples of the perceptual approach to the study of pictures can be found in this journal (8).

It is not often that word vehicles strike one as having any interest qua vehicle. On the other hand, pictures, as vehicles, are typically interesting. Everybody likes pictures. And, indeed, a most important function of pictures in communication is to gain attention, arouse interest, or please esthetically. Furthermore, a picture may serve both a referential and an emotive (nonreferential) function. A critical point that needs to be kept in mind, though, is that these referential and emotive functions are logically and psychologically distinctive. Thus, while pictures are important both referentially and emotively, it is not possible to study both functions within the same conceptual framework. This is the basis upon which it is asserted in Section I, following, that iconic signs are largely (if not totally) independent of their physical attributes for their meaning. But such a statement cannot be made in reference to visual displays that function in a nonsign capacity. In other words, the focus in this paper is upon that area characterized by the middle part of the continuum depicted in Figure 5.

I. That Sign Vehicles Are Independent of Their Physical Attributes for Their Meaning

It has been long recognized that digital sign vehicles are independent of their physical attributes for their meaning. This was implicit in an earlier development where the distinction was drawn between sign and sign vehicle. (Thus, no one concerned with the meanings of the words involved would claim that GOD is merely a mirror image of DOG.) It has been less evident, though, that something closely analogous can be said as concerns iconic sign vehicles.

Before illustrating this idea, the writer would recall that a picture presented in isolation--say, a picture of a triangle--would surely depend to a high degree upon the configuration of its physical attributes for any interpretation a viewer might place upon it. But such a display would not classify, in the scheme presented above, as a sign, but rather as a nonsign visual display. However, in the instructional situation, a verbal context is almost always involved, and this changes the situation drastically.

For instance, imagine that one were to form isosceles, equilateral, obtuse, etc., triangles out of as diverse assortments of elements as imaginable--e.g., one could form one triangle from ping pong balls, another using dead grasshoppers, another with tiny electric motors, etc.--and if the universe of all normal adults who had previously attained the concept of triangularity was asked, "How are these several collections alike?" it is probable that most members would guess that these arrangements exemplified triangularity. One could then repeat, forming another set of triangles of different sizes and angles, and forming them this time of violets, shrunken heads, and acorns. Asked the same question as before, our interpreters would again be likely to guess that the concept exemplified was that of triangularity. If this did happen, it happened despite the fact that the vast majority of the physical attributes involved varied widely across these several collections.

To take a somewhat different case: In The Cell (16) there is a picture of a firefly presented side by side with a picture of the Empire State Building. These pictures might have been intended to signify something about fireflies or buildings, and this is a most common use of pictures. But these particular illustrations happen not to have been used this way. They were not used to signify anything at all that can be directly seen. Rather, these particular illustrations were used to render pictorially the following verbal analogy:

$$\frac{\text{Height of Empire State Building = One Inch}}{\text{Length of a Firefly = One Micron}}$$

That is, the intent of the authors was to convey an intuitive notion of the length of the very small unit, the micron.

The frequency of use of visual displays of the sort just described is undoubtedly low if one considers the full range of instructional uses of pictures. First of all, many such displays serve primarily an attention-getting, interest-arousing function. Even restricting oneself to the referential use of pictures, and to the sciences, it is perhaps only within the formal sciences and the more basic of the natural sciences that one finds that a great deal that is "pictured" is, strictly speaking, "unpicturable" (i.e., that the state of affairs that is "portrayed" is not perceivable).

But, in this writer's opinion, the relative infrequency of use of this type of iconic representation is more than balanced by its extraordinary importance. And it is primarily to this use of iconic representation that attention will focus in what follows.

II. A Taxonomy of Visual-Iconic Signs

Students of pictorial communication interested in classification schemes for pictures have generally stated their classifying rules in terms of the physical attributes of the vehicles involved. But if one is interested in the meanings of visual-iconic signs, and if these meanings are largely, if not totally, independent of the physical attributes of the sign vehicles involved, any such taxonomy that might emerge will be inadequate. (There may, of course, be other kinds of purposes than those of concern here for which "physical taxonomies" would be adequate.) In what follows, the writer describes a beginning attempt to set forth a taxonomy of visual-iconic signs of a sort that is independent of the physical attributes of the sign vehicles thus categorized. This requires that a visual-iconic sign by analyzed in a way that takes account of the verbal context in which it is embedded.

A. The Formal Basis of the Taxonomy

A visual-iconic representation can be thought of as having three "parts": the elements, their pattern of arrangement, and their order of connection. Thus, in a circuit schematic of a radio receiver, the elements would be the capacitors, resistors, etc. Pattern would refer to the spatial arrangement of these elements. The order of connection would refer to the sequence in which these elements were connected by copper wires or other conductors. (The conductors are not here regarded as elements, though for some purposes it may be useful so to regard them.)

While the elements of a circuit and their spatial arrangement are ordinarily arbitrarily portrayed in the circuit schematic, the order of connection of the elements in the schematic is identical with the order of connection of these same elements in the actual physical circuit. In one critically important respect, then, a circuit schematic is an iconic representation. A visual representation will here be regarded as iconic if at least one of its three categories of "parts"--elements, spatial arrangement of elements, or order of connection of elements--is nonarbitrary.

Any one, or all, of the three "parts" of a visual representation can represent a corresponding aspect of a state of affairs in any one of three ways: realistically, by analogy (as explained below), or arbitrarily. This results in 3 x 3 x 3, or 27, types of visual-iconic representation. (More exactly this yields 26 types, for one of these 27 is totally arbitrary and therefore fails to classify as iconic.) Let the "parts of a representation be designated as follows: elements (e), pattern (p), order of connection (c). Let the manner of representation be designated as iconic (I), analogic (A), arbitrary (X). The resulting 27 types can then be shown as in Table 1. (It is another matter, of course, whether or not all these types exist or can exist.)

	e p c	e p c	e p c
Realistic pictures	I-I-I	I-A-I	I-X-I
	I-I-A	I-A-A	I-X-A
	I-I-X	I-A-X	I-X-X
Analogical pictures	A-I-I	A-A-I	A-X-I
	A-I-A	A-A-A	A-X-A
	A-I-X	A-A-X	A-X-X
Logical pictures	X-I-I	X-A-I	X-X-I
	X-I-A	X-A-A	X-X-A
	X-I-X	X-A-X	X-X-X

Table 1. The Logically Possible Types of Visual Representation Under a Scheme Given in the Text

The writer has begun to test empirically the scheme presented in Table 1, though quite unsystematically. This casual testing has seemed to confirm the existence of the three relatively superordinate categories (realistic, analogical, logical),[3] and examples of each of these follow.

1. Realistic Pictures. When the need is to represent some state of affairs of a sort that is visually perceivable either directly or with technological aid (e.g., microscope, time-lapse photography), one quite naturally employs pictures. This category is thus the most obvious one of the three because it includes pictures in the vernacular sense. However, this category does not include all pictures (in the vernacular sense).

For instance, in The Cell (16) there is a photograph of a worker in a clothing factory who is using a template to cut hundreds of identically shaped pieces of cloth in a single operation. To the question "Is this a picture?" one would say "Yes" if one were speaking in the vernacular. But to the question "Is this a realistic picture in the sense described here?" the answer would have to be "It depends." As this illustration happens to have been used in The Cell, it is not a realistic picture because what this illustration is intended to exemplify is something of the manner in which the peculiar structure of the DNA molecule operates to carry the instructions needed to determine genetic traits. The tailor's template doesn't look like any conceivable aspect

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[3]One of the writer's doctoral students, Mr. Glenn Brooks, has attempted to apply a (three-category) version of the present category set. These three are the relatively superordinate categories named: realistic, analogical, and logical. Brooks' experiences in this attempt have been illuminating.

of a DNA molecule, but it "carries instructions" somewhat as does the structure of the DNA molecule. Thus, this particular use of this visual representation determines that one would have to classify it in the category labeled "analogical picture," described next. But this same photograph--if used to illustrate a text where the discussion was concerned with factories, workers, cloth-cutting, or any of many other such things--would be classified as a realistic picture.

In fine, a realistic visual-iconic representation of some object in the visual world is a realistic picture provided that the communicator's intent is to make reference to the type of object portrayed. If the intent is to make reference to something else--something that is in some way analogous to the portrayed object or to its manner of functioning--the vehicle is an analogical picture.

2. Analogical Pictures. One might illustrate how the muscles are attached to (and articulate) the bones of the skeleton by using realistic pictures of muscles connected to bones. One finds just such an illustration in The Cell. Also in The Cell, one finds that this same notion can be illustrated by means of pictures of lumberjacks and trees: by showing a picture of the way two lumberjacks work together to support or move a felled tree. The tree is analogous to a bone, but it is not intended to look like a bone. The two lumberjacks are analogous to a pair of opposing muscles, but they are not intended to look like muscles. Thus, although such an illustration portrays objects in the visual world, these objects are portrayed only in order to show the nature of a structure or process: a process in which the portrayed objects "participate" in a manner common to the less familiar process (not so readily manifest) in the state of affairs that is of interest. This, then, is analogical representation. The sign vehicle in such cases will be labeled "analogical picture."

In the above example, the reference was to muscles and bones; and such a state of affairs as this can be portrayed either realistically or by analogy. In the following example, however, analogical representation seems the only alternative. Thus, there is a line drawing in The Cell of a golfer hitting a golf ball and caroming it off of a series of trees lining down a fairway. In the caption below this drawing, it is explained that the golf ball is like an electron, while the golf club is like a photon; and that a golfer hitting a golf ball caroming down a fairway provides a circumstance similar to what happens when a photon hits a chlorophyll molecule.

In short, analogical pictures can represent either the phenomenal or nonphenomenal world. In both cases, this is done through the bridge of the (visual) phenomenal world. This sort of representation would seem of potentially greatest value when, for whatever reason, some X-state of affairs is nonphenomenal; for instance, because X has no tangible existence, or because it is too small, too large, too distant, too transient to be recorded by aided or unaided eye.

3. Logical Pictures. An undoubted strength of realistic pictorial representation results from the interest value (aesthetic worth, dramatic impact) that this sort of representation can have. Thus, if some scene in the visual world is of interest, a detailed realistic portrayal of it will often evoke something of the same positively valued response that is evoked by direct perception of the situation portrayed. But just as the visual world is sometimes too complex for some purposes, so, too, for some purposes, are realistic pictures. A detailed realistic picture, in being worth 10,000 words, may thereby say too much.

This is the reason why barren, highly schematized pictures are often used. By schematizing, one hopes to eliminate noisy, noncriterial attributes. When "schematization" is carried to its logically furthest extreme, the elements in the state of affairs represented are represented in a totally arbitrary fashion. When this occurs, one has what is here called a logical picture: a visual representation wherein the elements are arbitrarily portrayed, while pattern and/or order of connection are isomorphic with the state of affairs represented.

An example of a logical picture has already been given: viz., that of a circuit schematic. Another is a highway road map. The elements (cities, towns) are typically represented by arbitrary geometric forms (small circles, stars) whose contours bear no relationship to the actual contour of the city's boundary line. But the relative position of the mapped towns and their order of connection by the lines drawn to represent roads are isomorphic with the state of affairs depicted.

Thus it is that a logical picture would seem to have a great potential for signifying relationships (or structure). Indeed, it would seem that in some cases, it is only by means of the logical picture that it becomes possible, iconically, to unambiguously signify relationships between elements.

There is a second type of logical picture. To illustrate, consider the concepts of atom and cell. Neither the structure of the atom nor that of the cell is ordinarily visible, but that which is involved in making these two sorts of things "visible" is quite different in the two cases. The cell simply requires magnification of what is actually there, and such a representation would here be classified as a realistic picture. But a representation of the atom requires something quite different, viz., "invention"; and the result is what is here called a logical picture.

The point is this: that the pictures physicists draw to display the structure of the atom are not to be taken as pictures of atoms but as pictures of theories about atoms. There is no reason to believe that an atom, enlarged sufficiently for viewing, would look at all like the pictures of it that are drawn (10).

But although pictures of atoms are not intended in any way to *look* like atoms, it is assumed that there are such things, i.e., that atoms exist. In a third type of situation, though, the referent of the symbol is not presumed to exist in any tangible form whatsoever, the referent being an idea. For instance, consider the problems of finding the sum of the positive integers from 1 to 10. This is accomplished fairly readily by rote mechanical means, but if one understands the structure represented in the accompanying illustration, one may solve this addition problem very quickly indeed. The mathematician Gauss did so at the age of six (7).

$$1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 = ?$$

$$\begin{aligned} 1 + 10 &= 11 \\ 2 + 9 &= 11 \\ 3 + 8 &= 11 \\ 4 + 7 &= 11 \\ 5 + 6 &= 11 \\ \hline &\quad 55 \end{aligned}$$

That which Gauss *might* have done was to directly "examine" a visual-iconic image that *may* have looked like the accompanying illustration: an illustration of the kind this writer would suggest might fruitfully be considered a logical picture.

Rather different sorts of examples have thus far been used in illustrating the logical picture. In some of the examples, exemplars of the referent category were directly visible to the unaided eye, others to the aided eye. In another instance, exemplars of the referent category were only potentially visible (e.g., an atom). In still another case, the referent was *essentially* nonvisible (e.g., an idea).

This diversity leads one to wonder how broad a territory the concept of iconicity can usefully embrace. In particular, is it useful to speak of iconicity when the referent has no tangible existence? It seems to this writer that there is *some* kind of iconicity involved even here: that the "isomorphism" in such instances must be an isomorphism between the sign vehicle and *one particular way*, of several possible ways, that ideas might be logically (hierarchically) arranged in *thought*. (The writer will readily admit, nevertheless, that speculation on this order may be premature in light of the difficulties involved in testing hypotheses that might be suggested.)

B. Estimating the Potential Usefulness of the Category Set

An armchair examination of the subcategories schematized in Table 1 may suggest to the reader that certain subcategories *cannot* exist--in the sense, for instance, that a round square cannot exist. That is, there may seem to be cases involving an internal contradiction in subcategory specification. The writer anticipates that this may be so;

but if there is anything to the formal analysis upon which the taxonomy is based, exceptional cases should prove especially informative, when analyzed. The writer's unsystematic attempts to apply the described category set have proved insight-provoking for him; but, of course, it is in the extent to which nonobvious hypotheses are suggested to others, in future applications of the category set, that will be found the value, if any, of the suggested taxonomy.

Initial empirical work with this taxonomy should attempt to gain answers to these questions. Can the categories of the set be clearly enough described so that independently operating judges will find it possible to classify reliably a large corpus of pictorial material according to the categories of the set? Can visual-iconic representations be found for every subcategory of the set? Is the category set exhaustive actually, or merely logically?

The corpus of material considered should be diverse as regards subject-matter area and should be weighted in favor of the formal sciences and the more basic of the natural sciences in order to increase the likelihood of finding as many varieties of logical and analogical pictures as possible.

In view of the rationale underlying the development of the taxonomy, it is not possible to categorize visual-iconic representations independently of the textual context in which they are embedded, nor can the taxonomy be applied to nonsign visual displays. Thus, one would have to choose a context unit that included both the visual-iconic representation of concern and the textual material that the visual-iconic sign was intended to clarify. The counting unit, though, would be the individual visual-iconic sign vehicle.

Major categories of correlations that one might anticipate finding--if one employed such outstanding, picture-rich texts as those of the Life Science Library--are correlations between the types of visual-iconic representation that were used and the nature of the subject-matter area in which they were used.

In the formal sciences, for example, one would anticipate relatively little need for realistic pictures (except for interest or attention-gaining reasons) and a relatively high need for logical pictures. In biology, to choose an especially sharp contrast, one would except much use of realistic pictures. In the basic sciences, generally, realistic pictures would seem valuable not only for the obvious reasons that need not be mentioned, but also for regularizing the irregular visual world (as in portraying a standardized cell that looks more like cells, in general, than like any particular cell); while logical and analogical pictures would be useful for showing spatial and nonspatial structure through visual-spatial analogy, especially when the referent was not perceivable.

C. An Extrapolation and Summary Comment

It has been rather regularly assumed that an iconic sign was limited to signifying "what was like itself" (13, p. 194). But this is not the case when these signs are used in conjunction with words as, generally, they are. For the iconic sign is highly dependent upon its verbal context for its signification. Similarly, it appears that the signification of verbal language may be markedly changed through the use of iconic imagery, or "mental pictures."

Hadamard (6) has explicitly urged this view: that is, that creative thought is often interfered with by one's language habits, and that the use of "mental pictures" often helps one break out of these "language traps." Language does indeed sometimes "categorize the world" in misleading ways. For instance, the speakers of Indo-European languages have great difficulty in seeing the totally intimate relationship between space and time. This may in part be due to the fact that Indo-European languages (though, apparently, not Hopi) apply the labels "space" and "time" to "the world" in a way to "demand" such separation (20).

Hadamard's conclusions were derived from a study of outstanding mathematicians and scientists whom he questioned concerning the kind of imagery they used in solving new and difficult problems. Most agreed, as did Einstein (who was one of these respondents), that words and numbers had to be supplemented when first dealing with unusually intractable problems on the frontiers of knowledge. Describing his own case, Einstein reported that he often used visual and kinesthetic images when coping with difficult problems; and that only after "playing" with the new idea in this way for some time did he find it possible, in a "secondary stage," to recast the new insight into words or mathematical notation.

The kinds of iconic imagery employed by Hadamard's respondents appear to this writer to be best classified as analogical or logical images. That is, they seem analogous to the above-described concepts of logical and analogical picture. Thus, though Hadamard's data are anecdotal, and to be interpreted with caution, it is suggested that the analogical and logical picture may have an unsuspected importance for instruction.

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AN INFORMATION-PROCESSING MODEL

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The model is an information-processing model and is an attempt to represent the operations which appear to be performed on incoming information from the time of entry through the receptor organs to the time when the information fades from the system or is used to make a decision relative to action, or is relegated to storage.

A representation of the information-processing model is shown in Figure 1. The point must be stressed that, despite the fact that some of the information on which the model is based is derived from physiology, none of the components of the model can be considered to represent anatomical components of the nervous system and the relationship to established physiological events is indirect. Despite the fact that the model does not represent phenomena with the veridicality which a theory should possess, it does nevertheless represent a formulation of knowledge derived from a large body of information. This knowledge could, undoubtedly, have been condensed and represented in other ways and the particular representation selected inevitably represents the personal preference of those who undertake the formulation. The value of the model must be judged in terms of the research that follows. A major criterion of the worth of a model is the extent to which it generates productive research. Alternative representations of knowledge might have been more useful to others. For ourselves, the model presented both here and in the previous publication was found to be a rich source of ideas for scientific enquiry.

A few general comments about the representation provided are in order at this point to prevent misunderstandings that are likely to occur.

First, the diagram represents a set of constructs inferred from data. The constructs involved are substantially different from those that are typically discussed in books on audiovisual materials, but they are believed to be much more consistent with available knowledge.

Excerpted from Studies Related to the Design of Audiovisual Teaching Materials. Final Report, U.S. Office of Health, Education, and Welfare, Office of Education, Contract No. 3-20-003. May, 1966, pp. 2-15.

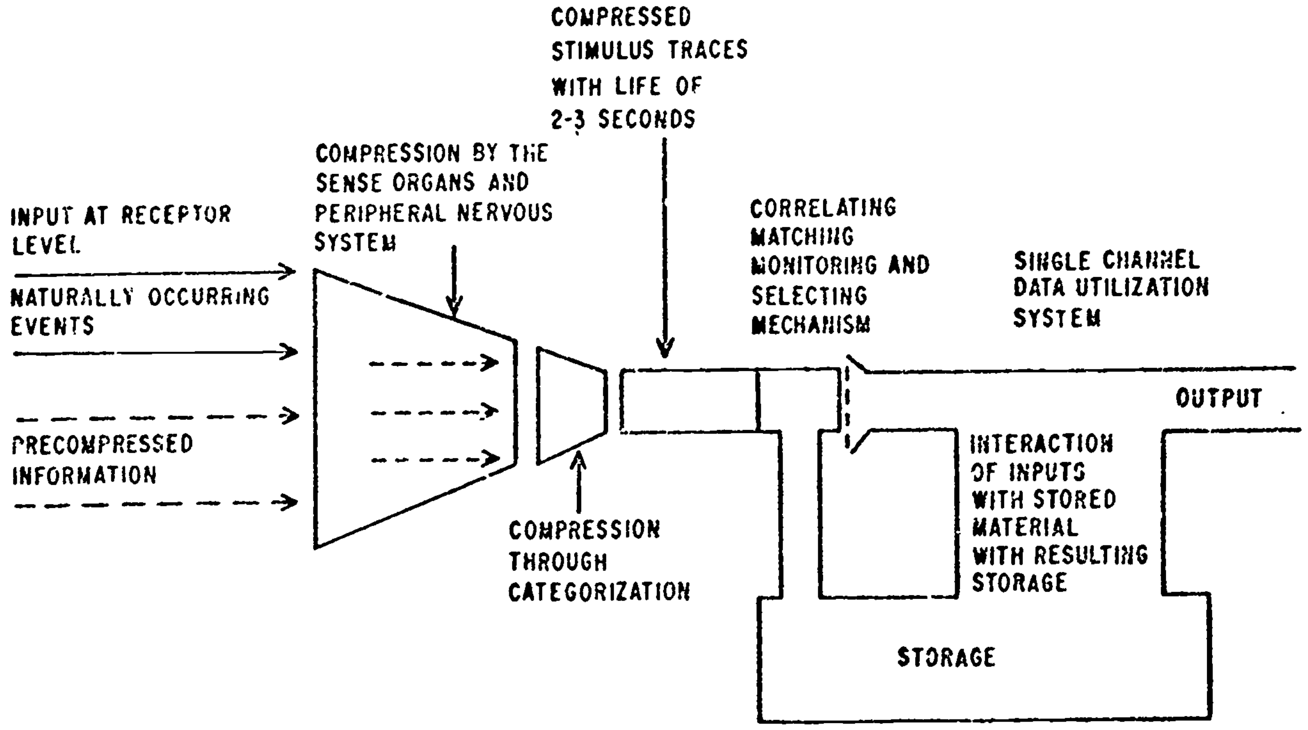

Figure 1. Information processing model derived from a model developed by Broadbent (1).

Second, the constructs represented are often sketchy, largely because they are derived from limited and very incomplete information, but some of the constructs are believed to be derived from an overwhelming amount of consistent evidence.

The sections of the report that follow describe the components of the information receiving process represented in the schematic. These sections are heavily dependent upon material presented in the earlier work of Travers et al. (8).

The Incoming Information

The information arriving at the receptors in typical educational situations may be in a naturally occurring form as it is in a realistic presentation. It may also be information derived from a real and naturally occurring situation but which has been subjected to a compression process. The compression process involves the retention of that information which is the more critical to the receiver and the discarding of the less critical information: it is exemplified by the use of black-and-white line drawings representing full-colored natural phenomena which have a wealth of detail which the line drawing omits. Very little is known about the effect of precompressing information either on the learning process itself or upon the ability to transfer what is learned to subsequent situations which involve a large number of irrelevant cues. While the virtues of teaching in realistic situations have long been extolled by audiovisual specialists, the precise nature of these virtues needs to be identified. While one may assume that the process of compressing information for transmission may resemble the process of internal compression, differences may well exist in the perceptual processes which result. Research on the precompression of information needs to be undertaken in order to gain some understanding of the effects this may have on the learning process. One problem is whether learning in the absence of large numbers of irrelevant cues, as occurs when information is precompressed, places a limit on subsequent performance in the presence of such irrelevant cues.

The Compression Process

The information provided by the environment undergoes compression at various stages during its transmission. Information may be compressed by the instructor prior to the impact of the information on the sense organs or it may be compressed after it has activated the receptors. Precompression of information, that is to say compression before it is transmitted to the human receiver, appears to have considerable advantages in promoting learning. Precompression permits a rational decision to be made concerning what is to be retained and what is to be eliminated, while compression by the nervous system involves at least some rather arbitrary processes. This position is substantially at variance with the position of present developers of audiovisual materials who have emphasized the great value of realism in modern methods of transmitting information, a policy which avoids compression. The latter position has illusory attractiveness, for the nervous system is a mechanism which does not transmit information in all of its original wealth of detail, but rather does it select and discard information according to a set of built-in rules.

Although precompression has substantial advantages over the procedure of transmitting information with all of its realistic wealth of detail and leaving the task of compression to the nervous system, the process of precompression has to be undertaken in a way which is compatible with that undertaken by the nervous system. In the case of visual information a considerable amount of information exists concerning the manner in which the nervous system compresses information, but much less is known about the compression of information transmitted through other sensory channels. In the case of vision, the evidence seems clear that most of the information is transmitted through boundaries and, hence, a representation which emphasizes the boundaries and de-emphasizes other information provides an effective means of transmission. The line drawing satisfies this condition for the effective transmission of visual information and it has been demonstrated empirically that it is one of the most effective methods of presentation. One may assume that a line drawing sometimes compresses information beyond that which would be undertaken by the nervous system. When this occurs, what are the problems encountered by the learner when he comes to apply the knowledge thus acquired to a situation providing a lesser degree of compression? The answer to such a question is not available at the present time and must be derived from research.

The boundaries of objects are obviously characteristics of particular importance in any transactions with the environment. Information concerning the position and nature of the boundaries is obviously necessary for making physical contact with the objects, for grasping or holding them, determining their size, and in performing other common operations related to them. Emphasis by the nervous system on the information transmitted by boundaries has obvious utility to the human organism and is not a completely arbitrary information-compression procedure. One presumes that other compression procedures have high biological utility built into them and are not simply processes which cut down information on an arbitrary basis to prevent the system from being overloaded.

The compression of auditory information presents problems which are being studied, but no well-defined mechanism has been identified. Attempts have been made to utilize processes referred to as time compression which involve either a process of speeding up speech with a resulting increase in the basic modulation frequency or by a process which involves chopping out sections at random. Such processes do not appear to compress speech in a manner which offers any great advantage for facilitating the transmission process. The clipping of phonemes is another alternative which probably offers greater possibility of undertaking a process of compression external to the organism similar to that which takes place within the organism.

At higher levels of the nervous system another compression process takes place. This is the process which has been referred to as categorizing behavior. Just where such a process begins is a matter of controversy. Some categorizing or coding may well begin to take place at the level of the first sensory nucleus, but it must be of a primitive nature and involve much coarser discriminations than the categorization involved at the higher levels of the nervous system, which is referred to as concept learning or concept utilization. Some compression of this kind would have to take place prior to the operation of any selector mechanism. Selection is generally in terms of the relevance of the input to the ongoing activity of the organism, though very intense stimuli as well as pain-related stimuli gain immediate access to the higher centers. A selector mechanism would have to work with both compressed and categorized information if it were designed with any parsimony.

Temporary Storage: The Stimulus Holding Mechanism

Theories of learning and perception during the last quarter century have tended to introduce the concept of a temporary holding mechanism which intervenes somewhere between the input at the receptor level and the utilization level. Hull (6), following a suggestion made much earlier by Pavlov, proposed that an afferent input is followed by a perservative trace which lasts a few seconds but declines rapidly to zero. Hebb (5) has also proposed that the nervous system is equipped with mechanisms for the temporary storage of information. These he calls "holding mechanisms." A very similar construct has been introduced by Broadbent (1), who has postulated the existence of a temporary storage device which holds signals for a few seconds. The data on which Hull based his construct was derived almost entirely from experiments with rats, but Broadbent has used exclusively data from experiments involving human subjects. It is a matter for surprise that the two constructs thus derived are so close in agreement one with another. Both agree that the trace held in storage can be utilized by the organism for only a matter of two or three seconds, after which time it has weakened to the point where it can no longer influence behavior. Both writers agree that the mechanism permits the organism to delay making certain kinds of responses and that the postulation of such a holding mechanism is necessary to account for certain experimental results. The mechanism is particularly important to the model proposed by Broadbent in that it permits the organism to utilize information provided simultaneously by two sources if the messages are short and last perhaps no longer than two seconds. The model also accounts for the fact that short messages may also be presented simultaneously through two sensory modalities and still be received in the single channel P-system which is the final information processing system.

A controversial issue is whether information held in temporary storage can be transferred directly to permanent storage without entering the utilization system. Studies on incidental learning provide a somewhat superficial suggestion that they do, but an argument could be made that the material learned by such means does actually enter the utilization system.

The Selecting, Monitoring and Matching System

The model adopted here follows closely that of Broadbent (1). The particular mechanism discussed in this section corresponds to the filter of Broadbent which leads to a single-channel P-system. The mechanism as it is described here performs the function of correlating, matching, monitoring and selecting. The mechanism postulated here has an outlet to the information utilization system which functions as a single channel.

Licklider (7) has introduced the concept that incoming information is correlated or matched with previously stored information. When the inputs are scanned to determine whether the inputs of information are identical with stored information, the two sets of information are said to be correlated. The correlating process appears to be of great importance in all organisms that have complex nervous systems, for these organisms all show a high degree of responsiveness to any novel objects, that is to say objects which differ in some way from those previously encountered. An organism that heeds anything novel or unusual in the environment is more likely to survive than one which does not give such items priority of attention. Teachers have long made use of the fact that novel objects and events attract the attention of humans as they do that of rats.

The continuous checking process which is inferred to take place insures that whatever is different from that which is anticipated in terms of previous experience has priority in obtaining access to the higher centers which are here referred to as the utilization system. This fact should not necessarily influence the practices of the designers of audiovisual material, for the response to the unusual often involves an emotional response which may not provide a favorable condition for learning.

The second process to be considered is that which Licklider (7) refers to as matching. While the process of correlating is analogous to finding out whether two door keys are the same or different, the process of matching is analogous to that of determining whether there is a lock to fit a particular key. Searching for a screw to fit a particular nut is a simple example of the matching process. Another example is that of looking for an envelope into which a particular document will fit. In such cases the environment is scanned for the relevant object. Matching, as Licklider describes it, is more complex than correlating and may involve functions other than those undertaken at the level of the monitoring system.

A third point to note is that the mechanism under consideration has to provide a continuous monitoring of the information coming in to the organism. This is a concept which would be easily misunderstood, for it does not imply the existence of a homunculus. The monitoring system could simply be a data analyzer, set in such a way that it could assign priorities to the various categories of compressed information available to it. Thus inputs of information of high value to the receiver would be passed on in preference to information of a more trivial character. Statements involving the receiver's name or statements directly related to his needs, such as "Here is the money I owe you," are likely to be transmitted further. The selector mechanism obviously has to have a system of priorities for determining blocking or transmission of the inputs of data.

The priorities of the selector mechanism can clearly be modified in a number of different ways. Need states are well established as influencing sensitivity to particular classes of information. The hungry man becomes acutely aware of signals indicating the presence of food. The person searching for the daily newspaper is highly responsive to white objects or parts of white objects projecting from underneath other subjects. From the point of view of the teacher, the most important point to note here is that the priorities can be changed by instructions given before information is made available. Thus the teacher can say "In the film you are about to see I want you to observe . . . ." The instructor may also lower the priorities of certain information by statements such as "When you are watching the movie forget about what is happening in the background, for that is quite unimportant." Such instructions influence the priorities which the selector mechanism applies to the incoming information.

If the selector mechanism did not function, the utilization system would become jammed with information and could not function effectively. It is, of course, only one of a series of mechanisms which limits the input of information so that only manageable quantities have access to the higher centers. Previous compression processes serve very much the same end.

The selector mechanism can obviously transmit only a very small fraction of the incoming information to the utilization channel. Since this is the case, it is of great importance to the survival of the organism that the transmission be other than arbitrary. The capability of the human to cope with a very complex environment attests to the extraordinary capability of the selector mechanism to set up a set of priorities which have survival value.

The Utilization Channel

Broadbent was the first to point out that a selector mechanism, or a filter mechanism as he called it, was essential for the final utilization of information, since the final process appeared to involve a single-channel system of limited capacity. Broadbent refers to this system as the P-system. Others have used such terms as the perceptual system.

While reference is now commonly made to the perceptual system or the utilization system as being a single channel system, the concept of a single channel is not entirely a clear one. The concept finds its origins in electronic systems which may be designed so that a transmission system can carry only a single item of information at a time, though many items of information may follow one another through the system in rapid succession. A telephone line used for the transmission of a single speech message approximates a single-channel system of transmission. The electrical changes at any point along the line can be represented graphically by the movement of a point on a graph. Such a transmission would involve one dimension other than time, the one dimension being the energy level. In this sense the transmission of auditory information derived from a single source can be represented as single channel system for transmitting information. Since most of the data considered by Broadbent is data involving the transmission of speech the concept of a single channel transmission is clear, for one can conceive of speech being transmitted through the utilization system much as telephonic communication is transmitted through a wire.

Now it is quite clear that the transmission of information along the afferent bundles such as the auditory and the optic nerve cannot be represented by a single channel system. Such transmission systems are complex, for they do much more than transmit information, performing also other functions such as compression and analysis. At a later stage analysis occurs so that one single source can be separated from another source and this presumably occurs prior to the operation of the selector mechanism. Beyond the selector mechanism, and probably even before, another restriction in the case of auditory transmissions is placed on the transmission of information; the information transmitted is selected in such a way that it forms a sequence in which the transitional probabilities are similar to those built into the receiver by experience. Thus it is possible to keep track of what one speaker is saying despite the fact that others are speaking at the same time and are attempting to transmit different messages. Events which arrive in a sequence corresponding to the stored transitional probabilities also represent, in a sense, a single channel transmission of information, even though each event in the sequence may be complex. In such a case the single channel concept refers to the fact that only a single series of transitional probabilities is involved.

The transmission of visual information does not fit the model of the telephone wire at all, although the auditory system may approximate this model at the level of the ear drum. Visual information can, of course, be transmitted by means of a single channel system, as it is in the long-distance transmission of pictures by wire, but at no time during the physiological transmission process can it be conceived as being transmitted in such a way. The transmission process at the retina and optic nerve level would be represented by a set of parallel channels which can be activated simultaneously. Presumably, when the information reaches the centers involved in utilization there are many simultaneous inputs. In what sense, then, can one speak of the utilization of visual material as involving a single channel system?

The answer lies also in the fact that visual information, as auditory information, is utilized in sequences which are such that the transitions from one input to the next are consistent with the receiver's built-in expectancies. The visual information follows a sequence representing one set of expected transitions and, in this respect, does not represent a series of parallel inputs each of which follows a particular system of transitions. In this sense, the utilization of visual information can be considered to represent a single sequence of visual events and the utilization channel can be considered to be a single channel system.

In a further sense, also, the utilization system can be considered to have properties of a single channel. This is the fact that when information from one sensory modality is being used, the inputs from other modalities are blocked by the selector system, though they continue to be monitored for priority of access.

Thus the concept of a single channel utilization system is basically a psychological one, and not physiological nor one derived from electrical engineering.

The utilization system is limited both in its single channel characteristics and also in the amount of information that can be processed through it. Time from one input to the next appears to be an important variable as shown in a study by Bugelski (2), not merely because of the length of exposure as such but because the longer time between inputs permits a greater number of operations to be performed on the information, which in turn has an effect on learning. The Feigenbaum and Simon (4) model, which closely resembles the Broadbent model, incorporates the idea that all inputs of information require a certain processing time and, since this occurs within a single channel system, the information handling capacity of the system is limited. While various attempts have been made to estimate the information handling capacity of the utilization channel of the human receiver, no satisfactory technique has as yet been evolved for this purpose.

The utilization system is generally protected from becoming overloaded by some such mechanism as Broadbent postulates in his filter system. Another protective device is afforded by the fact that when significant information is coming in through one sense modality, then there is likely to be a partial blocking of information coming in through other modalities. Under some conditions the higher centers can become overloaded with information with a resulting breakdown of the orderly process of information utilization. Broadbent (1) has referred to the latter state of affairs as one in which the information channel becomes "jammed." The studies which follow provide some illustrations of cases in which the information-handling system becomes overloaded with a resulting disorganization of behavior or failure to learn.

The System for Permanent Storage

Present knowledge seems much more capable at this time of generating plausible hypotheses concerning the manner of functioning of temporary storage mechanisms than it is in providing hypotheses concerning the mechanism of permanent storage. Hebb speculates that temporary storage, or the temporary holding of information, is produced by nerve impulses being transmitted through circular chains of neurons. There is some physiological evidence which lends support and credence to such an hypothesis. Such a mechanism would involve those neurons which are normally activated by the particular input and would provide for the continued activity of the particular nerve cells, but without implying that any kind of permanent storage is involved.

It assumes that the compressed and coded information is represented by the activity of these particular cells but does not suggest how the coding is related to the original inputs. The suggested mechanism would appear to present difficulties when one comes to account for the fact that temporary holding does not generally last for more than a few seconds. The proposed mechanism, at the best, can account for only limited aspects of short term retention of stimulus traces.

The long-term storage problem is much more complex. One must assume that the information thus stored is highly compressed and fragmentary, but capable of being reconstructed in such a way that something approximating the original stimulus inputs can be generated. The fact that electronic processes can be used to reconstruct fragmentary visual information into good representations of the original, as has been demonstrated by Cherry (3), suggests that much less may be stored of the visual inputs than is commonly supposed. An analogy is that electronic computers do not have to store logarithm tables in order to be able to produce the logarithm of any given number. All they have to store is a method of calculating logarithms. The visual storage system in the brain may use an analogous system storing fragmentary pieces of visual information and what are essentially rules for reconstructing the original information.

While the coded inputs may be stored as such, there is another very important relational property of inputs which has to be stored for behavior to be the way it is. This is the probability that sequences of categories of events will occur; that is to say when sequences do not correspond to past sequences, that information gains perhaps its highest priority for entering the utilization system. Just how such antecedent-consequent probabilities are stored is a complete mystery, but one can say that they are stored almost certainly in terms of categories of events rather than in terms of coded specific events.

Implications for the Design of Audiovisual Materials

The conceptualization of the information transmission process outlined here is believed to have certain implications for the design and use of audiovisual materials. The evidence supporting the position taken also throws doubt on the validity of many of the statements of principles for the design and utilization of audiovisual materials found in typical textbooks on the subject.

First, 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 common practice of filling both the auditory and the visual channels with a continuous flow of information would seem to have little support, except perhaps that it may satisfy some of the compulsions of film producers. The silent film with the alternation of picture and print would appear to find much theoretical support as a teaching device.

Second, 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. While one cannot deny that educational materials must help the learner to perform transactions with a real world, the conclusion does not follow that teaching displays should necessarily be realistic. Man does not transact his affairs with the environment by responding to the vast wealth of detail which physical processes transmit to his senses, but rather he is highly selective in the information which he uses and the cues to which he responds. A learning process which involves the presentation of that information derived from the environment which is of value to him, may well provide a much better learning procedure than a realistic presentation which includes a vast and overwhelming complexity of irrelevant detail. The learner may ultimately have to learn to discriminate the relevant cues from the irrelevant within the context of a realistic situation, though the internally occurring compression process may eliminate the need for some of these discriminations. 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. The line drawing indicates at a glance the important features involved in wiring, while the photograph requires careful study before the essential features can be sorted out from irrelevant features produced by shadows and shading. The commentary in many films is necessary only to help the viewer sort out the relevant from the irrelevant in the video presentation. Perhaps the study of the geometry of the circle should not begin with round plates, wheels, and tables, but with the circle itself, which establishes a category into which these various objects can be placed. The circle also includes that aspect of each one of the objects named which is likely to transmit much of the information to the perceiver, for boundaries tend to be major information carriers.

Third, the perceptual model on which most audiovisual materials are based is already well recognized within the audiovisual area as being a thoroughly unsatisfactory one. Information is not satisfactorily stored when a passive learner is passively exposed to inputs, though some learning may occur under such circumstances. While various attempts have been made to introduce activities as a part of the procedure involved in the use of audiovisual materials, the equipment involved does not appear to be particularly suited to the incorporation of learner activity. A part of the difficulty of incorporating such activity is that not much is known about the kinds of activity that result in effective retention and transfer.

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VISUAL PERCEPTION THEORY

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Psychophysical Theory

In order to establish a baseline for further discussion, it will be necessary to review briefly Gibson's 1954 article, "A Theory of Pictorial Perception" (6).[1] In this paper, Gibson notes that perception enables us to make discriminations among features of the physical environment, and to identify objects, places, and events when we encounter them on another occasion. Frequently, people have to be trained or educated in situations other than those in which the learning will be practiced. Thus, there is a need for substitute or "surrogate" stimuli which are relatively specific to objects, places, or events not at present affecting the sense organs of the perceiving individual. An important assumption is ". . . that direct perceptions correspond to realities, or rather that they come more and more to do so as the perceiver learns. Accordingly we are primarily interested in how perceptions mediated by surrogates also come to correspond to realities" (6, p. 7). Thus, Gibson's focal concern in this paper is the problem of fidelity in pictorial surrogates. A faithful picture is defined as one which reflects or transmits a sheaf of light rays to a given point which is the same as would be the sheaf of rays from the original to that point. In general, a good pictorial surrogate is one which corresponds to the original with maximum fidelity. However, pictorial (replicative) surrogates may vary with respect to their degree of realism or the extent to which they actually duplicate the features of the original object. Thus, between purely replicative surrogates such as realistic pictures, on the one hand, and purely conventional surro-

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Excerpted from "Visual Perception Theory and Instructional Communication," AV Communication Review, XIV (Fall, 1966), 301-317. The preparation of this paper was supported by a contract with the Office of Education, U. S. Department of Health, Education, and Welfare, under the provisions of Title VII-B of the National Defense Education Act of 1958.

[1]It should be noted, of course, that this article was written at least 12 years ago and may not reflect the author's views as he would state them at this time. (Professor Gibson has not published recently on the specific subject of pictorial perception, to my knowledge, although I understand he has a new book on the general subject of perception in preparation or in press.)

gates such as verbal and other abstract symbols, on the other, are "mixed surrogates" which have some general features of that which is represented. As for the relative values of the several varieties of surrogates, "Pictures and models are better than words and symbols for learning about concrete things . . ." whereas "Words and symbols (including graphic symbols and geometrical drawings) are essential for learning about properties, variables, groups, classes, and universals . . ." and, of course, words are needed to manipulate propositions and to form new ones (6, p. 22).

The import of Gibson's 1954 analysis seems quite clear. What we perceive is what is given--what is antecedently "there" in the external world, and the function of the replicative surrogate is simply to satisfy conditions, supplying a pattern of retinal stimulation which closely approximates that which would occur in the presence of the original. The conditions are physical and can be described in mathematical terms. Just how learning results from perception is not systematically discussed in this article; after all, the article is about pictorial perception, not about learning. But the implication which seems to underlie the entire discussion is that what we learn from perception is just what we see, or what is "given" by the initial visual stimulation. The strength of this position is that it is, in a sense, undeniably true. Its weakness, if it has one, is that it leaves out of account the variability of perceptions under constant or similar conditions of retinal stimulation, and the related notion that learning typically involves some "trying out" of the information we receive from external sources. This is not to deny the importance of considering what constitutes fidelity in a pictorial surrogate, nor the obvious instructional advantages of being able to simulate objects and other environmental conditions not directly accessible to the learner, but rather to note a distinction between a psychology of replicative surrogates and a psychology of perception as related to learning. But more about this later.

In a paper published in 1962, Hochberg (7) continued the psychophysical line of analysis in his discussion of the specification of stimulus variables that control our perceptions of pictures, exploring such problems as what constitutes an edge, what makes a figure look like a solid object, or the psychophysics of represented form. This informative survey pointed out that much remained to be done in this important area of research. In the same issue of AV Communication Review, a transactional view of perception and audiovisual learning was outlined by Hans Toch and Malcolm MacLean (14). This recent review of the transactional position and Hochberg's discussion from the psychophysical standpoint made it apparent that the issues discussed by Gibson (6) and myself (11) eight years earlier were still very much alive in 1962, as they are today and will no doubt remain for a long time to come. However, to say that the issues are "alive" is not to imply that they are prominently or frequently discussed, explicitly, in the psychological or educational research literature--quite the contrary. The issues are alive merely because some of the same underlying (often implicit) assumptions are still operative in divergent styles and interests that characterize current research and theoretical development. A good case in point is the important and challenging work recently reported by Robert M. Travers and associates to be discussed next.

An Information Theory Approach

Drawing upon the literature of experimental psychology (and to some extent upon their own research), Travers and his associates (15) have constructed a theoretical model for the "transmission of information" by audiovisual materials. In a broader sense, they offer an approach to the study of communication (and perception) in terms of information theory as applied to psychological research, drawing upon the prior work of Broadbent (4) in particular. Essentially, the proposed theory is a close adaptation of Broadbent's model of the human information-processing system which features the notion of a limited-capacity channel ("P system") fed through a selective filter from a short-term storage reservoir of sensory inputs--a concept which is fully described in Broadbent's 1958 publication, Perception and Communication (4). Travers' adaptation provides for a "compression" stage as information enters at the receptors and for some elaboration of the processes presumably subsumed under Broadbent's "selective filter." The central idea is that of a single-channel data utilization system which passes only one message at a time. Thus, in tracing the implications of his model for the use of audiovisual materials, Travers is particularly critical of the notion that multimedia presentations increase learning by virtue of the plurality of media involved. He holds that exactly the opposite effect may result when too much information is presented through two channels simultaneously, unless the density of information and rate of presentation is sufficiently low to compensate for the overloading by which relevant information may be lost. For similar reasons, Travers concludes that emphasis on realism in instructional materials is the "worship of a false god" (16, p. 380). The intelligent use of information by human receivers is a highly selective process which may be impeded by the presentation of realistic and irrelevant detail.

In order to understand Travers' position, it is necessary to examine at least some of the experimental studies from which his conclusions are drawn. In one study by Van Mondfrans and Travers (15), nonsense syllables and words were presented to subjects in three different modes: visually, by sound, and by the two modalities combined. In terms of the quantity of material recalled, it was found that at lower speeds of transmission, there were no significant differences among the three modes of presentation; i.e., it didn't matter whether the syllables or words were presented visually, in spoken form, or in "AV" combination. When the information was presented at higher speeds of transmission, "a significant decrement was found in the AV presentation." The lower effectiveness of the combined audio and visual presentation, as compared with single-channel transmission, was attributed to interference of one mode of transmission with the other.

In a similar experiment involving passages from a reading text (15), it was found that AV (combined audio and visual) presentations did yield better results at higher speeds than single channel, but it was also observed that subjects tended to block one channel or the other. This was interpreted to mean that when dealing with meaningful reading material, some subjects do better with the visual channel, some with the auditory--so a given subject may select his favored channel and block out the other. Thus, assuming selective screening of one channel or the other, the superior overall result for the AV presentation is still consistent with the single-channel model of information transmission.

In a third experiment by Chan, Van Mondfrans, and Travers (15), a set of nonsense syllables was prepared in two forms, one with special type and in color against a decorative background, the other in plain black and white letters with no decorative background. A different set of nonsense syllables was prepared for auditory and simultaneous presentation with the visual sets. Thus, each time a subject was exposed to a visual nonsense syllable, he heard a different (and potentially competing) nonsense syllable at the same time. One group saw the colored and decorated visual presentation, the other the black and white, each with the accompanying auditory stimuli already described. In terms of the total number of visual and auditory syllables recalled, both groups performed about the same; i.e., the difference was not statistically significant. The group that saw the colored and decorative presentation had better recall of the visually presented syllables, but at the expense of the auditory channel. The results with the other group were just the reverse.

With respect to the findings of the studies just mentioned, it is of primary importance to keep in mind the fact that they deal exclusively with verbal symbols, whereas most two-channel presentations actually used in instructional situations typically combine nonverbal signs in the visual channel with verbal auditory stimuli. It is not difficult to understand why Travers and his associates have concentrated their attention upon the relatively simplified problem of rate of transmission and interchannel interference where the sign stimuli in both channels are verbal. It is even plausible that the conclusions drawn may have general relevance and validity beyond the limits of these highly important and suggestive studies, but it is still necessary to distinguish carefully between the actual experimental findings and theoretical statements regarding nonverbal "realistic" stimuli which have not entered into the experimental work cited above. It is one thing to say that the "density" of information in stimulus materials presented to the learner may become a factor impeding efficient transmission; i.e., some presentations may be too realistic. It is something quite different to argue that "realism" is therefore "the worship of a false god" (16, p. 380). The latter conclusion really constitutes two assertions: (a) that there is somewhere a band of "worshippers" who presumably ascribe some sort of innate communicative or instructional value to "realism," as such, and (b) that the value of "realistic" presentations is illusory because they typically contain extraneous and potentially overloading information which generally ought to be eliminated by precompression of the message.

The first assertion seems to be directed primarily toward producers and designers of audiovisual materials, who do not ordinarily publish their views regarding such matters--but some of the charge spills over onto the professional audiovisual literature, where, despite some occasional extravagant claims in the past, it would be extremely difficult, I believe, to find recent published (or unpublished) statements expressing a "worshipful" or indiscriminate regard for "realistic" instructional materials in their own right. The second assertion seems to me an overgeneralization, subject to the interpretation that the same principles of compression which make it possible to speed up communication of verbally encoded information can and ought to be applied more or less across the board to any raw information of high density in the interests of efficient communication. Sometimes yes, sometimes no!

A point of interest here is that Broadbent, from whom Travers derived his model of the human information-processing system, tends to emphasize the value of auditory transmission of information by verbal symbols (even though he acknowledges that vision is the most highly developed sense) on the grounds of the unique importance of lingual communication in human behavior (4, pp. 2-3). Travers' work in this area, thus far published, also leans toward a linear, lingual model of communication (whether auditory or visual) which features measurement in terms of units of information transmitted per unit of time--an approach which, for apparent reasons, avoids the complications that would arise if the units being measured were incommensurate, or at least very difficult to equate. Or, to put it another way, one might speculate that the information theorist working in this area does not concern himself with qualitative differences among classes of sign stimuli because his focal concern is the problem of transmission. However, there is an important qualification to what has just been said. From an experimental standpoint, studies centered upon the concept of transmission tend to deal with uniform message elements, such as verbal symbols, perhaps for the sake of methodological neatness--but having identified findings which hold under such conditions, the experimenter finds nothing in his theoretical model to prevent generalizations which can be applied to a "mix" of verbal and nonverbal message components.

Essentially, the information theorist seems to be saying that what goes in one end of the communication process is what comes out of the other, except for what may be blocked, filtered, or garbled due to "noise." In terms of perception (and this has much in common with psychophysical theory), we perceive what is antecedently "there"--given suitable conditions of transmission--and what is "there" is that which is <u>already</u> classified, known, or understood, that for which we have an available response. So it doesn't make much difference whether the object of perception or item of information is a word, an object, or a picture of an object. Realism conceived primarily as "density" of information implies selection or "compression." This is a matter of great importance in human behavior and learning, and Travers' comments in this regard are timely and valuable. The danger that occurs in a discussion of realism as "density," in the context of information theory, is that it seems to lend itself to a tendency to equate the functions of various classes of signs and to reduce or transform raw iconic information into quasi-conventional symbols, such as schematic drawings, which become more or less interchangeable with their verbal equivalents. This may be most desirable in some circumstances, but exact specification of the proper (and improper) circumstances may be impeded by a model of communication and/or perception that has very little to say about classes of signs, or iconic signs in particular. Another theory, to be considered next, centers its attention upon the nature of the iconic sign as the central problem of pictorial communication.

A Theory of Pictorial Communication

James Q. Knowlton has developed a theory of pictorial communication focused upon social and psycholinguistic factors (8). Starting with the assumption that further theoretical and experimental development of this area requires a unit of analysis, he describes his monograph as an effort to develop a "metalanguage for talking about pictures" (8, p. ii). The dominant linguistic orientation of Knowlton's study is indicated in the following quotation: "Whether or not a pictorial symbol signifies depends upon whether or not the intended concept has already been attained by the interpreter of the symbol; and this last is preeminently a linguistic accomplishment" (8, p. 1.1-1.2). To a large extent, the function of pictures is to aid in the development of the linguistic conceptual structure within which they have meaning. But pictures also have certain unique functions which mark the limitations of language as a tool of thought. (Some of these will be mentioned presently.)

As a preface to his study, Knowlton undertakes a critical analysis of audiovisual research. He argues that the main trouble with this field of inquiry stems from its preoccupation with media and its lack of a suitable, carefully defined unit of analysis: specifically, the pictorial sign. Media presentations, such as sound motion pictures and television programs, typically offer a mixture of pictorial signs and verbal symbols. Thus, when an audiovisual medium is compared, as an experimental variable, with some "conventional" (say, exclusively or dominantly verbal) mode of presentation, the results must be inconclusive because there is no way to satisfactorily describe the unspecified "mix" of pictorial and verbal elements that constitute the audiovisual presentation. We don't know what behavioral results may be due to pictures, what to words, much less to unique combinations of these two classes of signs. Audiovisual research ought to be focused upon the distinctive component in audiovisual messages, which is the picture. To develop a science of audiovisual communication, we must first describe the unit for analysis--the pictorial or iconic sign. Knowlton was not the first to note this need, but he was certainly one of the first to engage in a major effort to do something about it.

In the compass of this article, it is impossible to present anything approaching a summary of Knowlton's monograph on pictorial signs, and to do justice to it. In this context, it will suffice to emphasize the fact that he would advise investigators of communication and teaching to pay attention to the qualitative differences among classes of signs. In this respect, he is in the philosophic tradition of Charles Sanders Peirce (13), who was the first modern philosopher to discuss iconic signs (which he called "icons"), and Charles Morris (10), who introduced the more recent term, "iconic sign," meaning a sign that looks like the thing it represents.

Despite their dependence upon the linguistic context of the culture, pictorial signs have important differences, limitations, and powers, as compared with speech. Knowlton underlines the fact that linguistic science has already provided important observations regarding some of these differences. For instance, speech requires little energy, a minimum displacement of other activities, depends upon the vocal-auditory channel, is independent of light, is nondirection, and rapid-fading. A person who can interpret a language can also produce it.[2] All of these factors are different in the case of pictorial signs, some of them drastically so. Another significant difference is that pictorial signs are continuous (capable of gradual and continuous modifications of form), whereas lingual signs are discrete.

Knowlton emphasizes the fact that it will not suffice to talk about the value of pictures or iconic signs <u>in general</u>, or as an entire class. The communicative value of a given picture depends, in some important measure, upon what we wish to signify. An "identity category" (specific referent) calls for a highly iconic sign; an "equivalence category" (concept) may be signified by using a schematic drawing with little or no realistic detail. But realistic iconic signs often "say too much" and schematic symbols may become too barren. In all cases, we must remember that language is the prime technology of the human mind, the master learning set, and we should use pictures to further the learner's command of verbal processes. Pictures used improperly or in the wrong context may even interfere with the operation of logical processes inherent in language. Our initial perceptions of the world do not provide an immediate grasp of reality. What is needed is a means of operating upon perception when it is false, or going beyond it to deal with concepts. The logical system inherent in language is an indispensable tool for this task (8, p. 5.55-5.56).

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[2]This statement and the preceding list of characteristics are based upon Charles Hockett's analysis of "design features" of speech.

On the other hand, language has its distinct limitations. There are certain kinds of special tasks for which pictures are uniquely suited or even indispensable. Pictures may lend strong dramatic impact to certain kinds of messages and thus facilitate acceptance. Pictures may be used to deal with aspects of the world that have not been encoded in language. Even more interesting is the suggestion that iconic imagery may play a critical role in the behavior of invention "where language may be of little use in first coping with fundamentally and distinctively new problems" (8, p. 6.17). Knowlton's analysis of iconic signs includes not only realistic pictures but also "logical pictures" and "pictorial analogies." In a summary statement dealing with the latter types of iconic signs, he observes: "Iconic representation would seem to have a widely ignored potential for 'portraying' nonphenomenal matters, especially theories; or, more generally, for making the unfamiliar familiar through pictorial analogy or through pictorial analogy by extrapolation . . ." (8, p. 6.35).

From the standpoint of perception theory and its implications with regard to instructional media, what can be said of the recent developments represented by the work of Travers and Knowlton? Do they merely approach a large and complex problem from different angles, or have they actually started from radically different sets of assumptions? In honesty, I am not prepared to attempt a complete answer to this difficult and admittedly philosophic question, but I think the question is a pertinent one. Within the limits of this paper, I can only suggest that the answer must start with the observation that one theory seems to be relatively unconcerned with the qualitative differences between classes of signs, whereas the other considers this problem to be central. Of course, information theory has a way of dealing with iconic signs in mathematical terms as constituted of "bits" of information, which is a unit of analysis also applied to verbal symbols. One could argue that the neutrality of the "bit"--its lack of categorical, qualitative characteristics--is merely a methodological phenomenon and has nothing to do with the macroscopic aspects of signs regarded as meaningful objects of ordinary experience; but this observation settles nothing. It merely transposes the problem from terms of content to terms of method. One must still consider why one approach is satisfied with a method that ignores or swallows up qualitative differences between categories of signs, while the other begins by making such qualitative distinctions a matter of primary concern. One clue to the answer may be found in the distinction between "linear" and "nonlinear" signs proposed some time ago by Susanne Langer (9) and others.

Perception and Nonlinear Signs

While Langer used the terms "linear" and "nonlinear" to distinguish between verbal and iconic signs, it has already been noted that some theorists tend to ignore or discount this distinction, with the net result that the total communication process seems to fall into the pattern of a simple linear progression of signs (whether verbal or nonverbal, or both), each sign depositing its particular load of meaning as it arrives at the terminus of the transmission system. The point is not that pictorial or other iconic signs cannot be used in a linear fashion; within limits, they can be used this way with some help from verbal signs, but when this occurs they become quasi-verbal symbols, conventional signs that have surrendered some part of their distinctive power as iconic signs.

Nonlinear (iconic) signs have a unique function in human communication and learning. Langer's discussion of linear and nonlinear signs stresses the sequential ordering, the strung-out arrangement of linear signs in time, as opposed to the all-at-once character of the nonlinear sign or presentation. But the distinction deserves further analysis. Single pictures or more complex iconic displays may be said to be nonlinear not merely because one beholds an entire visual array, all at one time, but because what is perceived has a degree of independent meaning, or openness of meaning, by virtue of the fact that it is not constrained by its place in some grammatical structure of which it is a term or part. The beholder who encounters an iconic sign or display is, of course, not cut off from prior experience. He always relies upon a deposit of past experience--what Kenneth Boulding has described as the "image" (3)--to cope with the present. But this sort of linearity, this cumulative building of meaning which enters into all perceptions, is something quite different from the formal linearity of signs which are bound together in the grammatical structure of a lingual statement. The nonlinear sign or presentation is free of the latter control, but not of the former. However, its freedom from grammatical constraint may be an important factor in the generation of meanings which require modification of given categories or the development of new ones.

This is not to imply that iconic signs or nonlinear presentations have some exclusive magical power of their own (which is wholly independent of lingual communication) to generate new meanings. New insights cannot be instituted as meanings in the human community without lingual formulation, whether accompanied by the invention of new terms or reinterpretation of terms already in use. And once a new idea has been formulated, the development of its widely ramifying elaborations and implications may magnify and spread the impact of new meaning through lingual means. There is no need to acknowledge the importance of the linear or lingual sign as representing the dominant mode of human communication. Language is the dominant mode of communication because the need to disseminate knowledge already gained, <u>and</u> to formulate and develop the implications of fresh experience, overshadows the little understood function of raw nonlinear elements in the communicative process. Perhaps it is because of the dominant role of language that there is a tendency in some strains of perception theory and related communication theory to ignore the distinctive nonlinear character of iconic signs and then to discount their importance because they don't serve the function of linear signs as well as lingual signs do. Of course, they don't do that and shouldn't be so employed because a picture ordinarily has no business merely "standing in" for a word, just as a word can't and shouldn't be expected merely to "stand in" for a picture or, for that matter, for a concrete object.

It has already been suggested that a model of communication which tends to describe this process primarily or exclusively in terms of "transmission" of information will also be inclined to ignore or discount the differences between iconic and verbal signs and to treat all alike as though they were merely "linear." There is much to be said for the simplicity of such a model, as well as its applicability to much of what occurs in human communication. Such an approach to communication appears to have a good deal in common with the psychophysical and other "extroverted" (2) theories of perception in that the emphasis in both instances is upon the dominant effect and uniform results of the "external" factors or "given" information that impinges upon the receiver or perceiver. Arnheim has described the "extroverted" psychologists (and philosophers) as those who believe that ". . . man functions under the impact of the outer world and that his ways of thinking about it and his image of it are dictated by the nature of that outer reality," whereas the "introverted" psychologists are those who ". . . consider the outer world amorphous" and believe that ". . . order, character, and lawfulness are imposed upon it by a mind stocked with ideas which are inborn, inbuilt, or adopted from other minds" (2, p. 11). This terminological distinction is provocative and provides a way to think about theories of perception. But there is a kind of futility in arguing the relative merits of the "external" stimulus as opposed to "internal" structuring of perceptual behavior; almost everyone seems to agree that both loci of control must be taken into account. After this argument has occurred, the choice of emphasis or relative weighting of external and internal factors may provide a convenient way of classifying perceptual theories, but something more is needed, it seems, to explain why some theorists lean in one direction, some in the other.

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A great deal of human experience and communication is constituted of information which is merely passed on, or transmitted, in the sense that the receiver/perceiver has a prearranged and highly predictable response as to the sense of the item of information or the message. The predictability of response to a sign stimulus is increased when the sign occurs as a "linear" item in the grammatical context of a verbal statement. An "extroverted" theory of perception is appropriate when dealing with such experience or such aspects of communication. When dealing with iconic signs, the "extroverted" theorist is concerned with factors that make responses to such signs reliable or highly predictable. Thus, predictability of response in the case of "realistic" iconic signs is sought by contriving a "surrogate" stimulus that will reflect a sheaf of light rays to a given point which is closely similar or identical to that reflected by the original object, for which the iconic or pictorial stimulus is a surrogate. However, "realistic" signs may give rise to divergent responses. So, if we want a "univocal" or highly predictable response, it is best to strip the iconic sign of some of its realistic details and schematize it, in which case it is modified into a quasi-conventional symbol (6).

An "introverted" theory of perception is needed to deal with another large segment of human experience and communication which is constituted of meanings that are not merely given, passed on, or transmitted, but are taken, seized upon, in some part generated by the receiver/perceiver himself. In this arena of perception and communication, the theorist is concerned with responses which are not highly reliable and not necessarily for the sake of increasing reliability of response. He may even wish to encourage divergent responses to the same information and thus to demonstrate that communication is not merely transmission, that perception is not just the apprehension of some meaning which is antecedently and completely "there" prior to the act of perception itself.

It would be impossible to live at the human level unless a great deal, perhaps the great preponderance, of what is perceived and/or communicated were taken for granted, as given by the source, as categorized and imbedded in the common lingual structure of the culture. It would also be impossible for man to adjust to change, to cope with the new, to expand human knowledge, to grow in understanding unless perceptual and communicative responses were in some degree spontaneous, self-oriented, and thus capable of dealing with the sporadic, the indeterminate, the ambiguous. Perception operates not only in situations that require an answer, but also in those that require the discovery of the question to be answered. The perplexing problem of perception theory is that it must account not only for that which is ordered, settled, determinate, but also that which is indeterminate and contingent.

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LEARNING AND THE TECHNOLOGY OF INSTRUCTION

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There has been a significant lack of fruitful interaction between education and the developing science of learning. Experimental psychologists concerned with learning theory and educational psychologists concerned with instructional techniques and devices have been trained in different academic worlds and in different universes of discourse. One result is the uneasy feeling that educational psychology and the instructional methodologies it generates have not been closely nurtured by a basic mother science. Indeed, it has been a rarity to find a single individual actively concerned both with the development of the basic science of learning and with its technological applications to educational practice. Increasingly, however, current activities indicate that more experimental psychologists who are learning-theory oriented are working on education and training problems.

The general question posed by this movement concerns the nature of an applied psychology of learning and the development of a technology of instruction. Applied research can be defined as research that is oriented toward the development and application of a practical technology. It is a meeting ground where applied and basic endeavors mingle, and where solutions to both theoretical and practical issues are attempted, often in the same experimental program. It appears, however, that these two endeavors, the science of learning and the development of an instructional technology, have different goals. No one, of course, will disagree with the proposition that the psychology of learning is fundamental to educational technology. The work of basic science is the search for new knowledge and the understanding of it by theoretical organization. Basic science espouses a recognition of ignorance, emphasizing how little we really know and the necessity for discovery. In contrast, applied science and technology concentrate on how much we do know and how this knowledge can ~~be~~ incorporated in practical procedures. The ways in which basic science proceeds do not assure systematic and fruitful interplay between basic knowledge, applied research, and subsequent technology--somebody must work at it. Only by this effort will laboratory findings and theoretical formulations be applied to training and educational practices. The analogy

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Reprinted from "Learning and the Technology of Instruction," AV Communication Review, IX (September-October 1961), 42-55.

used by Estes (4) is useful here; that is, the relationship between the science of learning and education is more like that os physiology to medicine than like the relationship of medicine to the patient. Expectations of a more direct relationship have been and will be a source of disappointment.

With the above in mind, this paper is essentially atheoretical. The basic notion is that application of current theories of learning is less fruitful at present than the application of current findings. To illustrate, all psychologists of learning, regardless of their stand on some form of reinforcement theory, agree that reinforcement has a role in acquisition of learning. Vigorous disagreement, however, shows up in theoretical interpretations of the consistent empirical findings. Most of the recent work on teaching machines and programed learning seeks to apply our findings about the effects of reinforcement. The empirical facts have been known for some time, but only recently quite seriously applied in the development of instructional devices. More important, however, than the specifics of current teaching machines is the readiness their development implies to utilize and try out experimental leads. Since the writer has devoted much attention recently to programed instruction, many of the notions involved in this kind of teaching aid influence the subsequent remarks.

Response--What Should Students Learn?

Response is the primary object of manipulation in instructional technology. Because the operations of instruction should result in definable changes in student response, they are designed to bring the responses under the control of the desired subject matter stimuli. In this respect, the lesson to be learned from the experimental psychologist is a methodological one. To be appropriately developed, the learner's responses should be operationally (behaviorally) specified in so far as possible, just as the task to be learned in the laboratory is carefully specified by the experimental psychologists. One indication of the lack of interaction between the experimental psychologist and instructional practice is the fact that educational literature stresses such terms as "readiness," "understanding," and the "whole child." These matters are amenable to experimental attack and manipulation only when they are behaviorally specified in stimulus-response terms; that is, in actual subject matter situations and observable student performance. This specification is a necessity for experimental psychologists in developing laws of learning. Increasingly, larger and larger units of behavior such as concept formation and problem solving are being studied and analyzed in such terms. And it appears that even these molar units of behavior are influenced by variables similar to those which influence simpler "laboratory" tasks such as trial and error learning and simple conditioning. It is the writer's impression, however, that there has been a general reluctance among educators to submit student responses to analysis in stimulus-response terms.

It is interesting to note that the experimental psychologists who have turned their attention to training research in the military have been confronted with the lack of explicit specification of the behavior under consideration. They have attempted to develop techniques of "task analysis" for behaviorally specifying performance objectives. In this endeavor, the psychologist had to face up to the fact that a definitive terminology for behavioral description was neither available nor forseeably forthcoming from the science of psychology. Much concern has been expressed over this basic lack, and at present--as Melton points out--the development of a taxonomical scheme for specifying the properties of the task to be learned and the objectives of instruction is urgent (15).

In work on programed learning, it has been found convenient to make distinctions between initial responses, auxiliary responses, and terminal responses. Initial responses or initial repertoire comprises the behaviors with which the student comes to the instructional situation. Terminal responses or terminal repertoire comprises the specified final set of behaviors with which he is to leave the situation. Since the behavior brought to the instructional situation is the raw material out of which the end-product behavior will be shaped, that initial repertoire needs to be laid out. The stimuli to which the student responds at this time should be used in guiding his responses to the subject-matter stimuli to which he should respond at the end of learning. In the course of instructional manipulation between these two points, the student emits responses to reach the terminal behavior. Responses the teacher elicits for this purpose can be called auxiliary behavior. The instructional process seeks to utilize auxiliary behavior to reach the desired educational objectives. This process is facilitated by determining, for each of the stages, the subject matter stimuli--words, symbols, and formulas are examples--to which the learner must respond, and the kind of response each of these requires--solving problems, writing, or building something are examples. These activities must be specified in terms of overt behavior so that appropriate feedback can be obtained by the teacher or teaching devices for use in instruction. Though precise specification of behavior is hampered by inadequate terminology and by a lack of psychological knowledge in analyzing complex behaviors, it is possible to specify to some extent such functions as transfer, understanding, and reasoning in terms which permit instructional control. These matters will be discussed in a later section.

Also involved in instruction are the behaviors imposed on subject matter learning--behaviors described as paying attention, learning to learn, readiness, and so on. These extra-subject matter behaviors also require explicit definition before they can be subjected to manipulation by specified instructional procedures. An illustration of this point is the contrast between the concepts of "readiness" employed in education and "learning to learn" as studied by Harlow (10). Readiness is generally considered to be some function of maturation and previous learning, but has been rather ill defined as a form of response that can be brought under the control of instructional procedures. Learning to learn, on the other hand, is concerned with inter-trial improvement in the course of learning, and has been brought more fully under experimental control than readiness. As a result, "learning to learn" defines a learning principle which is more ready for inclusion in an educational technology than "readiness." This distinction is discussed by Estes (4).

Also to be considered under the topic of response and aside from its explicit behavioral definition, is the way in which student responses are employed in the course of auxiliary behavior leading to terminal objectives. Consider here several of the notions currently employed in the construction of programed learning sequences for use in teaching machines. First, the transfer of stimulus control over a response: At the beginning of such a learning sequence, instructional stimuli are used to evoke responses that are already in the learner's repertoire. As the learner proceeds to perform stimulus-response combinations that are different from these, instruction takes place. What happens in the course of the auxiliary behavior is the gradual transfer of responses to new stimuli, and the bringing of new or extended responses under new stimulus control. The gradual transfer of behavior to new stimuli is what happens, for example, in one method of teaching spelling. The entire word is first shown, then it is shown with missing letters which the learner supplies until he can write the whole word in the absence of contextual stimuli and in the presence of spoken or pictorial stimuli. The essential notion behind this response transfer has general application to educational technology; some of its specific uses have been investigated by Taber and Glaser (19).

A second relevant notion is response prompting. When the initial repertoire is specified, the instructional procedure can utilize only these available responses. The instructional task is to get the learner to emit small increments in response moving toward the terminal behavior. It is sometimes thought that the successive approximation procedure employed in a Skinner box is a useful paradigm here. The analogy is useful up to a point. With a Skinner box one often waits for certain responses which are in the direction of the terminal behavior, and then reinforces these responses. In the classroom, it is more efficient to supply a variety of stimulus materials which prompt appropriate behavior which can then be appropriately reinforced. The use of prompting to enable learners to emit new or low strength responses with a minimum of errors is an important consideration in the development of programed instructional procedures. The occurrence of a response is made probable when the presentation of instructional stimuli is designed so that each learning step makes the correct response in the next step more likely. The probability of such success is increased by the use of prompting stimuli based upon what is known about the learner's initial response repertoire at a specific point in learning. Interesting examples of the kinds of prompts in use in program construction are contained in a recent collection of articles on programed learning edited by Lumsdaine and Glaser (15). The characteristics and uses of prompts and cues are provocative for further research and analysis.

Related to response prompting is the withdrawal of cues in the course of auxiliary behavior so that the student eventually responds to the stimuli desired in the performance of the terminal repertoire. As instruction proceeds, response prompts are gradually withdrawn so that the student learns to perform with minimal or covert cues and without apparent external prodding. Teaching machine programs refer to this withdrawal process as stimulus fading or vanishing. Again, the general notion seems applicable for technological implementation in instructional devices, but further research on specifics of this process, such as the rate, repetitiveness, and sequencing, is required.

Another parameter of response in instructional procedures is the form of the response. On this aspect there has been much pseudo-controversy. In his early work on self-instructional scoring devices, Pressey employed multiple-choice responses. Skinner, in his recent work, has emphasized the role of constructed responses. Psychological experimentors, alert for a controversial variable, rushed to test the effectiveness of these two "points of view." In reality, the basic assumptions of both Pressey and Skinner do not make one kind of responding more correct than the other. It is again a function of where the student is to go, the desired terminal behavior. In the development of instructional devices, however, the form and encoding of the responses can be an important matter. For device construction, multiple-choice responding is much easier to evaluate without the intervention of a human. Write-in responses cannot be so automatically evaluated, and covert responses leave little data for analysis. Some thought has been given to the coding of responses through a number or letter coding system which is more efficient for the transmission of information than the English language, and more susceptible to automatic evaluation.

However, the mode of response needs to be considered in relation to the task to be learned, as has been studied by Evans (6), Coulson and Silberman (3), and Holland (11). Future research must investigate the relationship between particular forms of response and stated educational goals, including the development of understanding and transfer of training. To be considered in this research is the effectiveness of response modes at various educational levels and with various aptitude patterns.

Reinforcement

There seems little doubt at present that a significant aspect of educational technology will be the management of reinforcing operations. This should continue to be so--despite the continuing development of theories to explain the learning process--since the central role of reinforcement in the acquisition of behavior is a long-standing empirical fact. Notwithstanding the various interpretations of acquisition in terms of "law of effect" and "contiguity," the operations employed to manipulate responses in the course of acquisition are similar for the study of both types of explanatory theories. The concept of reinforcement states that behavior is acquired as a result of a contingent relationship between the response of an organism and a consequent event. Or, as Estes puts it (5), reinforcing operations are those which lead to acquisition when appropriately correlated with response occurrences. Both the basic and applied research in learning are concerned not so much with what reinforcement is, but with how it operates. What both endeavors can supply is specification of the variables which determine the effectiveness of certain reinforcing operations for achieving desired terminal responses.

Work in the science of learning has pointed up certain characteristics of reinforcement which seem firmly enough established for use in the applied investigations which lead to the development of educational technology. One established fact about reinforcing operations is that the correlated or contingent event occurs subsequent to the occurrence of a response. It seems obvious, then, that one principle in the design of instructional devices should be the establishment of such a reinforcing contingency. This contingency is influenced by several factors in the learning situation. For example, a sufficient number of reinforcing response evocations must occur to strengthen the response; that is, to assure high probability of its occurrence in appropriate situations. A further well-established finding concerning response acquisition is that the contingency between a response and a reinforcing event be immediate. Delay of reinforcement may result in little or no learning. In instructional devices, this known fact about the delay of reinforcement has been taken most seriously in the development of teaching machines. In school learning, a major reinforcing event for the student is "knowledge of results," that is, whether or not the response he performs is considered correct. In programed learning techniques such confirmation is immediately forthcoming upon the completion of the student's response. The utilization of this fact of learning in educational technology is very dramatic in light of the frequent delay of reinforcement that occurs in many classroom procedures.

Another established finding in the study of reinforcement is the effect of the intermittency or scheduling of reinforcement contingencies. Essentially this finding takes into account the fact that reinforcing events occur with different frequencies and in different patterns in the course of learning sequences. While a great deal of activity has concentrated on this aspect of reinforcement, it has had little applied development in educational procedures. It has been indicated [see Ferster and Skinner (7), and Keller and Schoenfeld (12)], that with an optimum schedule of intermittent reinforcement, higher and more stable rates of responding can be attained than with continuous reinforcement. Estes and his students have shown that the response of individuals seems to be highly correlated with the overall proportion of reinforcement to non-reinforcement in a learning task. As Estes states this finding, " . . . the probability of the response will approach the probability of reinforcement. Thus, . . . if . . . 90 percent of English nouns encountered by a student formed their plurals with 's' and 10 percent with 'n,' we could expect that the student would form the plural of a newly encountered noun with 's' about 90 percent of the time" (4). The effects of intermittent reinforcement probably vary with the kind of task being learned. The implication, however, for instructional procedures is that this factor is influential, and requires applied research for appropriate practical implementation.

Interference and Transfer

As a general premise, it can be stated that interference in learning which results in forgetting and a decreased rate of acquisition is a function of competition between the response under consideration and other responses learned prior to, or subsequent to, it. The results of pertinent experimental study indicate a number of variables to be considered. Transfer comes about as a result of similar stimulus components in different learning situations so that the response is generalized. The education of a student involves, to a great extent, two aspects: (a) learning to respond to similar elements in stimulus situations--for example, to so generalize as to recognize all words of a certain class as nouns; and (b) learning to make differential responses to different stimulus situations--that is, to form such discriminations as are required to differentiate between nouns and verbs. Much instructional procedure aims at teaching students to generalize within stimulus classes and to discriminate between class instances. Interference in instruction often comes about in the course of this generalization-discrimination process, but it can be overcome by practice sequences presenting many response instances which progressively narrow the discriminations to be made. In teaching machine programs, "discrimination sequences" are often used to teach the student different responses to two stimulus situations which in the course of instruction might be confused. The series is set up so that the learner responds correctly to the appropriate stimulus, and also identifies situations in which a particular response is inappropriate. In so far as possible, he is not permitted at any point to perform an inappropriate response. Such a discrimination series should minimize interference resulting from the similarity of stimulus elements.

Interference often results from unintentionally evoking emotional responses which may be incompatible with the responses to be learned. The results of learning experiments point up situations in which such behavior is produced. In the process called "extinction," a response is permitted to occur in a situation where there are no contingent reinforcing events. As a result, the response attains a low strength and can be replaced by a response more frequently reinforced. In the course of extinction, it is noted that emotional or frustration behavior occurs. It is also true that after a history of continuous reinforcement, the omission of a reinforcement is frustrating and similarly results in certain behaviors which may be incompatible with learning the appropriate response. In the development of instructional methodology it seems desirable to minimize the possibility of the occurrence of such behaviors. One way of doing so might be to provide a history of intermittent reinforcement; thus, subsequent omission of a reinforcing event would be much less frustrating.

In education there has been much concern about transfer of training. The focus here is the student's ability to utilize his learning in stimulus situations which differ to some extent from those in which that learning occurred. Interference in the application of learning to these new situations often arises. The existence of positive or negative transfer can be presumed to be a function of the generalization-discrimination series that occur in learning. The notions of generalization and discrimination indicate that the search for transferable elements is less useful for the development of an educational technology than is the study of transfer produced through practice with graded sets of experiences containing a variety of instances with varying stimulus characteristics. This matter will be further elaborated in the section on reasoning and understanding.

An extensive body of research in the psychology of learning is the work on interference in verbal learning that is characterized by the investigations of Underwood (21) and others. They have studied the effect of a host of factors on the learning of a restricted class of verbal behavior. The factors include such variables as meaningfulness, task similarity, active recitation versus passive study, affective characteristics of the material, whole versus part learning, and such dependent variables as spread of effect and incidental learning. The direct relationship of these factors to classroom learning is difficult to see but, as Underwood has pointed out, it may be possible to determine their relevance to educational technology through classroom experimentation (20).

Practice

It is established that review and repetition are necessary for acquisition, and also for maintenance of previous learning. Of major interest are the conditions of practice over the course of learning trials. Such conditions are indicated by many of the aspects of learning discussed above. The general implication for instructional devices is that they must incorporate the appropriate amount of review and repetition necessary to maintain previous learning, including those concepts which need to be strengthened and used in further learning. Sufficient practice is necessary so that early material is mastered before or while new material is introduced. Practice should incorporate the conditions which facilitate learning. However, for many subject matters the effects of particular characteristics of practice and review upon response strength and retention are not known and must be determined by empirical classroom investigation.

The distribution of practice has been a very frequent variable in experimental study, and at present many experimental psychologists would agree that learning often appears to be most effective--that is, acquisition is faster and performance levels are higher--when practice is divided into a number of daily trials (4). This conclusion suggests that instructional devices should include directions for spacing learning sessions so that practice is interspersed with other instructional procedures, including discussion and laboratory practice.

Reasoning and Understanding

Reasoning and understanding as behavior developed by instructional procedures have been brought into focus by the present work on programed instruction. When teaching machine programs are discussed, teachers frequently say something like this: "Yes, the student seems to be learning, but does he really understand?" The best reply to this question prods the teacher to define the observable terminal behavior he desires. That reply goes something like this: "Tell me what kind of behaviors (perhaps test performance) you would like the student to display so that you know he is understanding and reasoning." With such terminal responses specified, it is then the task of educational technology to determine what combination of educational experiences including teachers, devices, and self-study, result in this behavior.

Concerning the role of such instructional aids as programed learning devices, it must be pointed out that terminal behaviors defined as understanding, concept formation and utilization, and reasoning seem to be brought about by continuous variations of the stimulus context in which the student responds. These variations are set up so that the student gradually receives new information, learns to make progressively finer discriminations and appropriate generalizations, and also learns to apply his responses to a wide variety of situations. This process helps to enrich the stude 's breadth of learning, and is an operational way of defining the development of understanding. Programed instructional sequences can provide a series of well-organized examples leading the student to develop abstractions and rather complicated concepts. As pointed out by Skinner, "An important goal is to 'enrich' the student's understanding by inducing him to permute and recombine the elements of his repertoire" (16). At the extreme of these stimulus and response variations, the goal of instruction is really not concerned with the learner's response to any one situation. This is only an example of an abstraction. The objective is that the student acquire not a uniform and explicit set of responses about a particular concept, but rather a repertoire which is applicable in a variety of situations so that he can use the concept to solve problems, describe it to others, modify it for certain purposes, build a model of it, and so forth. This terminal behavior can be defined as reasoning with, or understanding, a concept. Appropriately programed sequences which can be put into instructional devices and employed with other kinds of learning experiences can provide the stimulus and response variation which contributes to the growth of understanding.

Motivation

When one measures the usefulness of a learning concept in terms of the extent to which it generates applied research and applications for educational practice, the concept of motivation does not fare well. Neither the theoretical nor experimental concern with this concept presents readily translatable findings. In fact, many learning theorists have avoided the word in attempting to account for learning phenomena in more operational terms. In general, one is tempted to say that motivation includes those events and operations that make a particular response-event contingency reinforcing. Such a statement, however, indicates current ignorance of a variety of factors in the learning process which need to be identified.

Motivation as studied has been related to the drives produced by certain experiences in an organism's history. In the laboratory, the operation of deprivation--withdrawal, for example, of food and water--has been employed to make certain events reinforcing. It taxes one's ingenuity, however, to see how deprivation can be employed in the use of instructional devices. Furthermore, much research is required to investigate the nature and use of secondary reinforcers, such as school grades, the learner's desire to be correct, or for approval and status.

Sometimes the word motivation is used to imply certain behaviors that are the outcomes of instruction. For example, when a student continues to study after the usual classroom hours, or when he works independently on special projects, or when he uses the library to look up topics related to his school subjects, we often say he is "well motivated." To use "motivation" in this way, it is best for the teacher first to state such terminal objectives in behavioral terms, and then to introduce instructional practices that produce these behaviors. The judicious use of reinforcement is motivating in this sense. When a student receives frequent reinforcement in the course of learning, he often appears to become quite interested in the subject matter, and his constant success in handling it makes him act in a way we can properly call motivated.

It is, of course, presumptuous to attempt to talk in any definitive way about the problem of student motivation. Much research needs to be considered, such as the effects of anxiety as studied by Spence (18); the effects of "social conditions," including cooperation and competition; the generalization of motivating effects from one motivating condition to another, as studied by Kendler (13) and by Braun and others (1); and Glanzer's discussion of experimental work on curiosity and exploratory drive (8). For technological purposes it seems practical at present to define the terminal behaviors which fall into a class called "showing motivation." The task then is to manipulate the instructional situation in a way so as to produce these behaviors with some degree of consistency.

If any theoretical position has been taken in this paper, it is a behavioristic one. The underlying concept is that the process of instruction can be made an explicit subject matter for scientific study from which a technology of instruction can be developed. Instructional devices developed on this basis require us to become behaviorally explicit both about instructional objectives and about the procedures employed to attain them.

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HYPOTHESES OF FILM LEARNING

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* * *

SIGN SIMILARITY HYPOTHESIS: That films whose signals, signs, and symbols have high degrees of similarity ("iconicity") to the objects and situations which they represent will be more effective for most instructional purposes than films whose signals, signs, and symbols have low degrees of "iconicity."

Morris defines "iconicity" as the quality of "signs" to simulate the objects and situations represented in the communication. Signs (or symbols) vary in "iconicity" to the degree to which they are similar to the things or situations signified. Thus, for example, sound motion pictures have potential capacities for high degrees of "iconicity" in representing objects in motion as well as reproducing authentic sound.

It will be recognized that this is a restatement of the problem of "realism" in films. However, this problem has three phases: (a) The problem of representing objects, situations and processes as they actually are, (b) the problem of representing objects, situations and processes in such a way as to facilitate a particular perception and understanding of them, and (c) the problem of representing abstract ideas and the force of ideas.

It is possible with the sound film medium to introduce correctives in the stimuli of the visual and auditory stream of events, taking into account limitations, distortions, and selective processes of normal human perception in order to insure the intended accuracy of perceptions, dependent cognition, and understanding. Thus, action may be slowed down or speeded up, small objects may be magnified, inaccessible parts of machines or organisms may be shown in animation. Likewise, sounds may be amplified or otherwise modified in order to convey the desired or intended impressions. In other words, film instruction should take into account and correct for the known characteristics, "filters," and limitations of selective sensory-perceptual processes, and introduce adjustments in such ways as to correct and supplement

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Excerpted from "A Theoretical Orientation for Instructional Film Research," AV Communication Review, I (Winter, 1953), 38-52.

these processes in the interest of evoking the desired significances, understandings, impressions, meanings, and responses in the film viewers.

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RELEASOR-ORGANIZER HYPOTHESIS: That the signals, signs, and symbols of sound motion pictures function principally as releasors and organizers of meanings and responses in hu n subjects.

Given constant filmic stimulation of different individuals, reactions and interpretations vary greatly. Those reaction variations are dependent upon "individual differences." It is a stubborn, indubitable fact that the kinds of stimuli which are presented to subjects through the sound motion picture are perceived differently and interpreted with wide variations even though these stimuli be held constant. This is found to be true with subjects living in a relatively homogeneous culture; variations may be expected to become much greater when the viewers are from very different cultures.

These variations of responses and interpretations lead to the useful concept that the significance of the film mediated stimulation is both dependent (or inter-dependent) on the stimulation and on the activated brain processes ("engrams") of the experiencing subjects. Thus, it may be reasoned that the functions of signals, signs, and symbols are to release responses in subjects. The stimulus values of communication signs in sound films are not inherent in the signs themselves. Signs and symbols do not transmit meanings; they release meaning when and only when the subjects respond. The characteristics of these responses relate closely to personal life history differences.

Communication stimuli may be said to be multivalent for different individuals. Therefore, to insure desired degrees of commonality of understanding and uniformity of responses it is required that the ranges of individual differences of audiences be taken into account in planning films for defined training or instructional objectives.

In this conceptual framework the problems of ambiguity (variations of meaning) of film communication must be solved, and can only be solved, by dealing with the complex problems of human variability.

The releasor concept of signs and symbols must be supplemented by the related organizer concept. Previously learned "engrams" may be modified by new stimulation, and even new related elements may be "imprinted." New relationships may be shown, and old responses modified by film mediated stimulation. The results are conceived to consist principally of the reorganization of previously learned neural-organic patterns which intervene between film stimulation and the subsequent actions or reactions of the individual.

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CHANNEL CAPACITANCE HYPOTHESIS: That there are definable limits to the amount of content which can be channelled through a sound motion picture, i.e., through the visual and auditory modalities of perception; and there are limits to the capacities of individuals for reacting to, imprinting, and retaining the information or content.

Relative to this hypothesis there are two postulates: (a) That there are optimal amounts and rates of presentation and levels (of difficulty) of significance and meaning for different kinds of films. (b) That there are wide individual differences for reacting to and assimilating information presented in sound motion pictures.

We have defined in many ways problems for research which are partial approaches to this channel capacitance hypothesis: Rate of film development, idea or concept burden, or simply, the amount of information presented during a given period of time.

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We have assumed that the amount of materials in an instructional film which can be responded to and retained by subjects is importantly dependent on the factors of the organization of the materials. A project is now in progress on the problem of determining the contributions of the prominence of the organizational outline of a film and the effects on the acquisition of factual information. Much of the thinking of "gestalt" psychology can be mustered to support this assumption. Theoretically, improved syntactical organization with good continuity would be expected to facilitate both comprehension and retention. Thus, we may argue for the selection of subject matter and the production of films whose meanings have high degrees of contiguity and cohesiveness. Likewise, strong themes and good stories may provide necessary meaningful contiguity, and hence contribute to the instructional effectiveness of sound films.

PERCEPTUAL REINFORCEMENT HYPOTHESIS: That multisensory modalities of communication may be, under certain conditions, more effective for instructional purposes than single sensory modality communication.

The stimulus qualities of sound motion pictures are especially appropriate to (and limited to) the sensory modalities of vision and hearing. These two major sensory channels make available to those who would instruct through sound films or television a great range of channel capacitance. To use this potential capacitance effectively and fully is a challenging practical and theoretical problem.

Established psychological facts provide orientation toward a tentative solution: Stimulus processes even within the limits of a single sensory modality, e.g., vision, may interact to facilitate or to inhibit appropriate responses. When two sensory modalities are activated, e.g., vision and hearing, then possibilities are increased for both facilitation and inhibition (or interference).

It is easy to theorize that sound motion pictures should: (a) Employ the full potential capacities of both vision and hearing. (b) Arrange the streams, sequences, and patterns of stimuli, i.e., pictures and sound track, so that all of the elements are integrated and mutually reinforcing for the intended reactions or instructional objectives. (c) Insure that interferences, inhibitions, and distractions do not occur.

This line of thought raises interesting theoretical questions: What are the distinctive communicative functions of pictorial and sound signals, signs, and symbols? What kinds of instructional and communicative functions can best be served by each? How should the vision-hearing channels be integrated to achieve maximum impact or effectiveness of the streams of communicative processes?

There are two stubborn facts which we must consider and perhaps use: (a) Language and speech are much more highly developed for abstract communicative functions than pictorial representations. Speech is especially appropriate for representing and instigating abstract thinking and abstract concepts. (b) There appears to be greater dependence on visual impressions than on auditory impressions for checking on the validity, authenticity, or dependability of sensory experiences.

These considerations lead us to the core of the problem of choosing the sound motion picture for specific kinds of instruction for which its characteristics are most appropriate and feasible. The possibilities for "iconicity," specificity, dependability, and validity of pictorial language, complemented by the possibilities for flexibility, abstractness, and generalization of verbal language should make the sound film and television appropriate for maximum possible use of multichannel perceptual potentialities.

* * *

INFORMATION-DEPENDABILITY HYPOTHESIS: That information contained in sound motion pictures and perceived and learned by viewers varies widely in functional dependability, and that films with high degrees of informational dependability are most effective for instructional purposes.

This hypothesis implies that the information in instructional films should measure up to the strict criteria of pragmatic and validity tests. If, for example, a film purports to describe and explain what "warm fronts" and "cold fronts" are as weather phenomena and how pilots should fly their planes relative to these weather fronts, then the actual experiences of pilots flying in these weather fronts should confirm the validity of the information learned from the instructional film about these weather phenomena. To accomplish this, the information must be accurate in details, adequate in thoroughness and scope of presentation, and appropriate to the situation of application. Conversely, the information cannot be inaccurate, sketchy and incomplete, nor inappropriate or ill-fitted to the full and real situation of application.

This hypothesis relates to a basic and necessary attitude of viewers toward learning from films, an attitude which, it is believed, strongly influences film learning, namely, the confidence of viewers in the information presented by the film and in the "authority" of the film.

Furthermore, the possibilities of having the information of the film reinforced and confirmed are increased if the validity of the information is fully supported by the experiences of viewers in real life situations of application.

Let us illustrate this hypothesis by another hypothetical example: Suppose that a film is to be produced to instruct Americans about the life of a French farmer. Then, if the film, when produced, has accuracy, adequacy, and appropriateness, Americans who learn from it will have this information confirmed and reinforced when the Americans have direct experience on French farms of the kind represented by the film. Furthermore, if another film is used with the same Americans to instruct them about the life in French villages, it is to be expected that they would be more receptive and learn more effectively from the film representation, because of their confidence in the dependability and integrity of the first film.

Analyses of existing informational and instructional films reveal how inadequate they usually are when judged by the criterion of informational dependability. It is also observed that many of the imaginative, fanciful, and distortive characteristics produced and employed with artistic license are both inappropriate to and disadvantageous for informational films.

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PERSONAL NEED HYPOTHESIS: That the effectiveness of the film will be importantly determined by the degree to which it activates personal needs in viewers for the information represented in the film.

We subscribe to the dictum that learning depends on motivation, and furthermore that an important element of motivation is activated and realized personal needs for learning given content. Another way of expressing the central idea of this hypothesis is that when adjustment demands made on and recognized by individuals are related, through films, to information pertinent to these demands, individuals will learn rapidly and effectively; i.e., the films will be effective. From this viewpoint it may be argued that instructional objectives (goals) and the relevant information in films should be aligned with the learning objectives (goals) of the viewers, if the film is to be an effective means of instruction. In cases where this alignment of instruction and learning goals does not exist, then it will be necessary through the film, or by other means, to produce this relationship or substitutes for it, i.e., to motivate the subjects to learn. This is partially what we mean when we state that films must have interest for or develop interest in the viewers or learners.

It is postulated that externally imposed learning requirements, i.e., demands for effortful learning which is unrelated or poorly related to the accepted needs of the viewers, can only result in ineffectual learning of the film's content. The converse of this postulate is also held to be true.

A supplementary concept is that learning from films, like learning in real life situations, should have appropriate satisfactions and tension reducing rewards. Also, penalties, dissatisfactions, and increased tensions (anxieties) should be the consequences of failure to learn. Developing methods for making and using instructional films which adequately motivate viewers is a challenging and largely unsolved problem.

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PERSONAL INVOLVEMENT HYPOTHESIS: That, other things being equal, the instructional film which provides for the greatest degree of personal involvement in the filmically presented situations will be most effective.

The concept of involvement is complex and, among other things, encompasses three kinds of processes: (a) The projective responses of subjects, whereby they submerge themselves in the content of the film, i.e., the scenes, sequences, story, characters, problems, and issues. (b) The introjective responses of subjects, i.e., the processes of abstracting out of the film elements which are personally assimilated. (c) The retention and use of assimilated processes as determinants of succeeding responses and actions.

Many personal and situational factors operate either positively or negatively to affect the degrees of the subject's involvement in film situations. To define and control these factors is a principal line of research which should be vigorously exploited. The processes of projection, introjection, and reactions of subjects relative to the situations represented through films are so complex that the development of appropriate experimental designs and their execution is extremely difficult.

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LEARNING PRINCIPLES HYPOTHESIS: That the established principles of learning which have been developed by psychological and educational research have varying degrees of applicability in film mediated instruction, and that the application of the best of these principles will improve the effectiveness of film instruction.

A corollary of this very general proposition is that experimental films may be used in research to develop new principles and to correct, modify, and extend principles which have already been formulated. It is reasonable to argue that principles which have been formulated on the basis of data collected by "molecular" types of experiments like the salivary reflexes of the dog, eye-lid reflex of humans, or even behavior of rats in a maze almost surely will require modifications when applied in the "molar," more dynamic and complex experiments with sound motion pictures. There seem to be possibilities for film research to modify old and develop new learning principles which will be appropriately applicable to real life situations. Confidence in these possibilities is based on the close potential resemblance or similarity between film presented stimulation and real life situations.

It is an encouraging fact that instructional film research can draw on the theoretical resources of related fields; a vast experimental literature and body of facts and principles on learning processes exists which can be used both for forming research hypotheses and for testing in practical film production and use. Smith and van Ormer have brought together some of the learning principles which have relevance to film research, production, and use. Hoban and van Ormer have reviewed the experimental literature on films for the period 1918-1950.

We can only direct attention to this body of information which has great importance for those interested in sound motion pictures as a means of instruction. Also, attention should be called to the neglect on the part of students of the film and producers to consider the use of literature on the psychology of learning.

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ASPECTS OF VISUAL COMMUNICATION

by Sol Worth[1]

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The term "visual communication" most often refers to a broad range of phenomena called pictures or images. Some people prefer to use the term "pictograph" employed by Margaret Mead (18) to distinguish between a commonly observable external image and the so-called mental, or internal, image. Others prefer "visual perception" and refer more to the psychological and discriminatory powers of the eye and brain (10).

In larger and more commonly held usage, "visual communication" refers to almost any communication (or human activity) whose primary effect is first observed through the eye by seeing. Such diverse activities as reading, watching facial expressions of people as they talk (or don't talk), the "kinesics" of Birdwhistell, the "nonverbal communication" of Ruesch, painting, architecture, graphic design, television, and movies have all at one time or another been treated as aspects of visual communication.

Visual communication as it is being used here employs some of the terms formulated by Krippendorff (15). It is defined as the transmission of a <u>signal</u>, perceived primarily through visual receptors, treated as a <u>message</u>, from which <u>content or meaning is inferred</u>. This range of signals (partially listed above) sometimes called visual communication is too broad to permit precise definition or study under all of the variations described.

Any attempt, therefore, to study the cognitive aspects of visual communication must of necessity first limit the kind of visual signal under consideration, and concern itself with images of a specified

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Reprinted from "Cognitive Aspects of Sequence in Visual Communication," <u>AV Communication Review</u>, XVI (Summer, 1968), 121-145. This paper is an elaboration of an address prepared for presentation at a conference, "Prospects and Problems in the Psychology of Knowledge: On Cognitive Interaction, 1965," held at The Annenberg School of Communications, University of Pennsylvania, April 18-22, 1965.

[1]The author acknowledges the contributions made to this paper by colleagues at The Annenberg School and, in particular, the untold hours of discussion and argument with Shel Feldman, which helped in the formulation of many sections of this paper.

nature. It may be postulated that each mode of communication, through the range of materials it offers or does not offer, and through the elements and combinations of elements it allows and does not allow, imposes its own restraints upon signals we choose to treat as messages.

Previous study and experience with a specific form of visual signal called movies has led me to believe that this particular mode of communication offers fruitful possibilities for the development of an approach to the study of visual communication. These filmic materials, elements, and restraints, and their relationship to the meaning we draw from a visual communication, are the subject of this paper.

The Motion Picture

The motion picture and psychoanalysis are historical twins. In 1893 Edison presented his first motion picture and Freud published his Studies in Hysteria. While Freud was developing a method that portrayed inner "reality," Edison announced that "finally we have a method of showing the world as it really is." It is not accidental, I believe, that these opposite solutions to man's search for a picture of reality developed simultaneously.

In trying to understand the communication process that occurs through the mediation of film, one is struck by the historical juxtaposition of the film image and the dream image. It is clear that both modes employ image signals; that these images are organized in some fashion; and that they are reacted to with some affect and effect.

Unlike psychoanalysis--which started with a loosely formulated, partially systematized theory--film, like Topsy, "just growed." For the most part, it developed without conscious theory or formal plan, in much the same way that a language might be thought of as developing--by use. The implicit model underlying much early thinking about film communication was a simple one. There was a film and an audience. The audience looked at the film and had a film viewing experience. Reference was made to some properties of this film-going experience, and early researchers noted attitude changes occurring in audiences because of film experiences. Little or no reference, however, was made in this early body of work to the filmmaker--the initiator of the process culminating in the film experience of the audience.

On the contrary, however, attempts to describe the process of dreams, and the process by which we infer meaning from dreams, have started with the assumption that whatever the exact nature of that process--be it intra- or interpersonal--it could be understood only in terms of a model of the process of communication which involved both sender and receiver, dreamer and analyst. Whether these be the same or different people, the model describing the process includes the separate functions of maker and viewer, dreamer and analyst.

By analogy we would expect that a model of film communication would have to include both the filmmaker, the film viewer, and the film itself. Lack of such a model has retarded the understanding of film as a mode of visual communication.

To sum up then: It seems to me that the dream itself is most often an intrapersonal mode of communication through image events in sequence. The film is a similar mode of communication but most often extended to the interpersonal domain. Since film images can be recorded objectively, and the operations on film can possibly be objectified, film is more amenable to study and to definition than are dreams. Many of the actions of the filmmaker are observable, and many of the effects of a film on the viewer are measurable. The process of film communication might, therefore, be clarified by the use of an intuitive experiential model which regards (but is not systematic enough to define) film as a process and a mode somewhat similar to dreams.

Film Communication

Film communication begins with what I have elsewhere called a Feeling Concern (FC).[2] A person has a feeling, the recognition of which, under certain circumstances, arouses "concern that motivates him to communicate it to others. This feeling concern is most often imprecise, amorphous, and internalized. It cannot be sent or received as a film in this internalized, "feeling" state. Obviously, inferences can be made about internal feeling states by observing a subject's gestures, body movements, and so forth. My point is rather that there is an important distinction which must be made between the inferences we make from a person's own behavior, which can have a great variety of reasons explaining and motivating them, and the inferences we make from a coded expression in linguistic or paralinguistic form whose purpose is primarily communicative.

With the decision to communicate in the film "language," the sender must develop a Story Organism (SO)--an organic unit whose basic function is to provide an organism that will carry or embody the feeling concern.

The concept of story organism can be clarified by analogy. In teaching science, Bruner (4) has found it difficult to communicate such basic scientific concepts as "function" without embodying that concept in some organic unit. "Function" is therefore taught through biology. Biology becomes the story organism through which the concept of "function" is expressed. In a similar way, the story organism in film is the organism through which and within which the feeling concern is communicated.

It is only at this point, after recognizing the feeling concern and finding the story organism, that the communicator can begin to collect the external specific Image Events (IE) which, when sequenced, will be-

[2] For a fuller explanation of the following, see Worth (23).

come the visible film communication. This sending process can be diagrammed as follows:

FC ⟶ SO ⟶ IE

Let me try to clarify this by an example taken from a film made in one of my classes. One young filmmaker identified his feeling concern as "getting beat up." This was too amorphous to communicate more fully although the filmmaker stated that he knew the feelings and tone he wanted to convey. The next step in the process--the development of a story organism--occurred as he found the functional unit of "a prize fighter" who "trains" all week long while working at his job by day and fighting at night. He added to this story organism the units "his mother died" (which came from Camus' The Stranger), "for centuries man has been fighting against himself and his fellows," and the notion that what he wanted to show us was that it was "a tough gig."

With a list of story organism units such as these, it became possible for the filmmaker to get his specific image events, which he could then put together to make his film. He showed, for example, the prize fighter lying in bed staring at a poster announcing his fight. The camera sees the fighter through the bars of his bed, while the voice on the track recites the lines from Camus describing the feelings of the man whose mother had died. The audience slowly realizes (while looking at the bars) that the speaker is describing his feelings about jail and that the fighter sees himself as jailed within himself.

The receiving process occurs in reverse order, as a mirror image of the sending process. The viewer first sees the sequence of image events. Should he choose to treat these sequenced image events as a message, he infers a story organism which, in turn, "allows"[3] him to infer the original feeling concern which is the meaning or content of the message. The complete process can be diagrammed in the following way:

FC ⟶ SO ⟶ IE ⟶ SO ⟶ FC

As you can see from this suggested model of the total process, the message is contained in the total image event composed of the many individual image events that go to make up a movie. In order to understand this visual communication process, what we must understand is how the IE developed by the filmmaker is inferred by the viewer. Before going on to the formulation of a set of elements for this possible code or "language," I would like first to explain briefly some of the actual

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[3] Note that in using the word "allows," I am avoiding the question of what in the film and in the viewer interacts in such a way as to allow, compel, inhibit, or in any way control the viewer's inference. For a fuller development of this theme, see Worth (23).

film communication that has led to the present study, then to take a brief look at the history of interest in "meaning" in visual communication. This will be followed by a short summary of some theories concerning meaning inference from dream images leading to a brief analysis of some of the theories of film which have been used in the past. These theories will serve as the background for a presentation of a hypothesized theory of film "language" elements, operations, and cognitive processes as they provide a tool in the analysis of this problem. The approach is not to define these elements in terms of how the viewer breaks them up but rather in terms of how the maker puts them together and how these operations serve as cognitive signals to the viewer. In concluding, we will report preliminary findings that seem to verify this connection between operations performed by the maker and meaning inferred by the viewer.

The Bio-Documentary Film

In 1959 a program of study was started at The Annenberg School of Communications which attempted to combine the study of concepts and theories of film with the actual practice of filmmaking. Out of this program was developed what I subsequently began to call the bio-documentary film.

This form of filmmaking is intended to reveal subjective "reality" rather than to record the objective world. Its concern is with how a person sees himself and his world and how he translates that "vision" into film language.

In practice this has meant teaching people to make films which are about "concerns" rather than about subjects, and in which little attempt is made to teach the established conventions of film "communication," i.e., the proper way to make a cut, the "meaning" of a dissolve, how and when to pan, and so on.

Screenings of early bio-documentary films produced many puzzling reactions which have been reported in detail in an earlier paper (22). Although these initial screenings were not planned for systematic observation of audience responses, in reviewing the responses of about 1,000 viewers after some 25 screenings, I found some interesting trends and formulated several hypotheses.

First, young people using film communicated more clearly to people their own age, and this communication seemed to be along dimensions of feeling concerns not readily understood by certain groups of adults. Some adults, particularly those professionally concerned with film, and most particularly those concerned with "factual" films, were greatly puzzled and not infrequently hostile in their reactions to these films made by students and young people.

Second, and perhaps a correlary of the above, is that the bio-documentary films were different in structure from other films. Not only were bio-documentary films consistent among themselves as to theme and formal code of "linguistic" properties, but they differed across thematic and linguistic dimensions from those films made by "professional," adult, "experienced" filmmakers.

It was apparent that the interesting questions were not those of audience response but rather those of film difference. Although it is axiomatic that films communicate, the questions of what films communicate--substantively rather than in terms of specific subject matter--and how this communication takes place have been almost completely unexplored.

The problem under consideration thus becomes one of determining the properties of a signal transmission called a film; and of determining from which of these properties, and how, a person choosing to treat a film as a message infers content or meaning.

Approaches to an Understanding of Visual Communication

Let us turn then to previous approaches to the understanding of visual communications.

Although the early Egyptians developed pictures and sculpture as a method of communication with their dead kings, these pictures were not meant to be looked at by living persons. Most subsequent pictures and images were, however, conceived for the living as a communication about relevant religious, philosophical, economic, social, and aesthetic dimensions.

In the recent past, the most common approach to the understanding of pictures and of films (since films were assumed to be communications in a similar mode) has been through conceptions arising from what can be termed aesthetics.

Although this approach has wandered freely over the map of human interests and understandings, and has emphasized at various times the religious, expressive, perceptive, cognitive, illusionistic, symbolic, mythic, nonverbal, and semiotic approaches toward the understanding of pictures, it has for most of its history maintained one basic implicit assumption: that all events that undergo aesthetic scrutiny can be adjudged (by the relevant critical criteria of the period) either as "art" or "nonart," or as "beautiful" or "ugly." Aesthetic criteria of the past imply a value system which either forces one to make polar choices between art and nonart or includes both extremes on some scale, but rejects the middle. This analytic system is polar, exclusive, and noncontinuous and fails to provide criteria for the analysis of messages falling between the extremes of art-nonart, beautiful-ugly, useful-useless.

The question of whether a particular communication is beautiful or not is quite different from the question of how we know its meaning, although both questions are of interest. The aesthetic approach seems somewhat irrelevant in a study of films when the interest is not so much in judgment or analysis of the beauty of conception and execution as it is in the analysis of the processes of communication and cognition by which meaning is inferred.

As suggested earlier, some thinkers have seen connections between movies and dreams. In an appendix to Feeling and Form (16), Susanne Langer discusses the film as an art form and makes the following comparison between movies and dreams:

> Film is essentially the dream mode. . . . The percipient of a moving picture sees with the camera. He takes the place of the dreamer, but in a perfectly objectified dream. (Her italics)

She continues with a quotation from R. E. Jones in The Dramatic Imagination: "Motion pictures are our thoughts made visible . . . they flow . . . precisely as our thoughts do . . . they project pure thought, pure dream, pure inner life."

Perhaps so, but how? A consideration of the problem consistent with my earlier definition of visual communication leads one not to the question of how films or dreams project meaning but rather to the question of how we infer it. It seems reasonable to assume that neither a dream nor a movie has an intrinsic meaning apart from the meaning we infer from it. Whether the inference we thus make is either a valid or a correct one is another matter. If we can determine whether the rules of film communication are logical, we can make assessments of validity. If we develop criteria of correctness for this "linguistic" mode (the movie), we can make judgments about the nature of the truth we infer from a film statement. It is these questions, and questions deriving from them, that have led me to the point where it has become necessary to develop new approaches for the study of film communication. While aesthetic models offer insights into some aspects of the film-viewing experience, they seem unfit for use as conceptual aids to solve the above and similar questions.

Erik Erikson (8) tackles the problem of meaning in dreams by suggesting that there is no single determinable meaning; that the analyst is required to "abandon the classic scientific urge to look for the most plausible (and parsimonious) explanation." The analyst must rather try to determine the many probable meanings of the particular images he is attempting to analyze.

The concept of "many probable meanings" which Erikson discusses as the content or meaning of a dream is a recurrent theme in psychological and philosophical literature. Fingarette (9) discusses "frameworks of meaning"; Heinrich Kluever (13) wrote about "patterns of equivalence";

and John Kafka (12) commented that such "concepts thus allow a rational approach to paradoxical thought and contradictory perception." Osgood's (19) conception of semantic space and dimensions of meaning would seem to grow out of the same framework as did these earlier speculations about the determination of meaning from the dream image.

If one were to accept this multidimensional view of meaning and hypothesize that film can be studied through the paradigm of language--a "language" in many ways similar to that of dreams--it would become necessary to determine the dimensions along which meaning in film "language" is inferred.

Work is proceeding by the author and others in an attempt to develop these dimensions and some method for their measurement. The results will be reported at a later time.

In order, however, to work with film as if it were a language, a set of elements first would have to be postulated to describe the visual units involved; the operations that could be performed on these units; and the cognitive processes involved in drawing meaning from them. Let us now turn to a consideration of previous elemental theories of film.

Film Theory

In the early days of movies, the basic film unit was thought of as the dramatic scene. This was essentially a theatrical concept; the first filmmakers pointed the camera at some unit of action and recorded it in its entirety. The limitations of the scenic unit were technological and dramatic; how much film could the camera hold, how much time would the dramatic scene take to unfold.

The earliest films were thus single scenes of what seemed to be a single unit of behavior. At that time no one wondered about units of perception in moving images. It soon became apparent that these single behavior units could be glued together end to end to form a many-scened dramatic photoplay in the manner of live theater.

In 1902 Porter stumbled onto the fact that the scene was not the smallest natural unit of film. The scene itself was divisible. He found that isolated "bits" of behavior could be photographed and glued together to make a scene. Most people making films at that time insisted that viewers could not "know" what was on the screen unless they saw the entire scene in an unbroken flow of event. It soon became apparent, however, that the film unit could be broken down from complete views of the actors and actions to "bits" of views of actors and their actions without any loss of comprehension. This meant a "breakdown" not only of the perceptual field of, let us say, a "man" by showing us a sequence of a head or an eye or hands, but also a breakdown of the cognitive field by forcing us to put together separate ideas, or bits of ideas, across time. Just as we put together separate image events in film in the way we do tachistoscope images, so also are we able to put together idea bits such as an image of a man followed by an image of a snake, which might under some conditions compel us to infer, "That man is a snake."

In 1923 Sergei Eisenstein (6, 7) isolated a "basic" unit of film language and called it "the shot." He made no attempt to define it systematically, but described it merely as the smallest unit of film that a filmmaker uses. In constructing his story of film, he formulated a concept, "the collision of ideas," which he called central to film, and set down for the first time what one can see now to be a special theory of cognitive interaction. Using an essentially Hegelian framework of thesis, antithesis, and synthesis, he proposed that a shot equals an "idea," and that from one idea colliding with another there emerges a third idea. It might be interesting to note that the Russian word used by Eisenstein and translated into English as "collision" is the same word that Pavlov used and which was translated into English by psychologists as "conflict." If one reads the early literature on film and translates "collision" to "conflict," some interesting developments in the psychological literature become relevant and quite useful in understanding film communication processes (3).

Many writers on film reworded and amplified Eisenstein's basic concept until 1933. At that time Rudolf Arnheim (1), a psychologist working with Wertheimer and Kohler in Germany, attempted a further clarification and the formulation of an explicit theory of film which, while attempting to be more scientific, leaned heavily on Gestalt principles in psychology and seemed to lead theorists away from Eisenstein's "collision" approach.

Arnheim, working with these early Gestalt psychologists, added some insights about perception and persistence of vision to the general body of film knowledge, but his major effort was devoted to proving that film is art rather than a mere recording of the world as it is. His basic argument was that film is art so long as it is "imperfect." Color and sound decrease its artistic properties because they are devices to make film "more perfect."

Like Pudovkin (20), who in 1927 suggested such undefined elements as "contrast," "similarity," "synchronism," "recurrence of theme" and "parallel structure," Arnheim attempted to formulate operational units which were elements. He tried to define such laws or rules as "constancy of viewpoint," "perspective," "apparent size," "arrangement of light and shade," "absence of color," "acceleration," "interpolation of still photographs," and "manipulation of focus." In all, he formed twenty such units and was forced to conclude that there could be hundreds more.

In 1960 Kracauer (14) attempted also to formulate some structural and rule-governed units, and although his units differed from Arnheim's, they took a similar shape. He listed numerous subunits merging into four distinctive units: "the unstaged," "endlessness," "the indeterminate," and "flow of life." Slavko Vorkopitch, in a series of unpublished lectures on film held at the Museum of Modern Art in 1965, defined the film elements (although he didn't call them elements) by saying that "film can be understood to be an art composed of kinesthetic, ineffable, and transcendental" units. He meant (I think) an art composed of moving, transcending, and verbally inexpressible entities.

The previous theoretical formulations about film contain several major flaws. The early writers were intent upon proving that film was "art" or could be "art." Although they helped us to recognize some of the parameters of film, their thought was concerned with descriptions of effects such as Pudovkin's "contrast," "similarity," and "parallelism," and Kracauer's "The Unstaged," "The Fortuitous," etc., and was limited to discussion rather than scientific analysis.

Although some of the writers on film such as Spottiswoode (21), Lawson (17), Hodgkinson (11), and Bazin (2) mentioned the terms "film language," "grammar of film," or "film grammar," none of these authors developed a theory of grammar embodying "linguistic" elements or rule-like organization capable of syntactic structure. Although the term "grammar" has been used in connection with film, it has been used metaphorically, and no cohesive body of elements and operations has been formulated from which rules of syntax or use can be developed or studied.

In the attempt to test assumptions about the process of film communication in terms of film as linguistic, or coded, rule-obeying behavior, it became clear that the previous work in this area was unsuitable as a basis for research because these previously described elements lack economy of description, structure, and clarity and cannot be dealt with either systematically or empirically. It is therefore necessary to formulate a theoretical approach which makes it possible to analyze the films themselves and the "language" employed in making and inferring meaning from them.

The Elements

The hypothesis is therefore advanced that film can be studied as if it was the "language" of visual communication and that it is possible to determine its elements and understand the logic of its structure. In taking this approach, it is not necessary to take a position as to whether or not film is a language in the verbally linguistic sense. Obviously, such definitions of language as proposed by Chomsky (5), for example, would tend to exclude film. Study of film along such linguistic generational lines, however, would make it possible to determine if analytic procedures developed by linguistics are applicable to other modes of communication and in precisely what way. Accepting some precise definition of language enables us to consider film communication in a more systematic fashion and enables us to formulate theories and experiments about film communication in a manner logically consistent with work in other scientific fields. A set of parameters has been developed and will be discussed below, which can serve as a starting point leading to the development of a method for describing actual elements of film.

I call the study of visual communication vidistics. Vidists is concerned, first, with the determination and codification of visual "language" elements as used in sequence by the filmmaker. Second, it is concerned with the determination of these laws of "language" by which a viewer infers meaning from cognitive representations and interactions of the elements and their sequence.

Film "language" in this sense is thus thought of as a set of rules describing the interaction of specified elements, the operations on these elements, and the cognitive representations of them, in sequence.

Not only does a film as a material object combine and order these elements, operations, and cognitions, but this "language" also is designed to impel the viewer to relate them in specific ways if he chooses to infer meaning from the film.[4]

There are five parameters which, when defined, can become a starting point describing the structural elements of a film language. These parameters are an image in motion over time in space with sequence--including as an overlay a matrix of sound, color, smell, taste, and other as yet unknown technological or sensory stimuli.

The image, or in Eisenstein's term, "the shot," is the basic unit or videme[5] of the language. A videme, as I shall use the term, is a photographic image event that can be seen and that is accepted by viewers as something that represents the world. The videme is the generic name for the unit of film communication. There will be no attempt at a formal definition (for example, of the kind linguists have proposed) for the "word" or the "phoneme." I will, however, assume that certain relationships between the videme and derived units will maintain their relationships no matter how the basic definition of unit changes.

The concept of the photographic image event as I am using it is consistent with Kracauer's definition of film "as being uniquely equipped to record and reveal physical reality." He uses the phrase "camera reality," which comes closest to describing the limitations of what I have

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[4] Of course, the social, personal, and cultural context in which the film is made and viewed must be taken into account. My point is that the specific elements in a film communication must be determined before they can be related to the context. A code always exists within a context, and both must be known before their interaction can be known.

[5] For a fuller treatment of the concepts of "language" involved in the following discussion, see Worth (23).

called the photographic image event. Drawings, cartoon films, and scratches on film are thus excluded and are not considered as films. Though they are exciting and stimulating, they are considered more properly a form of painting than films. This is a matter of definition which, while arbitrary, is, I believe, a needed definitional point.

The cademe, or camera shot, is a continuous strip of film ranging in length from one frame to any number of frames, depending on the technological limits of film and camera size. The cademe depicts one continuous photographic image event. It can be defined operationally as the unit resulting from the moment of pushing the start button of a motion picture camera until the moment of pushing the stop button.

The edeme, or editing shot, however, is formed from the cademe by actually cutting the cademe apart and removing those segments one does not wish to use. The filmstrip that is left becomes the edeme, which can be joined with other videmes at will. It is possible to use an entire cademe or as much of a cademe as is needed or desired. It is then possible to sequence these resultant edemes in ways that are determined by the individual filmmaker, his communication needs, his particular culture, and his knowledge of the "language."

The edeme thus becomes the hypothesized basic element and building block of the language upon which all language operations are performed, and a basic image event from which all meaning is inferred. It is entirely possible--and I have not worked in this area as yet--that perceptual units are smaller and perhaps more instrumental in impelling viewers to perceive certain signals as messages from which they will infer meaning. I have chosen the edeme because organizing it seems intuitively to be the place from which coding and decoding starts. It is, however, entirely possible that further research will allow us to postulate finer units based on studies of perceptual and biological behavior.

The single cademe can also be thought of (in an analogy to speech) as the storehouse of usable sounds available to any one speaker for any one image event. The edeme then becomes those specific sounds a speaker finally isolates to form words and combines to form sentences, paragraphs, and larger units.

Motion and space are parameters along which this basic element--the videme--may vary. We describe the videme along dimensions and by variations of motion and space. The changes in motion and space occurring in the element become part of the coding structure of cognitive "bits" that allow us to infer meaning from film.

Motion is a parameter that can be measured both internally, within the element, and externally, imposed upon the element. Internal motion refers to the movement of any object within the videme, that is, motion that is fast or slow, rhythmic or random, left to right, up or down. External motion, on the other hand, refers to movement imposed upon the videme by the movement of the camera itself. Pans, tilts, dollys, zooms, and so on, are examples of external motion.

Every videme is also always seen in a specific space. The motion picture itself is always seen within some spatial boundary: a screen, a set of screens, or some as yet not considered space.

Space is a parameter referring to the size and position of objects in relation to the spatial bounds of the screen. It permits us to answer such questions as: Is the person or object big in a space, little in a big space? Are they off in a corner, or in the middle of a space, and are objects and persons seen to be close to the viewer or far away? The terms "close-up," "long shot," etc., are terms referring to the spatial arrangement of the object and the screen and are usually manipulated by the communicator through the use of lenses of varying focal length and the spatial relationship of camera to object.

Time, on the other hand, is a parameter related to the videme in motion and space and to the sequence of edemes. That is, it is a function of the videme and a major operation performed upon the edeme and can be thought of as internal and real when it is a function of the videme, and external and apparent when it is a function of the sequence.

Let us first consider internal, real time as a function of the videme. Time in this case refers to the real or actually measurable time that it takes a man to walk up a flight of stairs or cross the street. It is the time of motion shown in one cademe, and we could if we so desired measure this time with a stop watch. Manipulations such as slow motion, where we see a diver gracefully moving through the air, or fast motion, where people move at ridiculous rates of speed, are considered to be internal and real since we still can measure the time it takes for the movement in the videme to occur, and we are not fooled about the temporal quality of the behavior. We know how long the dive or the movement really takes.

Such seemingly similar manipulations as stop motion photography, however, in which we see a flower unfold in 30 seconds but know that it could actually have unfolded over an unknown time period of days or weeks, are not considered as examples of internal real time. A videme has previously been defined as one continuous image event. An operation which is then performed on it and destroys its continuity becomes, therefore, a parameter of sequence, which will be discussed later, and of external time rather than a parameter of the videme itself and of internal time.

External time, which is a function of sequence, is apparent. It is a parameter of temporal manipulation related to the sequencing of edemes, in which the sense of time we infer from the sequence of edemes has little relation to the time of the motion of objects that we actually see on the screen. Apparent time is not measurable with a stop watch.

It is a kind of time sensation from which we infer complete actions without seeing them completely and can therefore never know or infer precise duration. A simple illustration of an actual film communication can illustrate this. In constructing a film that shows an artist making a drawing, it is possible, in one cademe or camera shot, to photograph the entire unit of action which, let us say, takes twenty minutes to complete. By separating this cademe into edemes and adding other edemes, it is possible to construct a sequence that will look something like the following: Start with an edeme consisting of twenty seconds of the artist drawing, followed by a five-second edeme (taken perhaps at another time and another place) of a close-up of the artist's face. We can then discard five minutes of the original cademe of the man drawing and continue the sequence with a twenty-second edeme of the artist at work--again insert another edeme, a close-up of his hand and pencil if we wish, discard ten more minutes of the original cademe, and continue with a fifteen-second edeme of the artist drawing. We can continue this process of discarding large segments of cademe and inserting other edemes in sequence for as long or as short a time as we wish or as we have pieces of film. We can construct sequences in this way which will allow the viewer to infer the complete action which actually took twenty minutes from perhaps one minute of film sequence.

The viewer "knows" that time has elapsed for the subject in the film but has no way of measuring the exact amount. The viewer can measure the time of the actual sequence of image event stimuli, but cannot measure the time he "knows" to have passed in the film.

Sequence

These four parameters--image, space, motion, and time--that I have discussed above seem to belong to the same class of descriptive devices. That is, they seem to derive their importance as descriptors from their relationship--their ability to describe the videme itself--rather than from the ability to describe the relationship between videmes. It also seems to be the case that there exists a descending hierarchical order of attachment between the descriptive parameters and the videme. The image, for example, is wholly tied to the videme, as is the concept of the spacial arrangement of objects within the videme. Motion, however, measures phenomena that are within the videme and also take place across videmes. The parameter of time, which we will consider last, refers equally to objective events within the videme and subjective events across videmes.

A discussion of these parameters, or descriptors, can be thought of as part of the study of the semantics of the language, since what we have been concerned with up to now refers to single edemes with a semantic content of their own. The following section on sequence can be thought of as the beginning of a discussion of the syntactic content of the language.

This area of inquiry assumes as part of its interest the determination of answers to the following kinds of questions.

If I perceive "thing" A, and then also perceive "thing" B, what happens to make me know "thing" A and B or even "thing" X. (I will refer to A and B in connection as AB but do not mean to imply multiplication thereby.) In looking at a sequence of different image events, is there anything in the sequence and in the operations performed on the elements that allows or helps a viewer to infer meaning from them, regardless of the semantic content attached to each of the elements by itself? Sequencing edemes can be thought of as applying syntactic operations to edemes. This does not in itself imply a code, a set of rules, or a grammar--but it does make it possible to test visual communication phenomena along these lines.

This question of the perception of the sequence of image events through which we become aware of meaning forces us to examine other areas of communication in which sequence has been studied.

Sequence is a strategy employed by man to give meaning to the relationship of sets of information, and is different from series and pattern. As I will use the word here, sequence is a deliberately employed series used for the purpose of giving meaning rather than order to more than one image event and having the property of conveying meaning through the sequence itself as well as through the elements in the sequence.

A sequence of image events is a deliberate ordering of edemes used to communicate the feeling concern embodied in the story organism. This concept of sequence as a deliberately arranged temporal continuity of image events giving meaning rather than order is not meant to distinguish between dream and film, between conscious or unconscious motivation, but rather to exclude the kind of order that is merely piecing edemes together randomly such as the order that would result if a blind man put a set of edemes together or a seeing person put some edemes together without looking.

Man imposes a sequence upon a set of image events to imply meaning.

The major interest at this point is not so much and not only to understand a film, as it is to understand the processes by which meaning is transferred from a set of single edemes to a sequence of edemes; from which we can infer meaning not contained in the single edeme, but inferred as a result of the sequential structure itself.

Cognitive Aspects of Sequence

Some hypothesized laws of cognitive sequence in film language can be explored by examining other modes of communication that refer to sequence.

For example, we might find some interesting analogies by exploring some of the ways that sequence is dealt with in mathematics. Let us first consider the commutative law which contains the statement that AB = BA. If we think of A and B as representing edemes and do not at this point consider signs such as "times" or "plus," we can ask whether the meaning that a viewer will infer from AB is commutative. That is, will a viewer infer the same meaning from the sequence AB that he would from the sequence BA.

If we also examine the associative law which contains the statement that A + (B + C) = (A + B) + C, we are again able to find many parallel structures in film "language." Thinking of the letters A, B, C as representing edemes and disregarding the plus, we can ask what properties of film language would apply to make a viewer infer connections such as A + (B + C) or (A + B) + C.

If the commutative law applies to film language, it cannot then be true that if two edemes in a sequence are reversed, the meaning of the sequence will change. Or we can ask another kind of question: Is there a way that we can construct a sequence of three edemes, A, B, C, so that a viewer will put cognitive parentheses around two of them?

Are there cognitive signs in visual language that correspond to something like a parenthesis in written language? It is interesting to speculate as to the possibilities of there being signs in this language that make us infer connections such as plus, against, with, separated, and so on.

Such obvious manipulations as fades and dissolves suggest themselves immediately, and we plan to report at a later date on further studies attempting to describe such cognitive signs, signals, or rules, and to measure their dimensions of meaning in semantic and perhaps syntactic space.

To illustrate these questions in image terms, let us first think of a sequence composed of three edemes--a baby and a mother and a father. Can these three edemes be sequenced in such a way that the viewer will infer cognitive parentheses around two of the edemes? Is there anything in film "language" that would make us think of (a baby and a mother)--(and a father)? Or (a baby)--(and mother and father)?

It is suggested as one of the vidistic hypotheses that certain operations of motion, space, and time in sequence provide us with just such cognitive signs which help us to make these inferences from a sequence.

Some Current Research

The major argument at this point, then, is that elements, differing along the parameters discussed--image, space, motion, and time--are put into sequence by the filmmaker and that from both these elements and their sequence, the viewer infers meaning. One method for validating these assertions would be to demonstrate that elements differing along these parameters do, in fact, differ in the meaning inferred from them, and to demonstrate that different sequences of the same elements do, in fact, lead to different meaning inferences, in contrast to the null hypothesis of strict commutativity of film elements.

Two additional hypotheses may be advanced before proceeding to a brief account of some investigations undertaken by this writer and Shel Feldman in an attempt to test some hypotheses of the effect of sequence on meaning inference. First, with regard to the previous discussion of the operations involved in sequence, it would be reasonable to suppose that different inferences would arise from such different operations as a cut and a dissolve (a cut is the sudden shift from one edeme to the next, without any fading or overlapping; a dissolve involves the overlapping of two edemes, with the first gradually fading out and the second gradually fading in).

Second, it may be predicted that sequence may be more effective with certain pairs of elements than with others because of various learned expectancies. For example, consider two edemes that differ only in the image represented: pair X, made up of edemes A and B; and pair Y, made up of edemes C and D, where C and D differ not only in image, but also in space. Because pair X contains elements more similar to one another than does pair Y, it may be predicted that the viewer will strive harder to integrate A and B than to integrate C and D. In other words, the more the dissimilarities between the elements, the greater the likelihood of the viewer taking the view that the elements are not to be interpreted simultaneously. It is more likely when the pair is dissimilar that the viewer will suspend judgment or be attracted more by the importance of one element than the other or simply average the elements, with the order of the elements consequently immaterial. It is more likely that order will be interpreted as part of the signal itself with A and B, which are highly similar. Why, the viewer may ask, is he shown A <u>and</u> B unless he is to integrate them, and in the particular order in which they appear.

As an illustration, it would seem to follow from this discussion that a long shot of a woman and a close-up of a baby would be interpreted, in <u>either</u> order, as a mother and a baby (suspension of judgment) or as a mother's concern for the baby (the more "important" element defining the situation to the subject, regardless of order). In contrast, a long shot of a woman and a long shot of a baby might be interpreted <u>in one order</u> as the baby growing up, while <u>in the other order</u> it could be interpreted as the woman thinking back to her childhood--different integrations would occur, depending upon the order or presentation of the elements since the very similarity of the edemes in most respects arouses the viewer to attempt to infer why both are being shown. To repeat the hypothesis arrived at by applying some notions about need for closure to a consideration of elements in sequence, <u>the</u>

sequence will be more critical in determining the meaning in pairs of highly similar elements than in pairs of dissimilar elements.

A series of studies is now being conducted by Feldman and Worth in order to test the validity of the hypotheses that have been enumerated and to develop further the laws of film "language."

In order to remove some of the semantic content of real-life images, such as women and babies, geometric shapes are used in constructing the image-event stimuli. As previous work by others has shown, these geometric shapes are certainly interpreted by many subjects as more than geometric shapes, and their sequence is often interpreted as chasing, being chased, and so forth. These geometric shapes were used in constructing the stimuli not because they are meaningless, for indeed they are not, but because they offer the promise of being more manipulable and more subject to experimental control than would be images of babies, women, or Bulgarian heroes.

Incidentally, we have chosen line drawings, which according to our definition are not strictly image events. This was done so that we could begin our studies on a preimage-event level. One of my assumptions is that the "realer" the image, the greater the involvement of the viewer, and hence the more meaningful the sequence.

The actual stimuli were white outline shapes on a uniform black background. Two elemental stimuli were triangles: one, a large triangle in the center of the frame; the other, a small triangle in the lower right corner of the frame. The other two elemental stimuli were circles, which varied similarly as to size and position. Compound stimuli were formed by combining one edeme of a circle and one of a triangle: either both large and centered or one large and centered and one small and cornered; the fourth possible combination, small circle, small triangle, was not used simply because of the time limits imposed on the experiment. Each of the three combinations was shown in both possible orders and both with a cut from one edeme to the next and with a dissolve from one to the next. In total, then, there were twelve combinations shown to each subject. Each edeme was seven seconds long, with the dissolve accounting for four seconds of overlap, balanced by a fade of three seconds into the first edeme and a fade of the same length from the second edeme. The reversal of stimuli was accomplished by simply projecting the film backwards. These stimuli were shown to the subjects in one of three random orders after they had seen, also in random order, the four single elements (big centered triangle; big centered circle; small, cornered triangle; and small, cornered circle) in both cuts and fade-in, fade-outs.

After each single element or combination, the lights were turned on and subjects were asked to complete a 25 scale form of the semantic differential while the operator threaded the next film. The seven-point semantic differential scales included a number of evaluative pairs, such as beautiful-ugly, pleasant-unpleasant, and unfriendly-friendly; it also included some rather "literal" scales, such as sharp-blunt, angular-rounded, and curved-straight, meant to pick up the literal circle-triangle differences, as well as metaphorical scales, such as innocent-lustful, happy-sad, and serious-funny. After rating each stimulus, the subjects wrote a brief description of it.

The 20 subjects, who were students of a high status private school in the area, ranged in age from 13 to 19 and included both boys and girls. They were told simply that the experimenter was interested in the meaning of these stimuli; written answers to questioning at the end of the experiment showed no awareness of the true purpose of the experiment.

With regard to the original hypotheses, two are so clearly confirmed as not to be worthy of discussion at this point; the data for the entire experiment will be published in a separate paper and the interested reader may consider them there. Briefly, different edemes are perceived differently--circles are more rounded than triangles, and so forth--and dissolves are inferred differently than are cuts--dissolves are more amorphous, more interesting, more sensitive, and so forth. The hypothesis that from different sequences different meanings are inferred seems to be supported by a brief but superficial analysis, but more cannot be said at this time.

The final hypothesis, however, is perhaps the most interesting of all, and on this some conclusions can tentatively be drawn. As will be recalled, this final hypothesis states that sequence will be more critical with similar elements than with dissimilar elements. This result is suggested because of the assumption that the more similar the elements, the greater the tendency to integrate them into a new whole rather than to simply choose one or the other or to average, and because of the additional assumption that such an integration is more effected by order than are the other processes.

A preliminary test of this hypothesis was made by a medians test, the validity of which in this instance (since a factor analysis of the scales is not available) depends upon accepting the scales as relatively independent of one another, or at least expecting that the number of scales loading on each factor will be roughly equivalent. If one were to consider the number of scales in which the difference due to order was above the median and those on which the difference was below the median, over all subjects, the null hypothesis would lead one to expect these differences to be distributed equally for pairs of elements that differ only in image as compared with pairs differing in image, size, and position. In fact, the obtained X^2, corrected for continuity, is 5.10, the probability of which result occurring by chance along is less than .05. The direction of difference is that predicted by the alternative hypothesis already stated: the larger differences due to sequence occur with similar elements rather than dissimilar elements.

In summary, then, a recent experiment tends to confirm the psychological reality of the elements and operations that have been defined, and it also tends to confirm specific predictions about the effects of particular operations on particular types of elements, thus lending some support to the present approach to film "language."

Other Studies

It might also be mentioned that other types of studies are underway, including a test of the usefulness of this approach in other cultures. One of the fond hopes behind this research arises from the possibility of finding a "language" that transcends particular verbal habits.

A feasibility study, in collaboration with John Adair, an anthropologist, and Shel Feldman, has been carried out with the Navajo and other groups. We have been able to show that it is possible to teach people of other cultures to use film elements to communicate, and we feel that we can say (although our analysis is by no means finished) that members of different cultures use different rules when they combine videmes. These rules seem to be consistent across the culture and consistent with linguistic and other cultural rules (24).

To recapitulate the arguments of this paper, an understanding of film "language" is essential to understanding the image event; the image event is central in a communication process that moves from the feeling concern of the filmmaker to the story organism he chooses, through the image event, perceived in turn by the viewer and translated first into the perceived story organism and then into the perceived feeling concern; this communication process is the heart of visual communication.

Although the study of film as communication and as language is relatively new, the use of scientific modes of inquiry to lend new insights into forms of art and communication is not.

The present concern of artists with optical art is not very different from da Vinci's concern with the mathematics of space perception in perspective drawing. The fact that filmmakers can be concerned with problems of communication and cognition and that psychologists can be concerned with theories of filmmaking makes it possible to draw the wild hypothesis that communication itself may be possible after all.

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INSTRUCTIONAL TECHNOLOGY

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Recent Developments and Factors Influencing Future Developments in Instructional Technology

The basic responses of the field of instructional technology to the contemporary forces of social change have reflected, primarily, a concern with technical accomplishment. Relatively little substantial progress has been made toward providing adequate solutions to the whole set of problems involving what to teach, to whom, and how. In the opinion of this writer, this situation is closely related to one of the broad problems underlying the future development of instructional technology--that of changing the dominant physical science concept of instructional technology to a behavioral science concept and changing the prevailing mode of thinking among educational practitioners as to how professional knowledge is produced and how it should be evaluated. Unless this problem is recognized and solved, instructional technology may be unable to cope with the educational challenge of the present or the future.

Conflict between Two Modes of Thinking

Central to changing the prevailing mode of thinking is resolution of the conflict between what Conant (3) has called the theoretical-deductive and the empirical-inductive modes of thought, or what Snow (9) has described from another viewpoint as the dichotomy between "the two cultures," the literary and the scientific. The theoretical-deductive is best represented by mathematical thinking, particularly as applied in physics. Other forms of it may be found in theology, philosophy, law, economics, and political science. The other mode, the empirical-inductive, is best represented in the natural sciences and in such applications as medicine. Both modes have produced a vast body of scientific and technological knowledge, and both have influenced the teaching of these bodies of knowledge. Lawyers are more likely to use the theoretical-deductive mode; engineers and medical doctors, the empirical-inductive mode.

Reprinted from "Instructional Technology: Problems and Prospects," AV Communication Review, XV (Summer 1967), 133-144.

Educational researchers and other behavioral scientists investigating the teaching-learning process make the empirical-inductive mode of thinking their characteristic approach to problems of instruction. We know from research studies that teachers, in contrast, tend to reject the validity and utility of the empirical mode, preferring the theoretical-deductive mode when it is clearly inappropriate or inadequate (1). Why is this so? At the root, perhaps, is the educational practitioner's own education: the mode of thought prevailing in most teacher-education institutions is the theoretical-deductive.

This is not to say that training in the theoretical-deductive mode cannot be a powerful analytical and descriptive tool in the development of a science of instruction. However, it has no practical value if it does not lead to deductions which may be tested empirically, even though the method of testing may not be immediately available. Since methods courses in teacher education have consisted largely of deductions whose value rests on the assumed validity of theories rather than on deductions tested empirically, they are practical in the sense of that term. At best, they are good theory courses. And as a consequence, the typical educational practitioner neither generates nor seeks theories of instruction, nor is he committed to the testing of hypotheses or to the design of experiments concerning the instructional process. He does not create theories because he has difficulty seeing how theory relates to practice. When he does theorize, he tends to accept his deductions as valid because they follow logically from the accepted premises of his theory.

Prevalence of Faulty Assumptions

An interesting example of the dominance of the theoretical-deductive mode may also be found in the curriculum study groups led by the academic subject-matter specialists. Curriculum study groups such as the School Mathematics Study Group (SMSG), Physical Science Study Group (PSSG), the Biological Sciences Curriculum Study (BSCS), the Chemical Educational Materials Study (CHEMS) tend to focus on content *per se* rather than on the learning of content. Such groups have had very general conceptions of learning and have been totally convinced of the theoretical value of their respective approaches before they began. Thus far, initial assumptions have only been restated, and there has been an obvious reluctance to submit their systems to experimental verification.

One of the prevailing naive assumptions held by these groups is the notion that the ends and means of instruction are derived primarily from the subject-matter discipline and only secondarily from the learning and developmental processes of learners. To date, much of the restructuring of subject matter has been a process of trial and error, lacking in experimental testing. Empirical investigations and empirically oriented inductive theorizing such as that provided by Bruner (2) and other behavioral scientists have sometimes followed, but only after the programs had been determined and were well underway. In most instances, original deductions have been refined rather than tested in practice, and instructional innovations have been characterized by evaluations of the validity of effective accomplishment rather than by the validity of what was being attempted.

Further, the beginning of the reform movement in the secondary rather than in the elementary level of instruction has resulted in planning from the top down. It has also tended to focus on separate disciplines already established in the curriculum and to ignore or give scant attention to the developmental processes of learners or to their social or cultural backgrounds. Goodlad's (4) analysis, for example, points to the fact that the current curriculum reform is a middle- and upper middle-class movement and that the new curricula do not even come close to doing what we should be doing.

The revision of subject-matter content by academic scholars has been closely tied to school reorganization plans advocated by educationists in recent years. These plans propose new solutions to a number of persistent problems involving learner grouping, advancement, scheduling, use of space and equipment, and teacher deployment. In addition, there have been many proposals to educate slow learners, the academically talented, the culturally disadvantaged, and the physically handicapped. However, when one searches for psychological theories underlying most of these proposals or innovations, it is evident that no clearly tested psychological principles do, in fact, exist. Most of the innovations appear to have arisen from social and political pressures rather than from empirical investigation. The type of sensitivity to the needs of learners which we have seen in the work of Comenius, Pestalozzi, and Montessori, for example, is frequently missing in many contemporary developments. Too often the assumption seems to be that the adoption of new content, new organizational plans, new instructional media, or new designs for facilities and buildings is, in itself, sufficient for instructional improvement. It is interesting to note that the great bulk of research studies of nongrading, team teaching, and flexible scheduling undertaken thus far have yielded no significant results favoring these plans. This is not to say that an excellent rationale cannot be formulated for them; however, it is most important to recognize that most bear only a slight relationship to a basic improvement in the quality of instruction. For example, one rarely encounters any mention or effort to implement reflective learning, or learning which flows from a problematic situation about which a learner centers his thinking and research (6).

To date, implementation of new organizational plans has been hasty and superficial, with inadequate provisions for the total instructional system in terms of procedures, materials, media, and required staff. Some so-called nongraded classrooms, for example, have simply erased grade labels but have failed to provide authentic nongraded instruction. Teachers who have never individualized instruction in their graded classrooms can hardly be expected to know exactly how to individualize instruction in nongraded classrooms. Moreover, many educational practitioners have confused the concept of homogeneous grouping with continuous progress.

It is the writer's opinion that much of the failure to cope with the present challenge on an empirical basis stems from the adherence to the theoretical-deductive mode of thinking about instruction. Many educational practitioners bear the responsibility for creating and jumping on a bandwagon without the benefit of empirical-inductive examination. It is also clear that academic specialists involved in curriculum projects can also be charged with neglecting the empirical-inductive mode of thinking in their approach to curriculum reform. This may seem surprising since a major function of the university is to conduct research.

Experimental Verification Lacking

In order to understand why these scholars have not generally engaged in the experimental verification of their systems, it must be realized that most have been traditionally contemptuous of "educationists" and that any activity dealing with problems of learning and teaching in the lower schools has not been considered academically respectable. In fact, there has been no place inside the academic departmental structure of a university where elementary or secondary course revision could take place. Curriculum development projects, therefore, have had to be established outside formal university departments or in nonprofit organizations or colleges. Scholars participating in these projects (usually for short periods of time) often maintain their academic ties, with little hope of enhancing their scholarly reputation while so engaged.

Why, then, did they become involved in the first place? A precise answer is not easy. However, it seems clear that as a few scholars, particularly in the sciences, became acutely aware in the early 1950's of the scientific and mathematical shortcomings of secondary school graduates, they felt obligated to involve themselves in the updating and reorganization of precollegiate courses. Meanwhile, the launching of Sputnik I by the Societ Union in 1957 triggered a general movement of curriculum reform involving other university scholars.

The Potential Threat of the New Industrial-Educational Complex

Another recent movement offers prospects of continuing the alienation between the two modes of approach, further entrenching the physical science concept of instructional technology. We are referring to the development in the mid-sixties of a series of commercial mergers, principally involving electronics companies and publishing houses, for the purpose of designing complete instructional systems which provide for integrated materials and supporting equipment, the training of teachers in their use, and for the testing of the learners. School districts purchasing such instructional systems or materials literally "buy" the educational objectives and instructional techniques built into them. Can we reasonably expect the developers of these systems to produce empirically tested instructional systems, materials, and techniques when most educational practitioners and academic specialists have failed to do so? The answer probably is that we cannot--unless the present conditions change. For one thing, they work in a competitive market and few, if any, commercial producers can affors large sums for empirical demonstration of the effectiveness of their materials. Moreover, since the educational practitioner usually relies on intuitive judgments rather than on empirical data, the commercial producer needs to produce materials which meet other standards of judgment. However, in the foreseeable future, published instructional materials and devices supplied by industry may be increasingly submitted to experimental verification as a result of a recent U.S. Office of Education policy which awards, to business and industry, research and development contracts hitherto reserved for colleges and universities. Hopefully, too, this development may increase the sophistication of the educational practitioner in his use of criteria for evaluating these materials.

Prospects for a Behavioral Science Concept of Instructional Technology

If our foregoing analysis of the dichotomy between the typical approach of the educational practitioner and that of the behavioral scientist is valid, and if this same alienation between the modes of approach to problems of learning and instruction is seen to prevail among the academic scholars and the "educational businessmen," it then becomes clear that the estrangement between the theoretical-deductive and the empirical-inductive modes of thought will have to be resolved so that we may move toward a behavioral science concept of instructional technology. Unless we do this, it seems unlikely that we will be able to solve the educational problems created by a changing society.

Although this writer looks forward to the eventual development of an instructional technology based on the behavioral sciences and related interdisciplinary fields, he hesitates to set a timetable for such a transition, nor can he express great optimism about its early prospects. It appears to him that, barring some remarkable, unforeseen development, the emergence of a scientific technology of instruction will proceed at an evolutionary pace rather than in a revolutionary fashion as some have suggested. However, there is a wide range of possibilities on the horizon which holds much promise for uniting the theoretical-deductive and the empirical-inductive modes in a fruitful application of behavioral science research to instruction.

Although a behavioral science concept of instructional technology hardly exists today, we will examine in this section some promising trends and speculate briefly about the approaches which seem vital in the realization of a mutually interacting relationship between the behavioral sciences and instructional practice. No attempt is made here to present a complete method for implementing a behavioral science concept of instructional technology.

Teachers of Teachers and Teacher Education

Before we can develop a behavioral science concept of instructional technology, the schools, colleges, and departments of education who prepare teachers will have to shift their emphasis from the didactic theoretical-deductive mode of disseminating knowledge to the hypothesis-creating and testing mode. Although a thorough analysis of this problem is not within the scope of this paper, we shall consider a few of the implications of such a shift in approach.

The curriculum reform movement has not become an integral part of teacher-preparation programs either for teachers or teachers of teachers. What is needed, we believe, is to bring together professors of education and academic specialists so that they might teach each other and both learn to make the empirical-inductive mode their characteristic approach to problems of learning and instruction. For many years, subject-matter specialists have cut themselves off from a useful body of educational knowledge regarding the learning and developmental processes of learners while the educationists, in turn, have been separated, generally, from the mainstream of curriculum reform. It is essential, therefore, that the basic competencies of both the subject-matter specialists and the educationists are applied to problems of instruction. Some type of arrangement will need to be made whereby a continuing dialogue can take place. Perhaps a resultant mutual respect and understanding, traditionally lacking between these two groups, will ripen into a new, productive working relationship.

If we make the assumption that the teachers of teachers will ultimately adopt the empirical-inductive mode as their typical approach to problems of instruction, we will expect this to be reflected in a redesigned teacher-education program. This will make it possible for the beginning practitioner to engage in some form of research activity while he is training for teaching. This does not imply additional courses in statistics or research design. Rather, the object will be to get the beginning practitioner to do some hypothesis making and testing. Such a teacher-education program might also include experienced teachers in neighboring cooperating schools who would work with beginning students on specific instructional problems. Both the experienced teacher and the beginning student might be aided by a subject-matter specialist and an experienced investigator from the college or university. Similarly, local institutes might be established in which behavioral scientists (including professors of education) and academic specialists would assist teachers in formulating ideas and in carrying out research projects. In this way, a public school system, in cooperation with a college or university, could prepare future teachers as well as "re-educate" experienced practitioners in the empirical-inductive approach to instruction.

Research and Development Centers

A recent development which promises to provide a solution to the prevailing dichotomy between the theoretical-deductive and the empirical-inductive modes of thought in educational practice is the establishment of regional educational research and development centers or laboratories under the financial sponsorship of the U.S. Office of Education. For the first time in the history of instructional technology, these centers will test theories or hypotheses in a systematic manner before they are put into instructional practice. Furthermore, as increasing knowledge is accumulated in the behavioral sciences, a base can be laid for the development of a behavioral science concept of instructional technology. Whether the R and D centers will actually provide a model of the research process and set the pace for a scientific and technological foundation for instructional practice will depend largely on the quality of the staffs selected and on the policies and programs they adopt. The basic problem, in our view, as described, is to change the prevalent mode of thinking among both educationists and academic subject-matter specialists about the teaching-learning process. If the R and D centers cannot solve that problem, they may prove to be nothing more than so much "sound and fury."

How, then, can the R and D centers or laboratories help to bring about such a change in the mode of thought? A fundamental way envisioned by the writer is through the establishment of true laboratory schools under R and D center control. The primary function of these laboratory schools would be neither demonstration, dissemination, nor field testing, but, rather, research and experimentation. They would provide the direction and impetus for innovation and diffusion and for the "re-education" of teachers of teachers, educational administrators, subject-matter specialists, and experienced teachers by involving them in some phases of the research process, or what is usually called developmental research. Thus, in such experimental laboratory schools, representatives of all these groups would work together on bridging the gap between theoretical ideas and instructional practice, and could develop mutual respect for one another.

Hilgard (5) has provided a model for developmental research which might be used by an R and D center in conjunction with a laboratory school program. He breaks the research process into six phases or steps, beginning with pure research on learning and terminating with technological research and development and with the innovation of new instructional practices in the public schools. The first three steps are pure science research and often arise from theoretical issues having little or no relevance to application.

The first of the last three steps is a small tryout with a few students and a highly trained teacher--a feasibility test. This is followed by a tryout in a more "typical" classroom. Finally, the procedure is initiated on a larger scale, and studies are made of strategies of innovation and diffusion, or how new procedures can be adopted by those who have not participated in the experimentation.

The experimental laboratory schools which the writer envisions, financed by the Federal Government and operated by the R and D centers, would be implemented with the cooperation of school systems, colleges and universities, state departments of education, and private organizations within the geographical region served by the center. It is not our purpose here to develop a method for the organization and operation of such R and D center-controlled laboratory schools. We can only suggest that a good start might be made with the selection of high-quality personnel (educational administrators, classroom teachers, subject-matter specialists, and teachers of teachers) who would become involved for at least one year or longer in developmental research on the teaching-learning process in close cooperation with behavioral science investigators of the center. For their work in research and/or teaching, or both, they would avail themselves of all the R and D center's facilities such as research assistants, statistical and computer services, production services, and work space. When their period of activity at the R and D center had been completed, they would return to their own districts and schools to provide leadership in innovations which had been experimentally verified.

Although each laboratory school would be relatively small, the student enrollment would be carefully controlled and highly diversified in terms of social and racial background, abilities, interests, ages, and a host of individual differences. Here, atypical instructional procedures would be the rule, with the support of those cooperating rather than with the threat of interference. It would also be a place for extended observation and testing and where creative experimental treatments could be employed over a relatively long period of time. For example, one laboratory school might adopt an experimental theme such as Bruner's cognitive approach to learning; another, Skinner's operant conditioning approach. Other schools might derive their themes from techniques, goals, or values. Some schools would focus on individualization of instruction while others would concentrate on the development of creativity. Thus, the R and D center-controlled laboratory schools could provide an ideal experimental setting which the public schools are unable to offer.

It is obvious that we know very little about the complex motivations and conditions involved in instructional innovation and diffusion. The existing literature reveals a paucity of empirical evidence on how to accelerate the change process or what strategy of innovation to employ. We do know that we cannot anticipate significant changes in instructional technology merely through the dissemination of research reports or by providing for demonstrations.

Although the researcher usually believes that he has fulfilled his responsibility as a researcher when he disseminates information on his research, we know, unfortunately, that research and instructional innovation are rarely found together. The same gap may continue to exist if those in the new R and D centers produce research articles and disseminate information and material in the conventional manner. (We know, for example, that many teachers and administrators ignore good research because it was not done in their district or classroom.) Thus, an important function of the R and D centers will be to take a creative approach to communication while studying the problem of dissemination and innovation.

We see the proposed R and D center laboratory schools as unique institutions where behavioral scientists, teachers of teachers, educational administrators, classroom teachers, and academic subject-matter specialists could join in a fruitful attack on problems of learning and instruction in a realistic setting. The resulting cross-fertilization of knowledge and skills would ultimately advance instructional technology to the status of a profession in which the behavioral sciences would provide the underlying foundation and essential nourishment.

The Future Challenge to Instructional Technology

In a talk entitled "Education's Challenge in the Future," James E. Russell, secretary of the Educational Policies Commission, used these words (8):

> In that deep, distant future, people will face situations which are novel. If they are to succeed in establishing the conditions in which they can earn their own dignity, they will have to learn how to make responses which we do not today know how to make. When they meet novel situations that arise in their own lives, they will not be able to look to us for guidance. We do not have the knowledge required. They will not be able to consult the experience of our forefathers or even the accumulated experience of mankind. Whether they are good citizens about it will not make much difference. Whether they have ethical character will not help. Whether they perceive or are sensitive to its aesthetic significance will make no difference. They will not be able to ignore what is in front of them. It will do them no good to panic or retreat in confusion. It will not even be enough to pray. *They will have to think. Our job then is to teach them to think.* (Italics mine.)

According to Russell, we will have to redefine the goals of education, and this means overcoming what he calls the twentieth century fallacy (7)--the idea that educational goals should be defined in terms of overt behaviors which all children can perform and that "subject matter should be viewed as the proper end of education." Russell's viewpoint is that the whole of education can be redefined with reference to the rational tradition. But if we are to being these goals to reality, it will require the blending of philosophical insights with psychological and technological insights. There is a bridge, Russell says, from philosophy to psychology and a bridge from both to technology, and someone, somewhere, somehow is going to discover the footwork that will enable him to cross these bridges.

Furthermore, says Russell (7):

> . . . the man who will cross our bridge is one who is at home in two widely disparate fields. One is conventional pedagogy. He will need to know much about learning, about human development, about the world of education as we know it. On the other side, he will need to be sure-footed in the world of advancing science and technology. Computer development, electronic games, new forms of circuitry, the character of DNA and RNA, neurological research--a lot of fields of pure science must also be his preserve, buttressed by skill in the gadgetry that goes with them.

Where should we look for this man or men of the future? Is it necessary that they be in education now? Wherever they are, they must perceive that the crucial instructional problem of our time is to develop and improve a science and technology of instruction. It may well be that the men who will cross the bridge from philosophy to psychology to technology will be catalytic agents of a kind, perhaps called instructional technologists or educational designers, who will bring about the needed cross-fertilization of the knowledge and skills of educational practitioners, subject-matter scholars, and behavioral scientists. There is high hope that some men have already taken the first steps across the bridge; but the crossing will be long and will require great daring and insight. Yet, when it has been done, we may enter an exciting and rewarding era in instructional technology.

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TRENDS IN THE TECHNOLOGY OF EDUCATION

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The preceding section covers the current situation with emphasis upon the decade 1955-64, a crucial period for the development of educational technology. The changes occurring during this period were so striking (and some of them, such as the language laboratory, so unpredictable) that forecasting in this field appears extremely risky. Further, it cannot be overemphasized that developments involving any appreciable degree of novelty are still very slow to affect educational practice. In effect, events occur at two levels: An analogy might be to consider the interest in research and development now occurring in educational technology as the upper level of ocean currents which can be seen and measured, and actual practice in the majority of educational institutions and systems as the deep, slow swelling, cold currents that move in their own time and are difficult to detect.

Nevertheless, there are probabilities and trends in the situation, and prediction is possible, although its accuracy cannot be stated even with the precision of probability statements now used in weather forecasting. What follows in this section is such a prediction; it is the sole responsibility of the principal author. For reasons which should become clear, this forecast is divided into two parts--a short-range forecast and a long-range forecast.

The Next 5 to 10 Years

An analysis of the situation suggests that the next 5 to 10 years will be a period of consolidation and spread into educational practice of the technological developments of the last decade. The educational system has, in effect, been threatened with novelty; in the coming decade the novelty will be absorbed to the point where it will be no longer novel. There will be some new developments; these, however, will tend to be in the political-social-economic sphere and not, as many of the current thinkers in educational technology suppose, in materials, hardware, and psychological breakthroughs. Breakthroughs

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Excerpted from "The Emerging Technology of Education," Educational Implications of Technological Change, Appendix Volume IV, Technology and the American Economy, prepared for the National Commission on Technology, Automation, and Economic Progress. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, February, 1966, IV33-IV52.

and novel developments are always possible these days, but the current trends continue to suggest that their time is, perhaps, a decade or more away.

Based on the generalization that consolidation of gains will characterize the next decade, the following forecast is made from current trends:

1. Innovation--Change. It has become the official policy of the U.S. Office of Education to encourage educational innovation; further, the concept of innovation is "in" with the entire educational community at State, regional, and local levels. Three forecasts can be made in this area:

a. The principal site of education innovation will change from the lower levels of the school system to higher education. Colleges and universities will be forced to innovate, principally due to the flood of students, but with other factors acting as an influence as well. Universities, while sources of innovation for the whole culture, have been loath to make drastic changes in their own procedures, particularly their teaching procedures. The innovations which will be forced on the higher educational system during the next decade will, therefore, cause a great deal of strain.

b. With respect to the system as a whole--particularly the public school system--educational innovation will become institutionalized, centering upon the U.S. Office of Education and secondarily, the several State departments of education. Existing legislation and plans and the influence of a new educational establishment will all combine to push this now visible trend into actuality.

The principal instruments for this institutionalization are likely to be the regional laboratories now being set up by the U.S. Office of Education together with regional educational centers to be set up under title III of the Elementary and Secondary Education Act of 1965. The regional centers do not have to have this function, but at this writing, it looks as though part B of this section of the law, which does provide for exemplary (i.e., demonstration centers designed to spread innovative ideas) projects, will receive precedence over regional educational services. However, even if these instruments are not used for one reason or another, others will be found, and the innovative process will be institutionalized.

c. With the institutionalization of educational innovation, two things will happen. First, the innovations themselves as they are picked up by units of the system (schools, school districts, colleges) will become simplified and vulgarized, sometimes beyond recognition, and will lose a great deal of their power. This is principally due to the fact that the system as a whole is not sophisticated enough to absorb many of the new processes and procedures with all of their subtleties and qualifications. Secondly and more important, as the process of innovation is institutionalized, innovation will gradually become little more than change. This is based on the assumption that the "invention of the method of invention" as applied to educational innovation--and that is the avowed purpose of this institutionalization--will not necessarily work with the same force that it has with industrial technology. It is likely that the true innovators will begin to drop out of such an institutionalized system, and the remaining bureaucracy will not be capable of far-reaching innovation.

2. The Development of the New Educational Establishment. American education has always seemed to have more common procedures, goals, and even buildings and teaching materials than are warranted by existence of 50 autonomous and presumably different State school systems. There are many reasons for this, but among those often cited is the existence of an educational establishment. In the past, it has been stated that this establishment has consisted of the national educational professional associations, the teachers colleges and schools of education in universities, and the State departments of education. After 1950, this establishment came under heavy fire, and beginning about 1955, a new educational establishment began to emerge.

The significance of this new educational establishment for this paper is that it has a scientific-technological base. Essentially, it consists of four or five of the leading higher institutions in the United States, several foundations, a component of the new scientist-politicians that have emerged in the last 20 years and some able individuals both within and without Government. Its relation to the older establishment is almost nil.

The next decade will see the complete domination of educational thinking in this country by this new establishment as it develops and consolidates. Nothing in this statement should be construed as suggesting that there is anything conspiratorial about this emergence. It is doubtful, for example, whether individuals now belonging to the new establishment even know it as such. Rather, the emergence of such a group of intellectual leaders for education was almost foreordained by the development of our advanced technological society. Henceforth, the new establishment will orient American education more in the direction of science and technology as associated with its own processes and will absorb only that part of the older establishment which will fit this overall scientific-technological pattern.[1]

3. The Systemization of the Materials of Instruction. The already well-developed trend toward more systematic organization of instruction-

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[1] In this connection it is fascinating to note that recent news stories report that the new Russian educational program was prepared by a commission composed of members from the Academy of Sciences and from the Academy of Pedagogical Sciences.

al materials will reach fruition in application in schools and colleges within the next few years. Systems of teaching the structure of subject matters and certain skills such as reading will be applied on an increasing scale. These systems will make use of all of the available instructional technology[2] and will absolutely control the curriculum in the areas (such as physics) where they are applied. To some degree, competing systems will be created, and schools and colleges will be asked to choose among systems; however, since these systems are expensive and take years to develop, the choices will be limited. Further, there will be problems of obsolescence and logistics associated with them for which the schools and colleges are ill prepared.

The materials within these systems (films, programed learning sequences, videotapes, books, etc.) will increasingly be tailored directly to learning tasks and will represent much more of a rifle approach than the historic shotgun approach of the standard textbook or educational film. As such, their overall effect should be much more efficient. Further, research now going on in several places should have begun to supply some answers to the general question as to which medium is the most effective for a given purpose. If these answers do develop, the emerging instructional systems will also reflect this knowledge. Increasingly large amounts of money will be spent on developing these systems.

4. Developments in Hardware. Hardware, particularly in sophisticated systems, such as military weapons systems, can change or develop rapidly. On the other hand, in the consumer field, such as refrigerators and automobiles, the changes tend to be slower and are often more apparent than real. In the field of instructional technology, both possibilities are present.

a. Optical-photographic versus Electronic Systems. Because of the long leadtime that optical-photographic (conventional audiovisual) systems (projectors, silm, etc.) have had on electronic systems (television, videotape, etc.), existing instructional hardware is heavily weighted toward the optical-photographic for pictorial (and audio) storage and transmission. Further, photographic information is still superior to electronic by a factor of, perhaps, 100 to 1. There are other influences as well, such as accessibility.

The next few years will see a continuing invasion of this field by electronic transmission. Improvements will be made in the information capabilities of electronic systems; the transmission of color will become cheaper and easier; accessibility will be improved through cheaper videotape-type storage; and videotape recorders and players will become

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[2] It is believed that forecasts which claim all instructional systems will be computer controlled in the near future are wrong by at least 20 years.

smaller, less expensive, and easier to operate with reliability. By the end of the decade, a new balance will have been achieved between these two (partially) competing systems. Neither will disappear, but electronic storage and transmission or combinations of electronic and optical-photographic systems will claim a much greater share of existing hardware designed for pictorial storage and transmission than is the case now.

b. Television, Videotape, etc. As indicated above, videotape players and recorders will become smaller, cheaper, and more reliable. Whether the current methods of recording on magnetic tape will still be in use might be in question, as there are several other ways to use electronic impulses to record information on some medium; thermoplastic recording is an example. The precise means is unimportant from the educational point of view. What this does mean is that images and sound will be available in inexpensive, easy-to-use form.

In addition, it is to be expected that television will expand in its educational aspects during the same period of time. This expansion will principally be in the closed-circuit and 2,500 mg. areas and not in broadcast television for schools and colleges. The expansion will occur first in higher education, and it can be fairly confidently predicted that interinstitutional cooperation in the use of television, such as has been experimented with in Oregon, will be extended as the pressures on higher education increase. A professor in one institution teaching a class in another, or several others, will not be at all unique except in small enrollment, prestige institutions. Even in such cases, lectures from Nobel Prize winners and the like will probably be delivered by television.

Along with these developments in television and, for a while at least, overshadowing them, will be an enormous increase in the use of telephone lines to transmit certain kinds of educational materials. The last few years have seen some growth in the so-called "tele-lecture" technique where the lecturer at one location can speak to a group via amplified telephone at some other location. Recently, as at the Harvard Business School and in connection with various medical education projects, conference-type seminars between groups have been held using the telephone system. A new invention makes it possible for a teacher to draw while lecturing over the telephone and have the image projected by a special overhead projector at the receiving end; slides and other materials distributed in advance have also been successfully used with tele-lectures. Since this procedure is relatively inexpensive and very useful, it may be expected to grow spectacularly during the decade.

c. Other Hardware Developments. While improvements and changes may be expected in all audiovisual equipment, it is likely that the major advances will occur in the field of self-instructional devices. There are, at present, several prototypes under development of multimedia machines (still and motion picture and sound) designed as individual instruction devices. While the history of this type of teaching machine has not been too spectacular up to this point, it seems reasonable to predict that the next decade will find several types of these in use. This, of course, will set a new requirement for programing and production of materials.

The 8 mm. film, particularly with the new format (40 percent more information per frame), will constitute the most important development in the audiovisual field in the next few years. Following Professor Forsdale of Teachers College, it is believed that 8 mm. will be used primarily for individual instruction, although with the new format classroom projectors for groups of up to 50 in size may be expected to become quite common. As 8 mm. comes in, a technological lag problem will become apparent with the huge investment the educational system has in 16 mm. film and projectors. One way around this problem will be to develop individual instruction devices for use with 8 mm. film, particularly devices that permit student response. Considerable resistance to this development may be expected.

Multimedia-multiscreen techniques for large groups will continue to expand during the next 10 years. Lecture halls and briefing rooms will be built with such hardware requirements in mind. Automatic projection equipment will be redesigned in order to operate in gangs for this purpose, and control equipment will be developed on a miniaturized, high reliability form.

d. Computers and the Interface Problem. Since a separate paper has been prepared on computer applications to education, computers for computer-based instruction will not be discussed here. However, it may be important to point out or reemphasize that there are certain needed hardware developments related to computer-based instruction which will probably occur during the decade under consideration. These developments are referred to as the interface between the computer and the student and have been the subject of a recent study by Glaser, Ramage and Lipson (1). In the next 10 years various ingenious interface devices will be developed so that students may receive stimulation in various forms from a computer (pictures, words, numbers, sounds, graphs), may manipulate the subject matter so presented with instruments such as light pens, and may be informed on other portions of the interface device as to progress, what to do next, etc. Until such interface devices are developed, computer-based instruction will never achieve its full potential.

Essentially, at least a portion of what should go into such an interface device is the result of developments which, in the computer field, go under the general name of information display. Although the existing literature seems to suggest it, there is nothing in the educational picture which would require all such display techniques to be confined to devices requiring student response and controlling student behavior in detail. It is reasonable, in fact, to predict that information display techniques which are essentially electronic or electronic-optical in character will also be used in connection with television, other wave-propogated transmission and telephone to convey teaching materials from one point to another without elaborate response and measuring devices. As yet, with the exception of a few experiments, the techniques of information display in use with sophisticated systems, such as space and space support systems, have not been tried with education problems. The next decade will see many developments in this area, including simulation.

5. Information Storage and Retrieval. An area which may develop as spectacularly in the next 10 years as the language laboratory and associated teaching techniques did in the 1955-64 decade is the area of information storage and retrieval. As such, in its educational applications, it could represent an exception to the general orientation of this section.

The problem of the information explosion is well known; the fact that much information today never reaches the book stage in time but remains in the form of documents, articles, etc., has given rise to a whole new profession known as "documentalists"; experts in information storage and retrieval are calling themselves "information scientists"; and there are signs within the old-line professional library field of a deep schism between conventional librarians and information scientists and documentalists.

Obviously, new technological information storage and retrieval techniques can be (and are now, to a certain extent) applied to the problems of a conventional library. However, except for large university libraries, it does not seem likely that these techniques will make much of an inroad into school and college libraries during the next decade.

What is likely to happen is that sort of an end run will occur, and the new technology of information storage and retrieval will reach the educational system in some strength outside of the main library stream. There are several reasons for this. Again, the position of the U.S. Office of Education may be crucial; however, it is the considered opinion of the writer that even if that office were not a factor, this phenomenon would occur.

The U.S. Office of Education, however, will play a large role in this development providing present plans for its proposed Educational Research Information Center (ERIC) are implemented with sufficient funds and personnel. Operating from a center in Washington, D.C., and from, perhaps, up to 200 satellites or clearinghouses located in higher institutions and research centers of various types, microfiche (small sheets of microfilm) chips containing research documents will be supplied educational users ordering from a system of indices, bibliographies, and abstracts also provided by ERIC. This system is now underway on a small scale.

The availability of this information will create a demand for microfilm readers of various types and for equipment to reproduce hard copy from microfilm. Such readers are all--with some modification--potential teaching machines; further, the ability to reproduce hard copy presents the possibility of expanding such services to instructional materials too current to be available in any other form. Such a procedure has been experimented with in San Diego County, Calif., for some years with great success, where local industries and scientific institutions have been supplying schools with current scientific materials produced in this way.

If this development proceeds as suggested--and the probabilities are high--a full-fledged educational information storage and retrieval system may grow up outside existing channels. Further, because the hardware and services are adaptable, it is possible that a new generation of teaching machines will come into being based on the microfiche reader, thus short-circuiting a whole series of obstacles. The presence of hard copy-producing equipment might speed up the use and adaptation of newer curriculum materials, both in programed and in more conventional forms. Such a development would tend to restore a certain amount of curriculum independence to local school districts, providing staff and facilities were made available to take advantage of it. This latter development is highly unlikely. What is more likely is, as the State departments become stronger, curriculum materials will be supplied by the State departments in this easier-to-use form and curricular autonomy will be lost, not gained, at the school and district level.

6. Standardization. One of the strongest trends in the next decade will be a general move toward standardization, a move inevitable in any highly technical society. With respect to equipment and materials, several forces are at work that, potentially, could force standardization. The first of these is the so-called "State plan" by which many of the Federal educational programs dispense money to the States. In its most simplified form, the State submits a plan for a program, for example, dispensing funds under title III of the National Defense Education Act. Once this plan has been approved, the State, in effect, sits in control of the disbursement of the funds to its local and regional units. All the State has to do is to require standards for equipment in its plan and standardization becomes a reality. With the so-called "Compact of States" within the immediate future, providing for efficient communication between the States on educational matters, standardization could soon become national.

A second force, which has been discussed for many years but has never been released, is possible if the major cities of the United States were to combine in order to write common specifications for equipment and materials. Such cities represent a large share of the market and now contribute to the chaos in educational equipment standards by requiring annoying and, most often, useless differences in specifications. This raises the price per unit on such items as projectors, complicates bidding procedures, and localizes purchases. Economic considerations may force the end of this practice and a move to joint bidding or even centralized purchasing. Such a possibility is only a possibility and it is more likely that the provincial practices of the educational bureaucracies of such mammoth systems as New York and Los Angeles will remain at the level of their archaic city building codes. Of the two forces, the State force, even including centralized purchasing (a procedure opposed vigorously by the audiovisual industry), will probably prevail, and equipment and, to a certain extent, materials standardization will occur during the decade under discussion.[3]

At a broader level, greater standardization will be forced on the present quasi-autonomous school system than now exists through such factors as the increasing influence of Federal educational programs, even if no direct control is ought or applied; the inevitable cooperation of States and regions in educational matters; the introduction of whole systems of instruction; the possibility of a national assessment program; the reduction in the number of educational materials suppliers; the reduction in the total number of school districts in the United States; the general increase of communication; the prevalence of large-scale industrial thinking as it moves into the public sector; and the move toward computer data control.

7. The National Assessment (Testing) Program. Earlier in this paper it was mentioned that testing had been developed over the past several decades into a formidable subtechnology within the broader field of educational technology. The influence (some call it tyranny) of the New York Regents Examinations upon the curriculum of the schools in New York State has been commented upon for many years. Recently, this type of influence has extended throughout the Nation with the examinations of the College Entrance Examination Board, the National Merit Scholarship Examinations, the Graduate Record Examination, etc. Attention here is devoted to examinations that affect the curriculum of the schools and not to other forms of testing, such as psychological and attitude.

The next decade will see the institution of some form of national educational assessment program. The word "assessment" is used advisedly because the sponsors of the idea (essentially the new educational establishment) are proposing to combine standard achievements testing techniques with sampling techniques similar to those used in public opinion polls to assess "how well the schools are doing." Such a program would not be achievement testing in the accepted sense. A good

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[3] Materials standards are equally, if not more, chaotic than equipment standards. One of the earliest problems with teaching machines, for example, was that there were no standards for programs--either mechanical or educational. An abortive effort of a group of professional organizations to set up standards produced nothing.

discussion of the pros and cons of this issue may be found in a recent Phi Delta Kappan (2, 5).

Once such an assessment program is underway, it will become another powerful force for standardization. The technical capability (test construction, sampling techniques, computerized statistics) already exists. Current moves underway to make this capability operational by taking the necessary political, social, and economic steps will no doubt be successful. The claims already being made that such a program will not force a certain amount of standardization are rejected by the writer. That is not the issue anyway. The questions that remain to be answered are what kind of standardization and whether or not the standardization so created will be good or bad.

8. Trends in Administration. Many trends in the field of school and college administration could be singled out for projection. For example, at the brick-and-mortar level, school buildings will continue to improve and be made more compatible with the existing and developing instructional technology. Of all possible predictions in the field of administration, four are selected for comment.

The first, discussed at length in Mr. Bushnell's paper, will only be mentioned briefly. Data processing equipment and computers will become common tools for the school administrator in handling many routine problems; better decisions will be possible because of the immediate availability of better data. Centralized data-gathering centers will appear, probably as regional centers within the several States. Later, and inevitably, these will be joined into some kind of a national network.

Secondly, the most important function to be developed during the next decade will be a logistics of instruction. Everything within the new instructional technology--systems, complex use of materials, sophisticated equipment, new patterns of organization and buildings--requires formidable logistical support. The whole system will break down without it. Such support involves planning based on precise objectives and data, materials flow, equipment maintenance and replacement, backup manpower to the teacher, etc. Such thinking at present is almost completely foreign to school administrators at all levels except in a primitive form that provides sufficient pencils and sweeping compound for the year. Logistical thinking has rarely been applied to instruction; first, therefore, a theory of instructional logistics will have to be created. The pressures of the developing instructional technology will force it into being within the decade.

The third projection is somewhat broader than the first two but is related to them. Essentially, it is that organization patterns will move into larger and larger units for administrative purposes and that control will become more and more a part of what is sometimes called a corporate structure. In other words, the educational bureaucracy will enlarge, with an effort to make the parts (teachers, subadministrators, etc.) interchangeable.

The precise pattern of the enlarging units may take several forms during the decade ahead. The main point is that there will be an increase in size which, of course, will in turn increase the distance between the top levels and the point of contact with students. All State systems of education will tend to become real systems instead of the semisystems now existing. The regional laboratories, the Compact of States, and other such developments mentioned above, when combined with State plans, school district consolidation, and urban growth are all forces operating in this situation. It is hard to see anything but a diminution of local control of schools in the next 10 years. This diminution will tend to accelerate toward the end of the decade.

Finally, it is probable that one or more new private school systems, national in scope, will be started during this same period. These systems will be developed by the new industries moving into the educational field and will feature highly standardized, relatively fully automated, high-quality education designed essentially for upper and upper middle-class clientele. Such a system or systems will be accompanied by, but probably not related to, similar systems of private vocational training centers. This movement, too, will be gaining impetus by the end of the decade.

The school administrator required by these and many will quite clearly be a skilled professional manager, not the Latin scholar or part-time chemist-administrator, as desirable as such characteristics seem to many people; and he will not be so much the community-oriented, faithful service club member so highly valued in some school administration circles today. Subject matter scholars, through the technique of curriculum development projects, have learned to short-circuit school boards and administrators in matters of curriculum content. Increasingly, as methodology becomes more precise within educational technology, the same effect will be achieved by psychologists and educational engineers; thus, the issue of the ideal subject matter expert or liberal arts generalist qua school administrator will become completely dead, remaining to be mourned in the columns of literary magazines. The concept of the successful community-oriented administrator will also die, although a little more slowly, and the mourning will be heard at the annual steak fry.

9. <u>The Research, Development, Dissemination and Adoption Syndrome and the Resistance to Innovation</u>. As the process of research, development, dissemination, and adoption begins to operate with force (see part II), the traditional resistance of the educational system to change will crumble at an increasing rate during the next 10 years. Some enthusiasts for educational technology of any variety have consistently underestimated the power of the resistance of the system in the past; in the future, however, the timespan between idea and practice will increasingly be shortened. The current timespan between the de-

velopment of a new process and its adoption by a substantial majority of units of the system has been estimated at about 35 years. During the next 10 years this timespan will be reduced to about one-quarter of that length, or from 8 to 10 years.

10. General Developments in Educational Psychology and Methodology. Barring unexpected breakthroughs in understanding the physics and chemistry of the central nervous system which are, of course, possible, the situation in educational psychology as described above will not change much during the decade. Cognitive structure, inquiry, structure of knowledge, creativity, and student response manipulation will still be key concepts both for pure and applied research and for the development and testing of instrumentation and materials. Increasingly, a dialogue may be expected to develop between the cognitive structure-inquiry school and the operant conditioning school; a hard core of each will hold firm, but borders will become increasingly friendly. Experiments attempting to turn one system into another, as, for example, that recently reported by Schrag and Holland (3) will increase.

In the meantime, newer viewpoints, particularly those associated with cybernetic principles and information theory, will begin to gain momentum. A recent book by Smith and Smith may be a bellwether (4). Research patterns using these developing theories will begin to intrigue younger psychologists. The decade will end with some newer points of view having enough adherents to threaten what will then be "old hat" psychology.

Because the psychological situation will remain unsettled, the educational engineers will build bridges of learning on an empirical basis. The decade will see a great commitment to the empirical approach in the production of instructional materials and hardware. Materials and processes will be tested increasingly on suitable populations and will be revised until they work. The engineers, of course, will use whatever can be used from the studies of the pure psychologists; further, more research will be based on realistic student populations rather than small laboratory situations from which it is difficult to generalize.

The combination of the empirical approach and increased pure and applied research throughout the whole field of education and educational psychology represents one force that will turn a current form of thinking completely around so that it will point in the opposite direction.

The second force in operation relates to the national commitment to education as the uplifting force in our national life. For example, developing learning programs for such things as Operation Headstart and the Job Corps training centers are very difficult technical problems; they require, for their solution, large doses of educational technology considered broadly--methods, processes, machines, organization, skilled specialist manpower. Pious claims to the contrary, a knowledge of subject matter alone will be of little or no help in dealing with a 16-year-old illiterate from the Kentucky hills.

These two forces will combine into a pressure that will result in the rediscovery of educational methodology. From about 1950 to 1960 it was extremely fashionable to decry educational methodology as useless, as a fake medicine sold by charlatans, as something certainly not needed in the process of instruction. Those that grudgingly conceded that methodology did exist equated it with "tricks of the trade"--something that could be picked up overnight on an apprentice basis.

An illustrative example relates to the problems which led to the creation of Operation Headstart, a huge national operation designed to provide missing background for young, deprived children so that they might be ready to learn in school. It is now ironically forgotten that many critical books and articles appearing from 1950 to 1960 claimed that there was no such thing as "readiness" for learning and that professional educators, in maintaining that there was, were perpetrating a fraud on the American public. These books were read by the upper level economic group and the articles appeared in the "best" magazines. This general downgrading of methodological concepts, which resulted in its own mythology, is being attacked by events and will result in a complete destruction of this posture. Further, since control of subject matter is now secure through the technology of instructional systems, the entire dialogue between method and subject matter will be wiped out.

11. The Buildup of the New Educational Industry. As was indicated earlier in this memorandum, one trend of the last decade was the emergence of the science-based industries into the educational scene. The result of this in the next decade will be a pattern of power struggle, mergers, acquisitions, and new combinations, such as joint ventures between such industries, universities, and nonprofit corporations of the "think-tank" variety.

It is hard to see how the old-line publishing firms and audiovisual producers and suppliers can retain their current organization, appearance, and way of doing business. The next 10 years will see enormous changes in the educational business, which will generally be in the direction of larger, more diversified enterprises that will absorb many of the smaller companies and will force others out of business. The time of the lone salesman working out of his house for the small company and calling on a friendly territory will run out in this decade.

The existence of this larger educational industry will gradually force a change in bidding and purchasing procedures, and, hence, will influence the formation of the logistics of instruction. Such an industry will also permit more communication between the training segment (military, industrial, etc.) and the pure educational segment (schools, colleges, etc.) because materials and equipment will be supplied to both. If the pattern continues in the direction it seems to be going at the present time, these industrial giants will, through contracts, also be operating educational enterprises. The current operation of some of the Job Corps training centers by industrial groups and nonprofit corporations will be followed by the development of a general contracting capability under which such companies will provide instructional materials and services, build buildings, process data, catalog books and even hire or provide teachers and administrators for schools and colleges. Some of them may well develop their own school systems.

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PART TWO

MEDIA CHARACTERISTICS

FILM ATTRIBUTES

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The purpose of the present paper is to clarify constructs that can be used in studying the psychological effects of instructional media attributes. It is intended to discuss ways and means of which media attributes can be specified in terms that suggest appropriate forms of psychological and educational research. The basic assumptions underlying the proposed methodology are as follows: (a) one should expect interaction effects between particular media attributes, learner traits, and learning objectives, rather than main effects due to media attributes alone; (b) the media attributes under investigation should be explicated in terms which lend themselves to psychological research. They must serve as a bridge between the technical or structural descriptions of the attributes and their expected psychological effects or correlates. It is reasonable to view these assumptions as related, the former being an objective to research and the latter its vehicle.

The search for interactions between aptitudes and training procedures has not yet been systematically pursued on a large scale, although Cronbach, as far back as 1957, pointed to the need for such an approach. The applications of such an approach to the study of media-effects can also be stated in terms of hypotheses, as follows: (a) "In film presentation (or any other medium of communication) where critical information is presented via channels or channel interactions which are not unique to motion pictures, there is little reason to expect unique cognitive effects as a result of using film. The reverse might also be hypothesized: where critical information is presented via features which are unique to motion pictures, unique cognitive effects may be expected" (26, p. 64). (b) The unique attributes of the medium under investigation will have unique psychological effect only if they arouse in the viewer mediating mental processes which are relevant to the particular learning task at hand. In other words, a unique effect can be expected to result only when the use of unique medium attributes supplant in the learner mental processes which are required for the production of a particular learning outcome. Some of Hovland's experiments (15) indi-

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Reprinted from "The Specification of Film Attributes for Psychological and Educational Research Purposes," AV Communication Review, XVI (Fall, 1968), 225-244. The research and development reported herein was performed pursuant to a contract with the U.S. Department of Health, Education, and Welfare. Office of Education, under the provisions of the Cooperative Research Program.

cate clearly that whenever no significant differences obtained between film and film-strip presentations, the two seemed not to call for different mental processes relevant to the learning task. On the other hand, Festinger and Maccoby (13) showed a differential effect of sound-picture combinations on attitude changes, presumably because each of the presentations (distracting vs. direct communication) produced states which were directly relevant to weakening defenses against persuasive communication. (c) The effect of a particular media attribute depends in part upon the conceptual structure, attitudes, abilities, cultural background, etc., of the learner, e.g., where certain culture-dependent assumptions are implied in a medium there will be one effect on students of that culture and another on students who do not share these implicit assumptions (28). Consequently, what might be a unique and relevant medium attribute for one person could be irrelevant for another who differs from the first in his predispositions, abilities, etc. Here, the search for aptitude interactions, instead of main effects, and the search for the unique and relevant media attributes come together.

However, to study interactions of relevant media attributes with learner characteristics or learning tasks, one must know something of the nature of each factor. We wish to know not only that an attribute of some TV presentation facilitated learning in students of a certain type, a finding which might only be explained in post hoc fashion, but also we wish to be able to predict that the generalized use of that mode of presentation will result in given outcomes for students of that type. In other words, we need a theory that predicts and explains interactions between characteristics of learners and attributes of communication media. This requires detailed structural and functional descriptions of each.

Learner characteristics cannot be treated here. The present discussion must be devoted to problems involved in specifying the nature of media attributes, with particular reference to film. There have been previous attempts to explicate the unique attributes of the film medium (18, 24, 33) but most of these have been restricted to the semantics or the syntactics of the medium, hardly discussing systematically its pragmatics. A recent attempt by Pryluck (25) yielded an interesting discussion of the film symbolic structure, but only introduced the question of its potential effect on the viewer. The explication we aim at, beyond those mentioned above, should bridge the gap between structural descriptions of the medium and the psychological processes it might arouse. Thus, it is what Lumsdaine (20) referred to as the need to define factors under experimentation "in terms of theoretically oriented variables, and not solely in terms of gross physical characteristics of instructional media" (p. 601).

Is the Medium the Message, All the Message and Nothing but the Message?

Without defining for the moment what attributes of a medium are, one could agree that, say, movement, or the recording of reality, are essential aspects of photographic film. What do such attributes do to the message? They are not, certainly, the message itself. They provide a framework, a set of rules for the particular messages. That is to say: An attribute of the medium imposes some restrictions on the kinds of stimuli which can be presented but meanwhile gives the opportunity to convey some new kinds of stimuli. Three examples will suffice. One cannot record visual reality by means of written scripts without changing modalities. On the other hand, the script enables one to convey ideas, concepts and symbols which have no referent in the real physical surroundings, something which cannot, in general, be done by film. In a map, one cannot present things which do not lend themselves to symbolization, but one can present many things simultaneously. The film does not lend itself to presenting generalized concepts (how does one show "nevertheless"?), but allows the presentation of many particular real-life instances which one could not experience otherwise (18). Thus, the message is controlled by the attributes but not determined by them.

A film is not necessarily "cool" or "hot." Its "coolness" or "hotness" is determined by the interaction of attributes and messages. Moreover, the film medium has many different attributes, some due to the physics of photography, others the result of technical "tricks" or editing styles. The combination of such attributes creates new ones, since the interactions can become complex and subtle. As a result, two films may be structurally quite different and yet share common basic attributes. It follows that we can analyze single attributes and their interactions with the kinds of communication stimuli they allow, but we can hardly generalize over the whole medium. Some rather basic and simple generalizations are, of course, possible and needed. But to state that the whole medium is this or that,[1] regardless of the unique interactions of attributes in each particular case, is unwarranted.

To summarize the discussion, it seems possible to say that each attribute of the film is a rule controlling the message. New attributes stemming from the interaction of more basic attributes impose new rules and make each film potentially unique. Finally, it seems reasonable to study the effects of single attributes or combinations of attributes, but it is unreasonable to speak of the medium as a whole in this respect.

As now evident, the medium is viewed here as the set of all attributes which compose it. Movement, reality or presentation (not necessarily the idea behind presentation), multichannelness, etc., all belong to film and all when taken together compose the medium. If the medium is the sum-total of its attributes, no wonder critics recommend that particular productions of the medium must remain true to its set

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[1]See for instance the claim of Panofsky, quoted by Kracauer (18, p. 309) that ". . . it is the movies, and only the movies, that do justice to that materialistic interpretation of the universe. . . ." (Thus it is the only medium operating from material to idea, rather than vice versa.)

of rules or components. Without this restriction the production becomes a mixture of media, a bad outcome from their point of view. Notice, however, that it follows from this line of thought that the set of rules, i.e., the attributes, can be arranged in diverse ways, each way potentially affecting the message differently. Thus, the medium as the sum of its attributes cannot be equated with the message.

Let us agree for a moment with Kracauer's notion that "films are true to the extent that they penetrate the world before our eyes." Let us extend it also to the world before our ears. When the two are congruent, the message conveyed is nicely equated with the medium, as the sum total of the two attributes (visual reality and aural reality). Now imagine that the two are incongruent with each other, as in Festinger and Maccoby (13). It is no longer the same message, and the new message cannot be equated with the medium. Also, audio visual incongruity becomes a higher-order attribute of this film but it remains a potentiality of the medium, not a necessary component.

From the question of relations between attribute, message and medium, it seems necessary to move toward some specification of attribute as the key concept. Theoretically, the number of possible attributes which compose a medium may be unlimited. However, to deal intelligently with a complex medium like film it is necessary to restrict the list. According to what criterion can the limits be imposed? It happens, interestingly, that art critics, film analysts and psychologists who are interested in media effects, agree on one basic point. It is the assumption that the important attributes of a medium for specifying, analyzing, evaluating, or studying are those attributes which are unique to the medium under discussion (26, 33). We can expand this point and assume that the uniqueness of a medium is the sum total of its unique attributes, though the medium itself is composed of more than its unique components. No other medium (besides real life) can show movement without space restrictions, changes in modalities, or fragmentation. Hence, the attributes we should deal with in the present context are those existing only in the film medium or in its base, photography. It should be added, however, that attributes which result from the interaction of nonunique attributes might be unique to the film. Now, after restricting the list of possible attributes we must specify what an attribute is.

It seems that a reasonable initial specification would be as follows: Any structural component which has an influence on the kind of material one can present, the arrangement of the material with relation to other material, or the way the material is presented is an attribute of the medium. The fact that photographic film can show only objects which reflect light naturally influences the kind of material. The fact that each picture, inevitably shows more than is immediately needed influences the arrangement of the material in terms of foreground and background. The time-condensing element influences the way things are presented in sequence. A list of attributes of film constructed on the basis of such a tentative definition needs, however, some special treatment. We are not interested in what defines the medium of communication called film, for the sake of studying film. What we are interested in are those attributes which under certain arrangements, and when used to convey certain ideas to a particular audience, evoke the desired psychological processes.

Our need is to generate a list of stimulus variables with definitions based in the physical nature of film. From such a list we can then choose attributes of potential significance in psychological research. Since single attributes always appear in some context and since such attributes may themselves be considered as combinations of more elemental variables, it will be necessary to gain some multivariate conception and control of the complex stimulus aggregate. The problem is not unlike that faced by the differential psychologist interested in analyzing the nature of general intelligence as some organization of more specific human abilities. From observable item and test performances, clusters are formed to represent psychological traits. The attributes are in turn combined to represent higher-order constructs. Whether dealing with tests, traits, or higher constructs, the psychologist wishes to generalize to populations of persons and so samples large numbers of people for his intercorrelational work. Similarly, the film analyst may at present be faced with the need to consider samples from populations of films and correlational analyses of stimulus elements measured in these samples (an earlier example of this approach was provided by Snow (31). Unless it is known what stimulus elements vary together across films to form some attribute, the effects of context on a particular attribute may not be estimated. The need is for representative sampling and analysis of film ecology of the sort proposed by Brunswik (7). The communicative structure of film might then be understood in terms of a hierarchy of attributes formed from the stimulus texture through covariation among elements and classified according to several broad categories.

The Subset of Functional Attributes

Until now we have discussed the question of film attributes and their specification from a structural point of view. This seems to be a necessary preliminary step. However, not every unique attribute used in a film necessarily functions as a stimulus for the arousal of unique mental processes. Certain attributes, or combinations of them, may not function as stimuli for desired processes, or may often evoke processes which are irrelevant to the desired learning outcome. We might speak therefore from a functional, rather than a structural point of view and claim that for our purposes unique attributes of the film are those structural components which produce the desired mental effects. In light of such a functional approach (which will certainly not satisfy somebody outside psychology) the medium is differently perceived. The medium becomes, now, the sum-total of all its unique effects on the viewer. Structural features, the addition of which does not affect the viewer, become irrelevant for psychological or educational research, and thus remain as constants, rather than as influential variables. Pryluck and Snow (26) state in this respect that ". . . the structural characteristics of motion pictures are significant to the extent that they uniquely constrain or facilitate cognitive processes relative to the information presented" (p. 65). In a functional approach another factor has been added, namely, the task to be performed in response to the presented film. What may be an attribute arousing unique cognitive (and/or affective) effects under one set of task conditions may be irrelevant under another set. The conclusion follows that there are two lists of film attributes: one is the list of structural attributes, and the other, a subset of the former, is a functional list which contains only those attributes having unique psychological effect on the viewer. Since the latter depends on the kind of task to be performed, it is a flexible list that changes with changes in the task.

Tasks are here defined as the purposes or uses assigned to a film, whether instructional, commercial, or documentary. It should be noted that one film can serve many purposes. A commercial film may serve also as an illustration of social interaction for psychology students; a film designed to teach biology students about the social life of bees may serve as entertainment for non-biologists. The original function of a film (e.g., to present the relation between a man and a woman in a crowded town) magnifies certain structural attributes of the medium with the hope that they will be functional, that is, that they will arouse the mental processes the producer seeks. Using the same film for a different purpose (e.g., to show the relation between street and home life in a town) may leave some attributes without function and make others functional. Thus, each structural attribute has the potential of becoming functional, nonfunctional, and perhaps also dyfunctional.

Notice that the discussion shifts from the unique attributes of a medium to the unique communication experience it might provide. The former deals with the set of rules governing the structure of a medium (see, for example, 25). The latter refers to the subset of attributes functioning as a source for unique experience.

The Link between Structural Attributes and Their Functional Potentialities

To study the effect of media variables on mental processes, two steps must be taken: the first is to determine how one attribute or a combination of variables affect mental processes; the second is to determine why it affects as it does. There are many studies showing that certain variables have certain learning effects. However, one rarely knows why such effects occur. Studies of this kind can be found in various summaries; all too often there is no adequate explanation for the empirical results (1, 3, 20).

One reason it is difficult to go beyond the how to the why is that the conceptual links between technical or structural descriptions of a film attribute and its expected psychological correlates are missing. Such links might be found in the description of an attribute itself, though it must be in terms other than structural or technical ones.

To claim that, say, more abstract knowledge has been reached by the viewer because he was exposed to "shifts in the angle of the camera" is to say nothing more than that A caused B (in the best case) or that A and B go together. Stating that the same attribute has the function of "showing the various aspects of one phenomenon" reveals more. Following Piaget's theory, being able to visualize the various facets of one phenomenon is an important step toward being able to operate symbolically. Thus, we can relate the film attribute "movement of camera," its function "to reveal other aspects of the phenomenon presented," to its effect "more abstract mental operations with the given material on the side of the viewer." Hence, we suggest why A leads to B. The link is the functional description of the attribute under discussion. It specifies the attribute in terms which lend themselves to psychological prediction. The question of what kind of approach or discipline can be used to "translate" structural attributes into functional terms is essentially identical to the older question regarding the specification of stimuli, in general, and of graphic material in particular. Many attempts to specify graphic presentation in other than technical terms have returned sooner or later to rely on viewers' responses. Attneave (2), Berlyne (4, 5) and others have applied information-theory constructs and measures in attempting to specify the nature of stimuli. This resulted in the deduction of hypotheses as to expected psychological processes and effects. Similar successful applications of information-theory have been accomplished by Driscoll, Tongoli and Lanzetta (12), Sieber and Lanzetta (29), and others.

The information-theory approach, however, is not necessarily the only plausible one. Another approach, suggested recently for the explication of film attributes, is psycholinguistics (26). Both fields of study deal with the relations between communications of messages and the characteristics of the psychological processes and effects they arouse. Consequently they seem to meet our needs. We will try in the following pages to show how these two approaches--psycholinguistics and information-theory--can be used to specify the functional attributes of film for research purposes.

A Psycholinguistic Approach

The basic assumption of a psycholinguistic approach is that both verbal and nonverbal communication can be described in psycholinguistic terms. Within this discipline, one can further describe the kinds of information presented in a film, as in Ruesch and Kees's logical analysis of the film medium (27). Using their division of film information into two classes of codification (digital and analogical) as a base, Pryluck and Snow analyzed each of these into further subdivisions. Each subdivision represents one channel of communication, e.g., audioverbal (the words on the sound track), video nonverbal (the visual aspect of the film excluding printed words and symbols), etc. Six channels are listed, each assumed to transmit independent information. However, the different channels are presumed to interact, resulting in new kinds of information. Not all the channels are unique to film. The audioverbal channel, for instance (written scripts), is definitely not unique to film, nor is the audioparaverbal channel (intonations, pitch, etc., associated with speech). Only one of the single channels, the video nonverbal, seems clearly unique to film, though combinations of non-unique channels may create unique potentialities. The unique attributes of the film medium can be reasonably seen as subdivisions of the channels employed by the medium, e.g. "simultaneity of presentation" or "close-up" are components of the video nonverbal channel.

As noted above, an important premise for a psycholinguistic approach is that the material under discussion is a language having both vocabulary and grammar or analogues thereof. With respect to the video nonverbal channel of communication, however, it is not apparent that a language is necessarily involved. Whether the visual component of the film has a syntactic structure, and whether this structure governs the organization of words, is a long-standing question that cannot be answered here.[2] It can be agreed, however, that speaking of the grammar, syntax or words of a language implies the existence of conventions. This is obvious, as Chomsky (8) discusses it, with regard to spoken languages. Is it obvious with regard to films?

One could argue that though there are words of film, to whose conventional meanings we gradually become accustomed, still there is no agreed-upon syntax. Further, it can be argued that violating the rules of syntax in verbal communication destroys the transmission of most-essential information, without which no social structure could exist. This seems not to be the case with film, where the violation of syntactic rules, if these exist at all, may often be desirable. A new syntax, invented by a producer, may even facilitate the transmission of information. In any case, the fact that each producer can impose his own structure on his communication (as in other arts) corresponds to the assumption that the film does not transmit essential information. When, however, the information becomes crucial (as is the assumption in many military informational films) then the producer must use the simplest, most conventional structure or syntax. In this case a psycholinguistic analysis is clearly possible. On the other hand, in Rene's films as well as in Bergman's, one must adopt the producer's idiosyncratic syntax and analyze the components of the film from that standpoint. In the latter cases, no syntactic analysis of the film may be possible.

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[2]An interesting and extensive discussion of this problem can be found in Pryluck (25).

However, this is a relatively rigid conception of psycholinguistics and of film. The counterargument would run as follows: the information conveyed by films is expected to reach the viewer; thus the producer must rely to some extent on the viewer's association and expectations, as best as he can predict them. Underlying the different styles and grammars is a deeper layer of conventions with regard to visual symbols, sequence of presentation and general structure. The more comprehensible the information, the more complex the syntax can be, but still it is a syntax. A producer can introduce variations in syntax, yet the baseline is common to him and to other producers. One should not forget that in verbal communication also some violations of syntactical structure are allowed; poetry is but one example. Even with poetry one can analyze the syntax of one poet, of one period of poetry or one kind of poetry. The fact that there are various syntaxes need not disturb the analyst. Thus, it is possible to specify the common grammatical and syntactical structure of the medium and the variations within it.

Whatever the stand one takes in this controversy, it seems quite reasonable to suggest that the film medium in general, as manifested by some sixty years of usage, yields a common core of grammar and syntax. Films usually have a theme (whatever their specifically assigned function), they have sequences which intuitively (8) make more or less sense, and they have certain attributes which contain particular shared semantic meaning (e.g. we no longer must be told that a cut represents a shift in time and/or space).

Since there are sequences of pictures the meaning of which (from the viewers' point of view) can be rather safely predicted, one can assume the existence of semantic clarity or ambiguity and also syntactic clarity or ambiguity. Furthermore, film has presumably a core or kernel,[3] as implied in the idea that recent films are actually elaborations of earlier film attributes. But the problem of identifying words, phrases, and sentences in films still remains with us. While it seems potentially possible to apply psycholinguistics to the analysis of the medium, the analyst must define clearly what he regards as the unit of analysis. Each structural attribute, when taken out of context, may not lend itself to such an analysis, but sequences of attributes may do so (e.g. a massed long shot is followed by a close-up, then by a still and massed long shot from a new angle). By means of logical method one can thus describe a film in terms which are closer to psychological implications than are technical or structural specifications. The important point is that a link is being created between the technical specification of a film and its possible effects.

A study by Festinger and Maccoby (13) serves as an example. They report that a film constructed of two completely unrelated messages (a visually amusing display and a sound track which argues against frater-

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[3]Chomsky: a kernel is the core of basic sentences in the language which can be subjected to transformation.

nity life in colleges) resulted in significantly stronger changes in viewers' attitudes toward fraternities than did a regular film. The latter involved the same sound track as the former but its visual component illustrated the orally presented argument. In their theoretical discussion, they argue that "the critical variable would be the extent to which the attention of the person was distracted from the persuasive communication while listening to it" (p. 360). This statement takes a significant step toward explicating the nature of the experimental film in terms which lend themselves to psychological hypotheses. However, the reason why the viewers might be distracted remains unexplained. Suppose, however, that the lack of fit between the channels were described in psycholinguistic terms as semantic incongruity. Previous research with such ambiguity has shown that (a) subjects usually try to make sense out of such situations, i.e. to straighten out the ambiguity (35); (b) once subjects realize that there is something unexpected or incongruous in the field of view, they tend to devote more attention to it, rather than to other parts of the field (5); and (c) the part of the information which cannot be attended to immediately may nonetheless be placed in temporary storage for later treatment (6). Given these points, one may hypothesize that the misfit film in the Festinger and Maccoby study evokes these three mental processes while weakening the viewer's defense development. The distracting function of the film is realized when the viewer, instead of counterarguing and derogating points made by the commentator, tries to make sense of the semantically incongruent channels. The original theory of the authors is similar to that presented here, but it emphasizes only what the viewer is not doing, i.e., what the film is preventing the viewer from doing, rather than what it causes him to do.

An Information-theory Approach

Applications of information-theory constructs and methods have been accomplished with regard to complexity of stimuli (2, 9), information-seeking behavior (4, 5), response uncertainty (14, 17), individual differences in pre-decision behavior (29, 30), etc. Our ability to measure the amount of information carried by a certain kind of presentation, or the amount of uncertainty contained in it, and the way different people under different task-requirements react to it, is the key to the application of this theory. Here we do not necessarily specify kinds of information, as before, but only the amount of it to answer such questions as: How much information does the narration add to a sequence of pictures? How redundant is it? How much response uncertainty is aroused when frequent cuts are being employed, etc., when certain individuals are asked to perform certain tasks?

In a study by Cooney and Allen (10), it was found that a nonlinear film (simultaneous presentation of stimuli) resulted in more conceptual learning than a linear version of the same film, and that the linear film resulted in higher factual learning than the nonlinear one. This finding was obtained with sixth graders but not with eighth graders. The obtained results are difficult to explain without post hoc analysis.

Had we known, however, in advance, that for a given task and students the nonlinear presentation carried with it more information than necessary for the task, we could perhaps have predicted the outcome and explained it. The advantage of the proposed methodology lies in its attempt to relate nonlinearity (a technical term describing film structure) and factual learning by translating the technical description into terms more conducive to psychological prediction.

One point must be kept in mind: The functional attributes of a film, as noted previously, are not generalizable across all kinds of films and situations. Thus, the amount of information added by a long shot, for example, must be determined with reference to a particular function assigned to the film. A long shot may be redundant when the viewer must study details, but highly loaded with relevant information when he studies the relations between an object and its surroundings. In the former case the long shot introduces redundancy which may lead to boredom. If it adds irrelevant information, i.e. cues to which the viewer need not respond (21), then it increases noise. Noise in this sense would lead to interference of stimuli. The behavior of the viewer will then be predicted accordingly. In the latter case, the opposite might occur: The long shot adds relevant information while a close-up may introduce noise.

It is evident that not every structural attribute of film can be specified as a single entity out of context, e.g., camera angles, kinds of shots, the physical-reality nature of the film, etc. One can speak of larger or smaller information loads generally, however, with regard to long shots or close-ups, simultaneous or linear presentation, and some other attributes.

Expanding the information-theory approach somewhat, one can specify not only how much information (noise or redundancy) is contained, but also the kind of information involved given that the task of the viewer is known and analyzed. (The latter point has recently been discussed by VanderMeer [34].)

A study by Northop (22) compared three versions of a film--a discrete-item film (no inherent organization), a logical-development film and a chronological story-like film--in terms of factual information gain. Each version was presented both with and without inserted explanatory titles. Results showed that learning of facts was better from the discrete-item film with insertions than without, but that the opposite was the case for the logical film, where learning was better for the noninsertion version. The logical version of the film apparently contained sufficient information for the learner when it was without inserted titles. The addition, however, may have introduced noise, or at least redundancy, which led in turn to conceptual response uncertainty.[4] For the discrete

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[4] Response uncertainty is defined as the arousal of incongruent com-

version, initially higher uncertainty was reduced when titles (additional conceptual information) were inserted.

Jaspen (16) varied the density of presentation (more or less shots in a given unit of time and longer or shorter presentation of each shot). He found that the less visually dense versions of the film produced superior factual learning. Had Jaspen measured the amount of visual information introduced in each version, he presumably would have found that the more dense version invluded more information. It would not have been unreasonable to predict that the former versions imposed more perceptual uncertainty on the viewer which interfered with attending behavior. Thus, two different kinds of uncertainty were seemingly involved in the two studies, the understanding of which could lead to more penetrating predictions.

The application of information-theory concepts to the specification of one film-attribute was attempted recently by Salomon and Sieber (unpublished). The purpose of the experiment was to demonstrate an interaction between a film attribute and task-requirements. It was hypothesized, following the argument of the present paper, that the unique attributes under investigation would have unique psychological effect only if they aroused in the viewer mental processes relevant to the particular task to be performed. Two tasks and two versions of two films were utilized. The tasks were (a) to report as many details and facts from the film (CA), and (b) to generate as many different hypotheses about the story-line of the film, as possible (HG). The two versions of the film were as follows: one version was structured (S), i.e. presented in the logical order imposed upon it by the original editor. The other version was nonstructured (NS), i.e. the film was separated at its original cuts and resequenced at random. It was hypothesized that the nonstructured version (NS) would produce higher conceptual response uncertainty and would facilitate hypothesis-generation, since it would presumably evoke task-relevant processes. The structured version (S), on the other hand, was not expected to produce high response uncertainty, and would therefore facilitate less the performance of that task. However, with regard to a different task, i.e., cut-attendance, it was hypothesized that the opposite would be true. The S version should carry with it more information (or uncertainty) than the NS version, consequently facilitating more attempts at cue-attendance since it might provide some memory-supports. Memory supports, as used here, are devices such as visual displays or simultaneous presentations of data, which assist the subject in keeping track of information by reducing his dependence on memory. College freshmen (N = 160) were randomly assigned to one film version and one set of task requirements. From the obtained responses, average response uncertainty and redundancy

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peting responses to a single stimulus (4). Conceptual uncertainty refers to cognitive responses while perceptual uncertainty refers to a conflict between different cues one can attend to simultaneously.

were computed[5] (2) for each version-task condition. The two tasks (CA and HG) and the two versions of the film (S and NS) provide a 2 x 2 table in which the measures were obtained.

A clear interaction emerged: the NS version of the film under hypothesis-generation task requirements evoked more response uncertainty than the S version and was therefore less redundant. The opposite occurred under the cue-attendance task requirements. There, the NS version actually aroused less response uncertainty. Thus, under this task requirement it was more redundant. In other words, the absence of structure in the film interfered with this task.

By specifying one of the attributes of film structure in information-theory terms, we are now able to predict for which kinds of tasks each version will be most facilitating. Without such specification, our ability to predict the results of the experiment would be distinctly limited. For instance, suppose we study the effect of structure of film on learning detailed facts. We would hypothesize that this attribute makes little difference among students who are usually not aroused to a large extent by slight stimulus uncertainty. In recent studies, these subjects have been referred to as *low response uncertainty* individuals (29). Such students would recall details equally well from both film versions, under such task requirements. Only students who are more sensitive to uncertain stimuli (the *high uncertainty individuals*) can be expected to be aroused, and to profit, from nonstructured versions of the film. We might also predict that, when the learning task is to generate inferences, only the high uncertainty students will benefit from the NS version. The lower uncertainty subjects would presumably be overwhelmed by such uncertainty; their performance would be worse under HG requirements.

In the above example, we took a particular structural attribute of film and by empirical means tried to specify its functional nature in theoretical terms. These terms also have psychological import, enabling us to predict how and why differential learning effects occur. This suggests a generally important three-way interaction among stimulus, learner, and learning task.

Summary and Conclusion

The present paper began with a brief discussion of a basic methodological premise, namely that one ought to pursue interactions rather than main effects. We turned from there to a discussion of film at-

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[5]Uncertainty = $H = \Sigma p_i \text{Log}_2 \frac{1}{p}$, Maximum Uncertainty = $H_m = \text{Log}_2 N$, where N = number of observed alternatives when all are equiprobable; relative uncertainty = $R = \frac{H}{H_m}$, and redundancy = $C = 1 - R$.

tributes claiming that the functional attributes of the medium are actually a subset of the structural ones, the difference lying in the expectations assigned to the former with regard to effects on the viewer. Those attributes which are expected to arouse certain effects are the functional ones. It was also suggested that attributes should be described first in structural terms and then translated into functional ones. The latter specify the nature of the attributes in terms which link them to expected psychological processes.

Both approaches--psycholinguistic and information-theory--can specify the functional nature of attributes only with respect to film purposes. In neither case can attributes be described without reference to particular tasks to be performed, or to the context in which they appear.

The two approaches suggested have an important common core: They both begin with the stimulus material and seek a description of its effects on persons exposed. Since each approach is based on a substantial body of research, one might use either or both for the purpose of specifying film attributes. There is, however, one major difference between them. The psycholinguistic approach must assume the existence of some common language structure shared by different films. The information theory approach does not need such an assumption. The psycholinguistic approach is logical in nature and deals mainly with the kinds of information involved. The information-theory approach is empirical in nature and addresses itself mainly to the quantity of information presented.

Since the two orientations represent different bodies of observations and because they address themselves to different aspects of film, it may seem most reasonable to combine the two for a more powerful description of film attributes.

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PSYCHOLINGUISTICS OF CINEMA

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Some Conceptual Orientations

Structural Complexity

Previous consideration of the stimulus complexes included in motion pictures has suggested the existence of two major classes of information channels which differ in terms of the kind of information contained in each. Langer (23) characterized the two classes as discursive and presentational symbolism. Ruesch and Kees (46) have used the terms "digital" and "analogic" codification. However described, the distinction implies important related differences in the syntactic structure of communications in the two channel classes and, possibly, in the perceptual and cognitive processes associated with each.

The digital vs. analogic contrast corresponds roughly to the more familiar comparison between verbal and nonverbal content, but it is possible and useful to obtain a finer delineation of these general classes.

Digital information consisting of letters, words, numbers, and other familiar symbols is serial and discrete; it unfolds across a page, lecture, or screen one unit at a time. Its structural units are clearly delimited and defined; they can be treated singly or in combination, and they can be segmented and transformed by the application of statable rewrite rules. It is this abstract structure which permits the analysis of grammar apart from meaning.

Excerpted from "Toward a Psycholinguistics of Cinema," AV Communication Review, XV (Spring 1967), 54-74.

Analogic information is composed of pictures, gestures, intonations, etc. It is simultaneous and continuous and is capable of conveying in a single instant a wide range of continuously changing information as, for example, the action, utterance, and expression of a person who, while crossing a busy intersection, is surprised by the screech of brakes from an unseen car. The units of analogic information are not naturally delimited or defined. It is not readily apparent that a syntactic structure of analogic information can be abstracted from the semantic features of a given communication.

Even at the simplest descriptive level, digital information is an abstraction; analogic information is also an abstraction but of a different type. Digital data are symbols with conventionalized significance and no relationship to their referent. It is this lack of referential basis that gives power to words. With digital data it is possible to erect conceptual structures with no empirical referent. Except crudely, the units of analogic information do not often have symbolic significance, but they do usually have a referential basis. The units of analogic information are typically abstracted from that which is seen, heard, or recalled (as in the special cases of graphic arts and music).[1] The power of analogic information is its experiential nature; analogic information is specific and not easily capable of conveying generalization. Digital information is uniquely suited to generalization.

The matter is further confounded by the potentially complex interrelationships between digital and analogic information in motion pictures; the character of the total message can range from highly specific, as when the narration describes the scene shown, to highly general, as when the narration undertakes detailed conceptualization of the implications of the specific scene portrayed.[2]

As a start toward analysis, it can be suggested that in motion pictures there are at least six subdivisions of the general classes of digital and analogic information:

DIGITAL CHANNELS

Audio verbal: The words actually used in narration or dialogue.

Video verbal: Printed words and symbols projected on the screen as titles, etc.

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[1] Music is a special case in other respects. While the units normally have no symbolic significance, neither do they have a referential basis. Moreover, while the units of music can be conceptually manipulated, they are not clearly delimited. The problems of analyzing music would appear to be similar to those encountered in analyzing analogic data; hence the inclusion of music in this category.

[2] This is only a summary treatment of the problem of differential codification. More complete analysis of the various modes of codification is in preparation. For other discussions on the point, see Langer (23) and Ruesch and Kees (46).

ANALOGIC CHANNELS

Audio nonverbal: Sound effects, music, other nonverbal auditory cues.

Audio paraverbal: Inflections and intonations associated with spoken words, including characteristic accents and oral expressions used as words.

Video nonverbal: The visual component of motion pictures, including action portrayed, gestures, facial expressions, physical objects, settings.

Video paraverbal: Embellishments and elaborations on the printed words and symbols used in the video verbal channel.

The six channels enumerated are capable of transmitting independent sets of information. It may be that finer divisions could be made according to the criterion of independence; for example, gestures or facial expressions might be conceptually separated from the other elements in the video nonverbal channel. For the present, we have chosen not to exploit these possibilities. Further subdivision would serve only as a logical exercise given the existing methodological tools.

The independence of the audio paraverbal channel is due to the phonemic significance of stress and pitch in verbal expression. These phonemic variations account for the ambiguity of "they are cooking apples" and enable Sunday school children to make jokes about "Gladly, the cross-eyed bear." More generally, and encompassing the cognitive significance of affective communication, the independence of this channel is postulated on the view that the meaning of words as written is not necessarily the same as the meaning of words as spoken. The video paraverbal channel has been included in this typology as a matter of logical completeness. There is empirical evidence that this channel is of limited independence in simple information transmission (30), although pragmatic experience with print media suggests that the video paraverbal channel may have independence in broader cognitive contexts such as the affective domain.

The channels as separately defined are generally observed in complex interaction, and it is this combination which makes possible the communication of experiences difficult, or perhaps impossible, to convey through words alone. The same sequence of spoken words might be understood differently if uttered by a young girl rather than an older man. The communicator's voice can convey an attitude toward the material, suggesting that the material is boring and unimportant or is vital and exciting. The simple statement, accompanied by a smile, "My husband and I get along fine" could impart several different meanings. The statement could mean that the couple is extremely well adjusted, reasonably well adjusted, reasonably well adjusted but with problems, or, at the other end of the continuum, the statement could be interpreted as having ironic meaning. The tone of voice, the accompanying gestures, the smile (smirk, grin, grimace) all contribute meaning to the verbal statement. The paraverbal and nonverbal channels may transmit information which is at odds with the basic statement, or the information thus transmitted may amplify the statement. The addition of a narrator's comment to this specific scene could raise the scene to a level of generality not inherent therein.

Sound effects offer similar interactions. In addition to the recording of natural sounds which would ordinarily be expected to accompany the presented visual experience, sound effects have been artificially included in a manner paralleling the insertion of a narrator's comments. This technique has frequently been used for comic effect, as, for example, the ring of a gong when a clown is hit on the head, but also for serious effect, notably in the film <u>A Place in the Sun</u>. Here, a carefree lakeside scene was injected with foreboding by substituting the sound of a Stuka dive bomber for the natural sound of a motorboat. In these and other ways, the addition of paraverbal and nonverbal information can enrich or alter the intended and obtained meaning of verbal information.

<u>Functional Uniqueness</u>

The information channels and their possible interactions are not all unique to film and television. They exist to varying extent in all modes of communication, and it may be useful to consider the description of different modes in terms of the channels and channel combinations each includes. Further, each channel or class of channels may have its own syntactic and semantic characteristics, and a detailed structural analysis of each may be necessary. Different modes of communication which share the same channels should share much the same linguistic structure and should require relatively similar skills on the part of recipient individuals. Decisions regarding the tasks to be assigned to different modes of communication in education might well be based, therefore, on the extent to which the unique features, rather than the shared features, of each mode are relevant to given educational objectives. It might be argued, in fact, that the contribution of any given mode to instruction depends upon the extent to which its unique features are used.

Films can be used to record experiences which, under other circumstances, could be made available to the viewer's unaided eye or ear. A filmed lecture exemplifies this extreme. Films can also be used to <u>contrive</u> experiences which could not exist outside the film medium. The entertainment films <u>Citizen Kane</u> and <u>Last Year at Marienbad</u> or the educational films <u>The Quiet One</u> and <u>All My Babies</u> exemplify this end of the continuum. Between these extremes there are, of course, films which make varying use of unique motion picture capacities.

In film presentations where critical information is presented via channels or channel interactions which are not unique to motion pictures, there is little reason to expect unique cognitive effects as a result of using film. The reverse might also be hypothesized: where critical information is presented via features which are unique to motion pictures, unique cognitive effects may be expected. As an example, the films studied by Nelson (39) represent a case in point. For one film, the sound track alone was superior instructionally to the picture, while for another film, the results were reversed. When the main body of information is presented on the sound track by a narrator, it should not be surprising when a tape recording proves to be as effective as the film in conveying this body of information; if, on the other hand, the main body of information is presented through the complex interaction of motion and controlled auditory and visual exposure made possible by editing, it seems unlikely that another medium will prove as effective in conveying this body of information. In short, the structural characteristics of motion pictures are significant to the extent that they uniquely constrain or facilitate cognitive processes relative to the information presented. The idea of a constraining or facilitating relationship between form and content is, of course, related to the views of Whorf (56) on language and McLuhan (31) on mass media.

As early as 1933, on the basis of evidence dating from 1924, Rulon noted that "film technique fails to exhibit any superiority over a teaching technique which it merely duplicates" (47, p. 4). On purely logical grounds, if there is nothing that the medium is expected to do uniquely well, why be surprised when it doesn't do so? An airmail envelope may be used for an interoffice memorandum; one shouldn't be surprised, though, when there is no significant difference in the delivery. It can be suggested that a failure to recognize this possibility accounts for a significant part of the "overabundance of nonsignificance" arising from comparative effectiveness studies.

Within some of these studies, however, notable though isolated results have been obtained. Kanner and Rosenstein (20) had hypothesized that color television would be more effective than monochromatic TV in a task involving color coding of electronic equipment. After nonsignificant results, the authors suggested that the verbal labels for colors had been adequate substitutes for the actual colors. This view is consonant with evidence cited by Carroll (4) relating to words as carriers of sense impressions which would suggest that for simple tasks, at least, words have a "superior potency." The effects to be expected when verbal formulations are not adequate or the task is complex are still an open question.

Hovland (18) reported a study comparing the effects of documentary and commentator radio presentations in changing attitudes about the remaining length of the Pacific war. The versions did not differ in effect or credibility. One large difference in favor of the dramatic presentation occurred on a point that was made dramatically concerning estimates of damage done against Japan. A bombing sound effect was maintained for fifteen seconds to indicate the amount of bombing against Germany; the effect was maintained for one second to indicate tonnage against Japan. On the basis of the report, it is unreasonable to assume that no other variables were operating, but such data are suggestive of effects which existing formulations do not explain. Two similar items appear in another study by Hovland (18). Here, a comparison of film and filmstrip resulted in no overall difference in instructional effectiveness. On two points, however, the presentations did differ significantly. The first favored the filmstrip in teaching distance measurement on maps.

> . . . The movie used the rather unrealistic device of showing the distance scale being lifted up out of the corner of the map and applied to the map distance to be measured. The filmstrip, more realistically, illustrated the use of a strip of paper to transfer map distance to the scale for measuring. (18, p. 128)

The second point concerned teaching the measurement of contour intervals; this time the comparison favored the film.

> In showing the measuring of contour interval, the motion picture used moving viewpoint (from horizontal to vertical) to show how differences in elevation of terrain are projected onto a map in the form of contour lines. (18, p. 129)

It is not entirely clear that the use of movement in the example concerning distance measurement is any more "unrealistic" than the use of movement in the measurement of contour intervals. An equally reasonable speculation would be that in the contour movement example the depicted movement facilitated for the subjects the process of "cognitive transformation" (in the sense used by Guilford [13]). Such artificial transformations might conceivably facilitate learning in some situations (e.g., the bombing item) but be unnecessary or even inhibiting in other situations (e.g., the color and distance measurement comparisons).

It is clear that the audio and video nonverbal channels are relatively unique components of film and television, while the verbal and paraverbal channels are not. It is precisely these components which have not been subjected to a form of linguistic analysis, although some work has been begun (9, 14, 22, 26, 43, 46). More importantly, it is the complex combination of all channels through editing which may define both the functional uniqueness of cinema and the linguistic character of cinematic communication. It cannot be argued that a simple string of sounds or pictures constitutes "language" simply because receiver responses are evoked by such stimulation. But a film is more than a string of sounds and pictures. The strings are ordered, segmented, interlaced, emphasized, and punctuated by an individual (the editor) whose behavior seems closely similar to that of a speaker or writer producing a sentence. And it is not unreasonable to hypothesize also that such strings are rearranged, coded, compressed, selected, and chunked by another individual (the viewer) whose behavior resembles that of a listener or reader receiving a sentence.

Research Strategies

Gregory (9) has suggested that the motion picture is a distributive form of communication similar in many respects to modern English and possibly to some other relatively uninflected languages, such as Chinese. In Gregory's formulation, film scenes, in context, are presumed to be analogous to words or to phrased groups of words, while sequences of scenes are treated as analogous to sentences. Whether or not such conceptual filmic-linguistic parallels prove useful in the future, it can be suggested here that the objectives and problems faced in analyzing the two communication systems are similar and, hence, that research strategies previously applied in the study of written and spoken language should be applicable in the study of cine-language.

The present discussion will emphasize analysis of the analogic information channels in film, although it is recognized that an understanding of coordinated analogic and digital structure in sound motion pictures must be held as the ultimate goal. For verbal digital information, both the methods and the evidence available from psycholinguistic research are directly relevant. For the present, usable research strategies and tools may be discussed under two general headings--logical analysis and empirical analysis.

Logical Analysis

There are several logical tools and concepts which the linguist can apply in analyses of language structure. Some of these may have unique uses in considering film structure since they may aid in delineating apparent similarities and dissimilarities between film and verbal language and may suggest critical variables for experimental manipulation.

1. Syntactic Ambiguity. A common example of syntactic ambiguity is the sentence "They are cooking apples." The question of interest here is whether such ambiguity is possible in a film sequence. Since the specificity of photographic recording precludes the presentation of stimuli comparable to such generalized pronouns as "they," this form of ambiguous structure may not exist in film. On the other hand, it may be possible to construct film sequences in which the association between action and subject or object is left unclear. If so, it would be important to consider the structural characteristics of such sequences.

2. Semantic Ambiguity. Semantic ambiguity arises when a phrase or sentence inadequately elaborates the specific meaning of included words or when a word is considered out of context. It is known, for example, that words are more accurately perceived when embedded in spoken sentences (33, 34). This kind of ambiguity is possible in film, and it may be valuable to examine differences in scene meaning as a function of sequence context.

3. Syntactic Transformation. Miller (34) lists eight types of sentences formed by combinations of negative, passive, and interrogative transformations. In addition, Carroll (4) has discussed several other varieties of possible transformations and means by which complex sentences may be reduced to their basic sentence types. Can film sequences be similarly transformed and, if so, what are the structural characteristics of such transformations relative to original film sequences? Pre-

liminary consideration of this question suggests that a kind of active-passive transformation is an important emphatic device in film.

4. Recursiveness. Sentences are right- or left-recursive or are self-embedded (see [34]), and there appear to be comparable structures in film. An embedded sequence seems represented by one long scene in which all visual detail is presented more or le s simultaneously. In contrast, a right-recursive sequence "states" its subject-action-object orientation in an early scene, elaborating detail in subsequent scenes, while a left-recursive sequence presents its visual detail in early scenes and converges on the significant subject matter. The cinematic convention which prescribes a long-shot, medium-shot, close-up sequence seems to represent left-recursiveness in film.

5. Incongruity. While Osgood's (42) congruity principle is a psychological hypothesis, not a linguistic tool, it is useful for rational analytical purposes. It states that when two signs are related by an assertion (either associative or dissociative), the semantic characteristic of each shifts toward congruence with the semantic characteristic of the other, but the more meaningful sign shifts less. Osgood further suggests that the assertion relating two signs in a semantic system may be visual-perceptual, as well as verbal. It might be added here that such relations may operate both between signs within a scene and between scenes within a sequence. The use of congruity-incongruity relations between scenes appears to be an important structural device in films.

6. Semantic Redundancy. The linguist's type-token ratio is an accepted measure of semantic redundancy for verbal information, but there is no corresponding index for nonverbal information. The correlational analysis of physical film structure, discussed below, includes some approaches toward such a measure, but the concept of redundancy seems more appropriately listed here. It is conceived to refer both to visual content overlap between scenes and scene repetition between sequences and may have significant behavioral correlates.

7. Syntactic Redundancy. The variety-seeking nature of human communicators may produce a tendency toward syntactical changes to be imposed from sentence to sentence; having used a particular structure in one sentence reduces the probability that the same structure will be used in a second sentence. This kind of redundancy should also exist in film and should have important effects on viewer attention and learning.

Empirical Analysis

There are three basic kinds of experimental manipulation which seem relevant to the study of film structure, regardless of the dependent variables to which they are related. In addition, there are three varieties of correlational comparison which can be usefully applied. This discussion has emphasized research strategies appropriate for the analysis of existing motion pictures; obviously, experimental film versions can be constructed to incorporate many independent variables more subtle than those listed here, but these possibilities cannot be evaluated, it is contended, until a crude structure of existing film has been delineated. As a general strategy, such variables seem best investigated within the confines of the presently suggested, more grossly defined, variable categories.

1. <u>Channel Separation</u>. Through the use of sound and silent projection, subtitles, printed scripts, etc., it is possible to separate and subgroup the several information channels existing in film. The relative effects of various channel combinations on any of many dependent variables may be assessed. Also, other experimental and correlational analysis procedures may then be applied to separate channels.

2. <u>Sequence Change</u>. Changing the order of scenes and/or sequences is a primary means of manipulating structure and effects. It is apparent that investigation of the linguistic concepts listed above would utilize sequence changes to a large extent.

3. <u>Extraction-Deletion</u>. The contextual effects acting upon a given scene or sequence may be evaluated by comparisons between extracted versus inserted film segments. Similarly, a scene's contribution to context may be measured by comparisons between deleted and inserted film segments. Considerations of semantic ambiguity, incongruity, and redundancy can profitably make special use of such manipulation.

4. <u>S-S Correlation</u>. Language has a statistical structure; so too does film. It is possible to index, for whole films or film parts, the many physical characteristics of the stimulus aggregate and to intercorrelate these variables over collections of film segments, just as human attributes are measured and intercorrelated over collections of individuals. Typically, variables would be represented by frequency counts (or mathematical derivatives thereof) for film characteristics such as cuts, dissolves, changes in camera angle or distance, and other varieties of editorial and cinematic "effects" and devices. The resulting dimensions provide a useful physicalistic analysis of stimulus organization and permit relations among such characteristics and response variables to be studied. Some previous work has applied this technique to film (40, 51), although to date its use for relating stimulus variables to <u>response</u> criteria has been most successful in analyses of the printed language characteristics of frame segments in programed instruction (38, 48, 50).

5. <u>S-R Correlation</u>. Using whole film sequences, or parts defined by any of the manipulations and analyses described above, it is possible to relate specific response variables to assorted stimulus characteristics presented in a time series. For example, throughout the showing of a film sequence, GSR or eye-movement data might be collected and related

temporally to the series of cuts occurring in the film segment. To the extent that a particular structural characteristic is important in film, variations in structure should have behavioral correlates.

6. R-R Correlation. The most important dependent variables and measures for semantic and syntactical analysis of film would seem to be the following: semantic differential (42), cloze procedure (53), eye movement patterns (12), GSR (25), film analyzer data for any of several given response sets, filmic cognition and recognition memory tests (49), and verbal report data obtained under free association, recall memory, or structured interview conditions. Any of these variables may be used individually in experimental conditions as discussed previously. The point of this final section is to indicate that correlations for different treatment conditions using the same response mode or correlations among response modes are possible and, perhaps, uniquely useful. For example, verbal free-association responses can be obtained for systematically varied film sequences. Deese (5) has shown that associative structure can be investigated using factor analysis of free associations to specified stimulus word lists. Similar analyses are possible using specified "lists" of film scenes or sequences.

Some Preliminary Assumptions

A discussion of this topic fittingly concludes with a statement of some preliminary assumptions based on lessons learned in the general field of psycholinguistics. They are offered merely as heuristics for theory and research in cinema, with the recognition that further study will undoubtedly suggest the modification or discarding of all. Originally presented by Miller (35) as admonitions to psycholinguistic researchers, they may be paraphrased here as follows:

1. Not all physical features of film are significant for cinematic communication, and not all significant features of film have a physical representation.

2. The meaning of a film sequence should not be confused with its reference.

3. The meaning of a film sequence is not a linear sum of the meanings of the scenes that comprise it.

4. The syntactic structure of a film sequence imposes groupings that govern the interactions between the meanings of the scenes in that sequence.

5. There is no limit to the number of film sequences or the number of meanings that can be expressed.

6. A description of film and a description of a film viewer must be kept distinct.

7. There is a large biological component to the human capacity for articulate cinematic communication.

Finally, a general assumption implicit throughout this discussion has been that cinematic communication is a language, or is fast becoming one. At present, no vocabulary or syntax can be elaborated as support for the contention, though it is believed that intensive study along the lines suggested can eventually produce some understanding of these components. The assumption may have theoretical utility for the study of cinematic communication without having ultimate validity. It is interesting to speculate in this regard, however, on the extent to which verbal language had developed recognizable linguistic characteristics during its first century.

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SINGLE AND MULTIPLE CHANNEL PRESENTATION

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Research on the channels of modern communication media is much older than the media themselves. The media channels, after all, correspond to the human sensory modalities, of which vision and hearing are of principal usefulness.

Since the advent of motion pictures and television, however, it has become customary to subdivide the visual channel into two components: a pictorial channel (non-verbal) and a print channel (visual verbal). This division departs from the older neurological bases. The distinction is in the type of information or coding, rather than in the neural pathways utilized. Less frequently, the auditory channel is divided into two components: auditory verbal (spoken words) and auditory non-verbal (sound effects and music). The tendency to define channels according to the kind of information presented indicates the nature of the interest of the researcher in communication. He is concerned with the organization of information and its presentation to the human senses. The development of a concept of channels, therefore, has followed the line laid down by research on communications in general.

The present review deals with three channels of information presentation: the pictorial, the auditory verbal, and the print. These channels are basic to all current mass media. The more particular concern of this review is with the effects of these channels when used in combination to present information. As such, the relevance is chiefly to television, motion pictures, and other media using more than a single communication channel. A large literature has accumulated concerning the learning of information presented by multiple channels. This paper suggests a theoretical formulation by which the diverse results set forth in this literature may be better knitted together, and also suggests clarifying experiments where reconciliation is difficult. To these ends, the writer has systematically organized the literature.

Reprinted from "Single and Multiple Channel Communication: A Review of Research and a Proposed Model." AV Communication Review, IX (November-December 1961), 235-262.

The review is divided into four sections. The second, third, and fourth of these deal with the principal topic: the learning of information presented over multiple channels. The first section reviews the literature of experiments comparing one channel with another. That such a review is necessary may surprise readers who are already acquainted with existing reviews. The writer himself was surprised to discover the following facts that call for a new enumeration: (a) No previous review provides sufficient coverage of the relevant studies, and some experiments had escaped all reviewers. (b) The reviewers, often uninformed of each other's work, reviewed different studies. (c) No complete bibliography was widely available. (d) The reviews did not include information on the sensory modes basic to the channel differences. The first section of this paper attempts to correct some of these inadequacies.

I. Comparative Effectiveness of Three Single Channels: Audio, Print, and Pictorial

Although the earliest attempts to review the literature on the relative learning capacities of the sensory channels are found in reports of psychologists working on learning problems in the Ebbinghaus tradition, the first major efforts to organize the experimental results seem to have been stimulated by the extensive use of radio in the 1930's. Hollingsworth (49) devoted a chapter to the comparison of the audio channel with the visual. Elliot (25) made an extensive review as an adjunct to his own experiments with school children. Carver (15) contributed a chapter to a volume of radio research edited by Cantril and Allport. Reviews by McGeoch (85) and Stroud (120) continued the learning theory orientation. Klapper (63) included a chapter on the comparative effects of media in his monograph on the effects of mass media. This chapter was later included without the bibliography in a volume edited by Schramm (64).

The year 1950 marked two new research approaches to channel comparisons. The growth of interest in human engineering produced one of the best reviews to date, that by Day and Beach (20). A parallel development of interest in instructional film research led to a summary by Hoban and van Ormer (48)--the first review to consider the comparative effects involving the pictorial channel. Hovland (50) touched on the relative channel efficiency problem in his review of mass media research, but he based his observations on those of Klapper.

The major concern of all these reviewers except Hoban and van Ormer has been with audio-print comparisons. The principal patterns for organization of the experimental results have been the age and intelligence of the subjects; the difficulty and meaningfulness of the information presented; and the length of time between presentation of the information and the testing of the information. The conclusions of these separate reviewers are not repeated here since the analysis to follow includes the organization and the material on which these reviews were based. Reviews of the human engineering aspects of the sensory modes by Broadbent (9), Cheatham (16), Henneman (45), and McCormick (83) will be considered in a later section.

Audio and Print Channels:
Comparative Effectiveness for
Nonsense Syllables and Digits

The studies which have directly compared the learning of information in the print channel with that in the audio channel are divided according to the nature of the presented information. The division is not arbitrary, but is in accordance with one of the dimensions along which there are consistent differences--the difficulty or complexity of the material. Nonsense syllables and digits, the first type of material to be considered, are relatively difficult material as compared with, say, common words. Fourteen studies are available. Eight[1] of these found the print channel more effective; five[2] studies favored audio; and one[3] indicated no differences. The results favoring audio were achieved with young children; those favoring print, with older children or adults. These results are not strictly comparable, but may be summarized as follows: Relative channel effectiveness depends on the difficulty or complexity of the material for a given group of subjects provided the subjects can read. With material such as nonsense syllables and digits, adults find print an advantage. The reading skills of younger children, however, are so limited that the audio channel is probably the most effective for them regardless of the task.

Audio and Print Channels:
Comparative Effectiveness
for Meaningful Words

Fifteen studies which deal with lists of meaningful words presented in serial order are here considered. Eight[4] found the print channel more effective; three[5] favored audio; and four[6] found no differences. The studies supporting the audio channel used material suitable for young children. The findings favoring the print channel are all derived from studies with adult subjects except for the study by Carver (15). In every case indicating a print advantage, the material--such as foreign vocabulary and spelling--is relatively complex. Three of the "no difference"

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[1]Carver (15), Conway (18), Gates (32), Koch (67), Krawiec (69), Munsterberg and Bigham (95), Smedley (116), and Whitehead (125).

[2]Carver (15), Conway (18), Hemmon (44), Smedley (116), and Von Sybel (123).

[3]O'Brien (100).

[4]Calkins (11), Carver (15), Frankl (29), Kay (59), Kemsies (60), Kirkpatrick (62), Lay (75), and McDougall (84).

[5]Carver (15), Hawkins (42), and Pohlman (104).

[6]Carlson and Carr (13), Kemsies (61), Quantz (105), and Swift (122).

cases can be dismissed: (1) Swift (122) found results which fluctuated with difficulty level. (2) Quantz (105) was dealing with a single subject. (3) Carlson and Carr (13) experimented with rather unclearly differentiated "vocalizable and unvocalizable" words; these results are thus difficult to interpret within the context of the other experiments. The findings are in accord with the previously stated generalization: the print channel becomes more effective relative to the audio as the difficulty of the material for the subjects increases provided a fair degree of literacy is present.

Audio and Print Channels: Comparative Effectiveness for Meaningful Prose

Twenty-three studies have compared the effectiveness of audio and print channels in presenting educational talks, passages selected from fiction, essays, and advertisements. Superiority of audio was supported by eleven[7] of these, print by nine,[8] and three[9] found no differences. All of the studies favoring print deal with adult subjects and complex stimulus material. Again, the studies supporting the relative effectiveness of the audio channel used young children as subjects, or adults and older children with simpler information. There are two exceptions: Williams (127) found loud speaker presentation of a lecture more effective than a printed lecture for college students. Erickson and King (26) found audio superior for grades one through nine. Despite these exceptions, the generalization for nonsense syllables, digits, and meaningful words may be said to apply to meaningful prose also: the effectiveness of print relative to audio increases as the difficulty or complexity of the material increases provided the subjects are literate.

Pictorial Channel's Effectiveness Compared with Audio and Print

Studies involving the pictorial channel comparison are too few to permit differentiation by kind of subject matter presented. Also, their comparability is not satisfactory--a fact to be kept in mind in appraising the results.

Only fourteen studies of pictorial comparisons have been found. Five[10] of these found advantage for the pictorial channel over the print.

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[7] Burtt and Dobell (10), Carver (15), Dewick (21), Elliot (25), Erickson and King (26), Goldstein (35), Lacy (71), Russell (111), Stanton (119), Williams (127), and Young (129).

[8] Carver (15), Corey (19), Haugh (41), Henneman (45), Krawiec (69), Larsen and Feder (73), Lumley (78), Mead (86), and Russell (111).

[9] Green (37), Russell (111), and Worcester (128).

[10] Calkins (11), Hermann, Broussard and Todd (46), Kirkpatrick (62), Moore (90), and Pohlman (104).

Six[11] found a superiority for pictorial over audio, and three[12] studies found no consistent differences. (Of the six, Pohlman (104) used actual objects rather than pictures of them.) The weight of the studies certainly favors the pictorial channel. This generalization, however, may not be expressed with the same confidence as the audio versus print generalization because: (a) it is based on fewer studies; (b) the older studies are defective in experimental design and measurement; (c) the testing always involved verbal items, a fact which surely worked to the disadvantage of the pictorial channel; (d) the relative difficulty of the pictorial and verbal information is neither known nor controlled; (e) finally, the studies of Nelson (97) and Nelson and Moll (98) compare the effectiveness of the visuals in films with their sound tracks, a procedure which introduces many possibilities for bias.

Some speculation has been advanced concerning the seeming superioity of the pictorial channel. A position summarized by Miller et al. (89) is that pictures present more cues which can be used for discrimination, provided these cues are present when the discrimination is tested. Such speculation, however, seems somewhat premature. The empirical evidence must be considerably strengthened before any theory may be proposed with confidence.

Discussion of Single Channel Comparisons

Before proceeding to generalize from the studies among which there is considerable agreement, some attention should be paid to those experiments which have yielded contrary results. The pattern of results among the dissenting investigations is not sufficiently consistent to warrant serious theoretical attention. Some inconsistencies are perhaps the result of vagaries of sampling; others may be a product of weaknesses in experimental design including lack of randomization, improper control of conditions, insufficient number of replications, invalid or unreliable tests, and lack of probability statements. The older studies, of course, are most deficient along these lines. Some reviewers have suggested an arbitrary cut-off date prior to which all studies would be unacceptable. But this cut-off would eliminate some very enlightening studies--those of Munsterberg and Bigham in 1894, for instance. The only possible recommendation is that weaknesses of certain studies must be kept in mind in evaluating their findings.

Two other explanations may be suggested for certain of the discrepancies. The first is the yet-to-be-deduced relationship between the situation in which information is presented for learning and the situation in which the learning is tested. To test an audio presentation

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[11] Calkins (11), Kirkpatrick (62), Moore (90), Pohlman (104), Sumstine (121), and Weber (124).

[12] Laner (72), Nelson (97), and Nelson and Moll (98).

against a print presentation, and then measure the effect on written test is probably disadvantageous to the audio presentation. Disadvantage to a print presentation is also probable when it is tested by means of the audio channel. This discrepancy is uncontrolled in a large number of the reported studies. An attempt to discover a consistent test channel bias in the various studies was not successful, but this does not eliminate the possibility of such a bias as an important factor in specific experiments.

A second tentative explanation of the discrepancies applies only to presentations and tests involving the audio channel. When subjects are permitted to observe the lips and facial movements of a speaker, the intelligibility may be increased. This effect is implied by the results of Williams (127), and was systematically investigated by Neely (96) under conditions of noise. Unfortunately, information concerning this aspect of the experimental situation is not adequately reported in many of the studies reviewed, and systematic comparisons are not possible.

If we consider the exceptions as minor empirical aberrations, this generalization is possible concerning the majority of the studies comparing effectiveness of the audio and visual channels: Audio is a more effective channel than print when the information presented is simple and easily understood by the subjects, and for illiterates and semi-illiterate (e.g., children) regardless of the difficulty of information.[13] Print shows increasing advantage over audio for literate subjects roughly proportional to the increasing difficulty in their comprehension of the material. This generalization does not differ in any important respect from those made by previous reviewers, although increased confidence is possible because of additional studies.

Propositions as to Sensory Modes

Since new studies do not seem to be modifying the empirical generalizations at this level, it would seem desirable that future studies be designed to achieve a more basic level of explanation. One suggestion of a direction that such experimentation might take may be found in some propositions concerning the nature of the sensory modes upon which our conception of channels is based. The most appropriate paper in this area is a review by Cheathan (16). This paper is difficult to obtain. An apparent summary of it was published by Henneman (45) as an introduction to an experiment he made. A further condensation made by McCormick (83:427) seems so satisfactory to the present purpose that it is reproduced here:

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[13]Previous reviewers have noticed an advantage for audio when a delay intervened between the presentation and the testing of the information. This generalization was not investigated in the present review because the recall situations were divergent in so many respects as to make comparisons impossible.

1. Auditory stimuli are essentially temporal in nature. . . . Visual stimuli, however, are characteristically spatial. . . .

2. Auditory stimuli typically arrive sequentially in time, whereas visual stimuli may be presented either sequentially or simultaneously.

3. . . . auditory stimuli . . . have poor "referability," meaning that they usually cannot be kept continuously before the observer, although they can be repeated periodically. Visual stimuli offer good referability, because the information usually can be "stored" in the display.

4. Auditory stimuli offer fewer dimensions for the coding of information than do visual stimuli.

5. Speech (as one form of auditory stimuli) offers greater flexibility such as off-the-cuff variations in connotations, nuances, and inflections. Visual stimuli, on the other hand, require advance coding.

6. The "selectivity" of messages in speech offers a time advantage, since the pertinent information is already selected for the receiver. With visual stimuli, however, searching for information may be necessary, as in looking for information from tables, charts, maps, etc.

7. The rate of transmission of speech is limited to the speaking rate, whereas visual presentations can be faster.

8. Auditory stimuli are more "attention-demanding"; they "break in" on the attention of the operator. Visual stimuli, however, do not necessarily have this captive audience; the operator has to be looking toward the display in order to receive the stimulus.

9. Hearing is somewhat more resistant to fatigue than is vision.

McCormick's third proposition seems a plausible explanation of the increasing advantage of the print channel as the information becomes more difficult. Comprehension of a difficult unit of a message may be aided by reference to previous and subsequent units in the sequence. Such referral is not possible in the audio channel. The fourth proposition also concerns advantage for print. As any student of anatomy knows, the neural pathways from the eye to the brain are much more numerous and varied than those from the ear. Thus, theoretically, the capacity of the eye far exceeds that of the ear. However, Jacobson (52 and 53), who has analyzed the informational capacities of both organs, suggests that the brain is capable of utilizing only a very small percentage of the information conveyed by either the eye or the ear (less than 1 percent in the case of the ear). To account for the brain's failure to utilize much peripheral stimulation, Broadbent (9) proposes a provocative explanation: filtering in the central nervous system.

McCormick's fifth proposition may be related to the advantage of the audio channel with easily comprehended material, since the widely varied possibilities of vocal emphasis and punctuation greatly exceed those of print symbols having similar purpose, and may well be more readily perceptible. His eighth proposition, also, may shed light on the instances of audio advantage. However, the experiments supporting its superior attention-getting have all involved subjects whose attention focused on some other task. Superior ability of auditory stimuli to retain attention has not yet been demonstrated.

The accumulated evidence is not sufficient to allow generalization from the studies comparing the pictorial channel with the audio and print channels, but--as has been noted--the results tend to favor the pictorial. Further experimentation attempting to confirm this observation is necessary.

We have now completed our comparisons of three channels used independently--the pictorial, audio, and print--as to their effectiveness in inducing learning. We shall now consider simultaneous presentation of information over multiple channels.

II. Multiple Presentation Combinations of Pictorial, Print and Audio Channels

Details of Experimental Model

Multiple channel presentations involve at least two of the channels under consideration. Although television and sound motion pictures are examples of multiple channel media, the typical experimental situation is much simpler than any everyday experience with these media. Partly because of its great simplification, the experimental situation may be termed a model of the general case in which information is simultaneously presented over several channels.

Before proceeding with a review of the experimental results, it is necessary to consider the details of this experimental model. An analogy of the model may be helpful. A newscast is presented over television. Pictorial material with print titles appears on the screen accompanied by the voice of the newscaster. When the newscast is finished, a test is administered to the viewers to determine how much of the presented news they learned.

In generalizing terminology, information is presented simultaneously over some combination of the audio, print, and pictorial channels. The effectiveness of the communication is measured by some kind of test administered to the recipients.

The requirements of experimental design have imposed considerable formality upon the experiment which parallels the newscasting analogy. Where the newscast permits considerable variation in the employment of the three channels, the experiment requires simplification. Continuous simultaneous presentation is the most common experimental usage of channels. When channels are alternated in presenting information, the number and length of the alternations is carefully arranged.

Likewise, the information presented in the experiment is usually much more formal than newscast material. Lists of nonsense syllables or meaningful words are the most common type of information utilized in experimental presentations. When other materials such as prose passages are used, the difficulty of the material is usually first assessed.

In multiple channel experimentation, the relation of the information in each channel to the information in other channels should be specified. There are four possibilities here: (a) Two channels may present redundant information such as the same word, printed and spoken. (b) Two channels may present related information of an object and verbal description of the object. (c) Channel information--such as a picture of a tree in the pictorial channel and the word nine in the audio--may be unrelated. (d) The information presented may be contradictory as in the simultaneous presentation of the printed word, woman, and the spoken word, man. Scaling methods for meaningful materials such as Osgood's also may be applied. In experimental practice the relationships of information among channels have not been specified, but usually related or redundant information has been used. In those studies which have mentioned the relation of information among channels, the relationship has been subjectively rather than operationally determined.

Testing of Learning

An important aspect of multiple channel experimentation is the testing of the information which has been presented. While considerable assessment of the commercial media takes place, commercial communications usually are not designed to include tests and other response measures. With the experimental model, the criterion of the success of the communication is always specified. Some measure of learning is the most usual index of communications, although attitude scales, sales volume, and other indices of a communication's persuasiveness are also utilized. This review, however, is limited to studies which had learning in the more formal sense as their objective.

The experimenter has considerable latitude in his choice of a criterion of learning. The recipient of the information may be asked to reproduce it subsequently, or to recognize it within a context of related information. Reproduction or recall has been a popular learning measure in comparisons of the audio and print channels. However, since reproduction of pictorial information is difficult, recognition is a more satisfactory criterion for experiments involving the pictorial channel.

The use of a recognition criterion requires some additional considerations. The previously presented information is now embedded in similar but not previously exposed information. A question arises as to what channel or combination of channels should be used to present the information a second time to test for recognition. This problem also arises with associative learning for similar reasons. Much importance will be attached to this question in the discussion which is to follow. Most experimenters have used the print channel alone for testing regardless of the channel utilized in the original presentation.

However information is presented for testing, there are several responses which the recipients may be required to make. The most common of these is writing. The written response may take the form of meaningful words, or a check, a cross, or other indication of a choice from several alternatives. Among other methods of response used to indicate choice is the manipulation of electrical or mechanical switches. Vocal response, also, is utilized, particularly when reproduction of the original information is required. Is the mode of response an important variable affecting learning comparisons under multiple channel conditions? Investigations of this aspect of communications have yet to be made.

In summary, the experimental model we are examining is as follows: Simple information, such as lists of meaningful words and pictures of common objects, is presented over combinations of the audio, print and pictorial channels. The information thus simultaneously presented is usually redundant or related, but may be unrelated or contradictory. Recipients of the information are always tested to determine how much they learned. The test may require reproduction of the information, or it may require the recipient to recognize the information within a context of similar material. The second presentation of the information for testing may be made with any combination of channels. However, single channel testing, usually print (a written test), is most common.

The experimental model is rather removed from the media situation to which we should like to apply the results. A particular discrepancy to be noted is the experimental requirement that the recipient pay attention to the presented information. Without this requirement the experimental results would, of course, be uninterpretable. Nevertheless, the effect of this imposition on the validity of the extrapolation of the experimental results has not yet been determined. This lack, together with reservations about the other experimentally imposed formalities should be kept in mind when attempting to generalize from the experimental literature.

Redundant Information:
Audio Plus Print Compared
with One Channel Presentation

Mass media often use audio and print channels simultaneously to present the same verbal message. This case of redundant information in two channels is the only case likely to occur in mass media simultaneous usage of these particular channels. The cases of related, unrelated, or contradictory information occurring simultaneously in the audio and print channels are theoretically possible, and have been studied in a limited number of experiments which will be reviewed later. The experiments reviewed at this point are all comparisons of simultaneous audio-print presentations with either audio presentations alone, or with print presentations alone.

The empirical results are as follows. Of nine studies comparing simultaneous audio-print presentations with audio presentations of the information, four[14] indicated superiority for the combined channels, two[15] favored audio, and three[16] indicated no differences. With regard to the comparisons of simultaneous audio-print with print, seven[17] studies supported the simultaneous presentation, and two[18] found the presentation equivalent. Hartman (40) found the audio-print combination to be the most consistently effective of seven possible combinations of three channels tested. It is apparent that a simultaneous audio-print presentation is more effective than either audio or print alone when the information simultaneously presented is redundant.

These experimental results are reasonably clear-cut, but difficult to interpret. The theory has been advanced that increases in learning produced by increases in available cues are not to be expected unless the additional cues are available when the learning is tested. In the case considered here, we have been concerned with information presented simultaneously in the audio and print channels, tested in either the audio or print channels. Contrary to the theory just stated, the simultaneous presentation proves more effective despite the fact that the additional cues are not present when the information is tested via single channel.

McCormick (83) points out the similar facilitation of reaction time from combined audiovisual stimulation. The question of the possibility of simultaneous acquisition of information through different sensory channels is of relevance here, and will be discussed in more detail subsequently.

Related Material: Pictorial Plus Verbal Presentation Compared with One Channel

The studies reviewed here have all compared pictorial-verbal presentations with either print or audio. In most cases, pictorial and verbal surrogates for the same object or situation were used. The information in the channels, therefore, was related. Testing the learning of the information was either by recall or recognition except in the studies of Kale (56) and Kale and Grosslight (57) investigating association learning. The presentation of the information for testing was always verbal (printed or spoken) except in the studies just noted which also used pictures as stimulus materials in the testing situation.

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[14] Elliot (25), Koch (67), Munsterberg and Bigham (95), and Smedley (116).

[15] Henmon (44) and Schuyten (112).

[16] O'Brien (100), Pohlman (104), and Quantz (106).

[17] Elliot (25), Henmon (44), Koch (67), Munsterberg and Bigham (95), Pohlman (104), Smedley (116), and Young (129).

[18] O'Brien (100) and Quantz (105).

The number of studies involving simultaneous pictorial channel presentation is not sufficient for subdivision according to variations in the presentation or testing situation. Even taken as a whole, the number is inadequate for generalizations. Thirteen studies are reported. Four[19] supported the superiority of the pictorial and audio channels over the audio alone; three[20] studies found audio-pictorial presentations better than pictorial alone. Jones (54) found motion picture presentations of novels superior to the reading of them in one respect: the movie produced more understanding as measured by an essay. Weber (124) found pictorial and audio in combination better than a pictorial presentation, but Sumstine (121) found the opposite. Pohlman (104), who used real objects--rather than pictures--plus printed verbal descriptions of the objects, found them superior to an audio-print presentation of the verbal surrogates. Jorgensen (55) could show no differences between a television newscaster presentation and a newscaster with motion and still picture illustrations. While his study does not utilize the channels of major interest, it does contribute evidence on the addition of a pictorial component.

Three additional studies--whose relation to those already cited is peripheral rather than central--may be listed. Bousfield, Esterson and Whitmarsh (8) successively added black and white, then colored pictorial representations of objects to verbal descriptions, and achieved an increment of learning with each addition--a very surprising result in view of the wholly verbal testing. Kale (56) investigated English-Russian word associations, adding sound and pictorial surrogates to a basic print presentation. This situation, when analyzed in terms of the previously suggested model, is quite complex. The results reflected the complexity, but tended to support the advantage of the pictorial addition. It should be noted that in the Kale experiment the additional pictorial cues were also present when the information was tested. A subsequent study by Kale and Grosslight (57) found superiority for a print-pictorial combination, but not for audio-pictorial versions. Hartman (40) also found audio-pictorial the least satisfactory of the verbal-pictorial combinations.

The comparisons of pictorial-verbal presentations with single channel presentations strongly indicate advantage for the combination of channels. Despite these consistent results, there is good reason for caution in accepting them. The studies are few and different in design. In those studies comparing motion picture and television presentations of complex material with verbal presentations, the conditions for the comparison were not fair to the verbal channels, the verbal presentation being simply the sound component alone which was not designed for independent presentation.

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[19] Barrow and Wesley (6), Goldberg (34), Nelson (97), and Nelson and Moll (98).

[20] Nelson (97), Nelson and Moll (98), and Pohlman (104).

Regardless of the validity of the general conclusion, a more basic approach to multiple channel presentations is necessary. For the remainder of the paper we shall be concerned with a synthesis of theoretical views and experiments based on the experimental model previously presented. The case of redundant information simultaneously presented in the audio-print channels has already been discussed. We shall not consider the stimulus generalization model for simultaneously presenting and ting information in multiple channels; the possibility of interference ng channels; the special problem posed by association learning with multiple channels; and the kinesthesis-participation-practice controversy.

III. Stimulus Generalization Model for Information Simultaneously Presented

The stimulus generalization model predicted that learning of related and unrelated information simultaneously presented by multiple channels increases as the situation in which the learning of the information is tested becomes more similar to the situation in which the learning was presented. The derivation of this model is lengthy and has been given by Hartman (40). A somewhat briefer version, but retaining all the references, will now be developed.

Morris (91), Carpenter (14) and Gibson (33) have noted that the significance of cues, signs or symbols varies in the degree to which they retain the properties of their referents. Gibson distinguishes between conventional surrogates, arbitrary words and linguistic symbols, and nonconventional surrogates such as pictures. He also notes that the degree of relationship between a picture and its referent depends on physical stimulus similarity.

Elliot (25) noted that the comparative effectiveness of the audio and print channels could not be properly appraised unless both channels were also used to test the learning. Reed (107) reports data on recall of meaningful words which indicates that audio and print presentations were more effective when the testing was by the same channel as the original presentation. Roshal (109) stated the problem more formally, and noted that learning gains resulting from increased correspondence between the presentation and testing situation were deducible from the proposition that the probability of any stimulus' evoking a response was increased as the similarity of that stimulus to a second stimulus which had already evoked the response was increased--the definition of the phenomenon of stimulus generalization in SR terminology. Roshal tested the formulation by making films of knot tying from a variety of camera angles. He demonstrated that the film whose camera angle was identical to the subjects' view in practicing with the knots was the most successful. Further work by Kale (56) failed to show that verbs (action words) could be illustrated more successfully with motion pictures, and nouns (static words) with still pictures. Lefkowith (76 and 77) confirmed the stimulus generalization hypothesis for pictorial representation by demonstrating that a line drawing presentation led to better learning than a still picture presentation on a line drawing test, and that still pictures, in turn, surpassed line drawings when the results were measured by a still picture test. Hartman (40) showed that the stimulus generalization model could be applied to the resulting differential amounts of learning from the seven possible presentation combinations of the audio, print, and pictorial channels tested on the same combinations of the three channels.

Miller et al. (89) give an excellent discussion of stimulus generalization applied to communication mass media. Hartman (40) has modified and synthesized this position as follows: Stimulus generalization is an empirical observation that similar stimuli tend to evoke similar responses. An interpretation of this empirical generalization may be proposed which is somewhat similar to the theories of Guthrie and Estes. Generalization between two stimuli is a function of the number of cues which they possess in common. If a response has been learned to a stimulus, it may be argued that the subject has learned to respond to various cues or substimuli which the stimulus possesses. As the number of identical cues associated with two stimuli is increased, the probability that a response associated with one stimulus will be elicited by the other increases. In probabilistic terms, if a single cue can evoke a response, and if every cue of a previously learned stimulus has equal probability of such elicitation, the probability that a given response will be evoked by a second stimulus increases as the number of cues common to both stimuli and sufficient for the response increases.

If the two situations in which information is (a) presented for learning and (b) then presented again for testing are looked upon as two complex but similar sets of stimuli, the learning demonstrated in the second or testing situation may be expected to increase as the testing situation becomes more like the original situation in which the information was learned. This leads to the expectation that single channel testing such as the usual printed questions will not elicit fully the learning from a multiple channel medium. It is also to be expected that adding cues to the stimulus to be learned enhances its probability of evoking the response, since there are more handles available for the learner to grasp. However, these cues will have little effect if they are not present in the situation where the learning is used and tested. Pictorial illustration of print and audio should facilitate learning provided the pictures relate properly to the words, and do not interfere. Facilitation among multiple channels may be expected, but only with multiple channel testing.

Now that we have proposed this theory, it is desirable to discuss objections to it. First of all, cues are not equal in their probabilities of eliciting responses. Some cues are more likely to elicit response than others. Miller calls cues with high probabilities of response relevant cues and cues which have little probability of being used, irrelevant cues. Therefore, the addition of some cues is facilitating; the addition of others is not. Still other cues, as Miller et al. point out, may add only interference. Laner (72) analyzed the responses to a written test of learning from a motion picture, and concluded that emphasis on relevant cues was more important than fidelity of presentation. But with relevant cues, as with certain types of information theory, the probabilities of effectiveness should be determined in advance--a difficult matter and often impossible. Furthermore, this discussion assumes that the probabilities are independent rather than conditional, an assumption which in many instances of perception is not justified.

Second, this adaptation of the stimulus generalization model is most appropriate for discrimination learning, but discrimination is more complex than it has been made to appear. French (30), for instance, has demonstrated that different percentages of reinforcement yield strikingly different amounts of generalization for stimuli with identical cues in common.

Finally, there are some empirical facts which do not fit too well. From stimulus generalization theory we would expect that additional cues which are not present when the learning is tested will not induce additional learning. As has been already noted, the simultaneous presentation of redundant information in the audio and print channels is one exception. Another exception is found in the experiment of Bousfield, Esterson and Whitmarsh (8) which achieved additional learning from additions of pictures but without use of the pictures when the learning was tested. Hartman's findings, however, are to the contrary.

There are still other problems in applying the simulus generalization model to multiple channel learning presentation. However, work which may be of considerable interest to researchers in the mass media is proceeding. A very timely review of the stimulus generalization literature by Mednick and Freedman (87) has recently appeared. A major problem--now partially solved--was to extend the stimulus generalization model to the cognitive areas and to multiple dimensional stimuli. Dicken (22), Diven (23), Haggard (38), Lacey and Smith (70), and Razran (106) have achieved stimulus generalization gradients along meaning continua. Shepard (114) has produced and successfully tested a multiple dimensional model for which stimulus generalization gradients have been obtained. The remaining difficulty is to apply the model to the situation where alternation of attention among stimuli is possible. Shepard and Jenkins (115) report an unsuccessful assault on this problem using complex pictorial stimuli. (In this situation, translated into multiple channels, the subjects may disregard the information on one of the channels under conditions of simultaneous presentation.) But research is continuing and a solution may be in sight. Some of the difficulties encountered in extending the stimulus generalization model are undoubtedly cases of interference in attention to the information, or interferences produced by the meaning of the information itself. We shall now turn our attention to the relevant experiments on both matters.

Interference among Channels

The observation that interference may occur when information is simultaneously presented is as old as multiple channel research itself. In 1894, Munsterberg and Bigham (95) experimented with unrelated information in two channels under conditions of alternate and simultaneous presentation. They noted reduced learning under these conditions when contrasted with single channel presentations, and also noted that the audio channel seemed more resistant to interference. However, the difference in difficulty of information between the channels is a more likely contributor to this difference than the supposed audio advantage.

No further investigation along these lines occurred for a period of almost fifty years, probably because multiple channel research concentrated on the redundant case where interference is not likely to occur. However, some experimental designs produced interference accidentally. Koch (67) noted interference with alternate presentations of the audio and print channels. Two studies, one of Heron and Ziebarsh (47), the other by Williams (127) found audio presentation superior to a live speaker, and postulated interference from distraction in the live presentation. Laner (72) found interference and facilitation between a film and its sound track. Kale and Grosslight (57) also found sound track interference with a simple educational film for teaching foreign vocabulary. Hall (39) reported facilitation and interference among pictures and various kinds of printed titles. Lumsdaine and Gladstone (81) noted interference when humor was added to both channels of a vacabulary teaching film. Neu (99) also found interference from attention-getting devices.

None of the above studies went beyond the reporting of the occurrence of interference. It remained for those who applied information theory to the military problems of human engineering to reinstate the experimental paradigm of Munsterberg and Bigham, although usually without noting the original authorship. Henneman (45) examined the effects of introducing a simultaneous motor task on the learning of meaningful prose passages. The audio channel proved more resistant than print under these conditions. Mowbray (92) investigated the case of simultaneous presentation of unrelated information (letters and digits) over the audio and print channels. He observed, as had Henneman (45) and Munsterberg and Bigham (95), that the audio channel had superior resistance to interference. He also noted that the more difficult alphabetic information suffered more than the numerical information. Mowbray (93) made further investigations with meaningful prose passages. In these experiments the scanning of the print was greatly reduced by presenting the material by tape, with vision restricted by an aperture to about one-third of a line. Under these conditions the audio advantage in resistance to interference was reduced to a non-significant level, but the superior resistance of difficult material when paired with easy persisted. Mowbray concluded that simultaneous attention was only possible when the difficulty of the information presented was low enough to permit attention to alternate between channels. In a third experiment, Mowbray (94) confirmed the indivisibility of attention with difficult material. In this experiment the information presented was utilized in completing outline maps. Print proved more resistant to distraction, in this instance, perhaps an indication that the generalization of an audio advantage under conditions of distraction is limited. Klemmer (65) corroborated the superior resistance to interference of the more difficult of two simultaneously presented information series. He also found superiority for the print channel, but the finding was contaminated by the direction of the difference in difficulty and by the difference in the mode of the coding (frequency-coded tones, position-coded print). In a more carefully controlled experiment, Klemmer (66) used colors for visual information and tones for audio. After equating difficulty in single channel presentations, he obtained an advantage for the visual presentation under simultaneous interference conditions. The unique nature of the information presented makes integration with previous findings difficult, however. It is unknown whether this effect would be obtained with more meaningful information. Spilka (118) noted that the addition of print cues improved the comprehension of auditory information under conditions of noise. Hartman (40) confirmed the hypothesis of greater interference in the less difficult channel.

The scope of the experimentation on interference is limited almost entirely to the case of unrelated information simultaneously presented by the audio and print channels. Within this scope three generalizations seem possible: (a) that interference occurs when unrelated information is simultaneously presented and attention cannot be successfully alternated, and that it reduces the learning in both channels; (b) that increasing the difficulty of the presented information results in increasing losses through interference; (c) that when the information presented in the channels is of unequal difficulty, the less difficult information suffers the greater loss.

Advantage for either the print or audio channel in resistance to interference seems specific to other conditions. One of these may be the nature of the task under which learning is measured, as we discussed previously. Experimentation on comparative channel resistance must be careful to avoid the initial differences in the difficulty of information which have contaminated other studies.

The Mowbray and Klemmer experiments are of particular interest for the light they shed on the possibility of simultaneous sensory learning. Mowbray (93) interpreted his results as negating this possibility; he was particularly critical of Hebb (43) among others who were favorably disposed to accept this possibility. Broadbent (9), who is inclined to accept the Mowbray experiments, concluded that learning of simultaneously presented unrelated information may occur only when some alternation of attention is possible. He discusses the problem at some length in regard to his own proposition of filters in the central nervous system.

It is evident that presenting unrelated information in several channels simultaneously compels the recipient of the information to alternate his attention among the channels. As the information becomes more difficult or more complex, the recipient becomes less successful in this alternation, and may finally abandon one of the competing channels, concentrating his attention upon the other. How often the average television viewer encounters this type of interference is unknown, but if television presentations are unsuccessful in coordinating their communication channels, it may be much more frequently than one would imagine.

Since the alternation of attention required by the presentation of unrelated information in several channels reduces the learning in all channels, multiple channel presentations clearly have no advantage under these conditions, and, indeed, may be inferior to single channel presentations. Facilitation does not exist under these conditions. However, competing information is only one type of interference. Interference may also be generated by adverse cognitive relationships in information. We shall consider this possibility in the following discussion of the association under multiple channel conditions.

Multiple Channel Association Learning

Most of the studies previously reviewed have dealt with recognition, discrimination, or recall of all the presented information. Under conditions of association learning, one part of the information is learned as a response to the other. The information which serves as a stimulus is presented during both learning and testing. The information serving as the stimulus and that serving as the response may be either related, unrelated or contradictory. Various combinations of channels are possible for presenting both the stimulus information and for the response information which is to be associated. In testing for learning, different combinations of channels are possible for the presentation of stimulus information. The response has typically been written or oral reproduction of the information to be associated. As such, the testing of pictorial information has not been satisfactory, although the problem is easily solved if discrimination (recognition) rather than reproduction is substituted as the task.

Four studies have investigated the channel contribution to association. Lumsdaine (79) pioneered with his doctoral dissertation, of which there is a more readily accessible abridgment (80). He investigated all possible pairings of words and pictures in the stimulus and response positions, e.g., word-picture, word-word, picture-word, and picture-picture.

In all cases, the subject responded with a written word. Three different groups were investigated: (a) college students, mass tested; (b) grade school students, mass tested; and (c) college students, individually tested. For all three conditions the picture-word association proved superior and the word-picture association, inferior. The word-word and picture-picture associations were intermediate. Lumsdaine interpreted these findings as supporting his hypothesis that pictures are superior stimulus information for association and inferior response information, while words are superior response information and inferior stimulus information. Comparing the word-word and picture-picture conditions, for which Lumsdaine made no predictions, the word-word association was superior for both mass tested groups, and the picture-picture association was superior for the individually tested groups.

Bern (7) designed an experiment along the lines of Lumsdaine's, but differing in two respects: (a) he substituted discrimination for recall, allowing the pictorial response to be represented; (b) the subjects were all individually tested college students. He found association conditions of picture-picture and word-picture superior to picture-word and

and word-word, the order of differences being the order given. He concluded that pictures make better response terms than words. Bern also made an attempt to measure the learning in terms of changes in the facial musculature.

Interpretation of the results of Lumsdaine and Bern is complicated by their random pairing of items of information to be associated. The extent to which the items paired were related, unrelated or contradictory is unknown. Two other studies avoided this difficulty by choosing to associate foreign printed language and pictures, thus achieving the condition of unrelated information between the verbal-pictorial channels. Kale and Grosslight (57) used pictorial and English and Russian verbal descriptions of common objects. They found the picture-word association slightly, but not significantly, superior to the word-word association. They used recall as the measure of learning rather than discrimination in two channels. Kale and Grosslight also added English surrogates to the Russian, producing related pictorial and print information to be associated with unrelated Russian. This condition produced a significant advantage over the word-word associations. As mentioned previously, the addition of sound in the Kale study produced interference. Kopstein and Roshal (68) further tested the association of pictures and English words with Russian words, using recall. They found picture-word association learning superior to word-word association both in a picture-word testing presentation and in word-word testing presentation. It should be noted that the difference was much larger under the picture-word testing than the word-word.

To derive their hypotheses, both Lumsdaine and Bern have postulated chains of intervening subassociations between the stimulus and the response information to be associated. Lumsdaine cites a study by Pan (102), which indicated that better association between unrelated words could be achieved by providing words that mediated between stimulus and response. Lumsdaine's derivation is quite complex, and the following simplification is perhaps an injustice. Pictures make good stimuli because they do not evoke competing verbal associations. Words, on the other hand, do evoke competing verbal associations, and for this reason, are poor in the stimulus position. Words, according to Lumsdaine, make better responses than pictures because they possess a greater variety of associations which can be attached to the stimulus. Second, verbal associations are less specific than pictorial associations and, therefore, are easier to attach to a given stimulus.

Bern (7) bases his argument along the lines of Osgood's discussion of mediation (101). He cites studies of Dorcus (24) and Karwoski, Gramlich and Arnott (58) which showed that free association to pictures produces operational responses, while free association to words calls forth many contrasting words. These contrasting words, reasons Bern, are almost as likely to become conditioned to a stimulus as the original response word which called them forth. Bern reconciles his results with those of Lumsdaine by contending that Lumsdaine's recall testing required an additional verbal association with the picture which reduced the effectiveness of the picture in the response term.

When all four studies are considered together, the weight seems to favor Lumsdaine's conclusion that pictures are superior as stimulus information, particularly if the possibility of competing response association is small, as was the case with the Russian word studies. Since the extent and nature of the stimulus-response interference is unknown in both the Lumsdaine and Bern studies, generalization for these conditions does not seem possible. Bern's finding of better performance for conditions involving pictorial response with the introduction of pictorial testing is in agreement with the stimulus generalization hypothesis for presentation and testing conditions. The present experimental results certainly are not sufficient confirmation for the hypothesized association mechanisms which have been formulated.

The Kale and Grosslight (57) study found increased learning with the addition of English subtitles. Since these titles were also present in the testing of the learning, these results would be expected under the stimulus generalization hypothesis. Results not expected under the hypothesis have been found in a series of experiments which dealt with multiple channel association learning without terming it as such. These studies, originating with Gagne and Baker (31), have found that the association of verbal response with pictorial stimuli has resulted in improved discrimination of the pictorial stimuli without use of the verbal cues when the discrimination was tested. The results so far are not unanimous. Seven[21] studies yielded positive results and five[22] were negative.

This evidence must be regarded as inconclusive, but the possibility of learning facilitation through association is one which requires the attention of multiple channel experimentation. There is better evidence to support the notion of interference through cognitive association. But, once again, the available experiments simply concern the existence or nonexistence of the interference phenomenon. What is needed is controlled experimental variation of the cognitive relationships under multiple channel conditions. Until this need is met, it is impossible to go beyond the generalization that both interference and facilitation may result from the cognitive relationships among information in various channels, and that occurrence of both phenomena is independent of any expectation derived from the stimulus generalization hypotheses.

Participation:
Kinesthesis or Practice?

Participation is the active reproduction by the recipient of the information presented during learning trials. Such participation has been observed to enhance learning. The studies reported here are not exhaus-

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[21] Cantor (12), Baker and Wylie (4), French (30), Gagne and Baker (31), Goss (36), McAlister (82), and Rossman and Goss (110).

[22] Arnoult (2), Cleff (17), Lawshe and Cary (74), Robinson (108), and Smith and Goss (117).

tive but furnish some documentation for this observation. Fourteen studies are reported. Nine[23] are in favor of the generalization, and four[24] against. One study by Ash and Jaspen (3) showed that concurrent participation (tying knots) during a film presentation facilitated learning if the film had a slow rate of development, and inhibited learning if the film had a rapid rate of development.

The effectiveness of vocalization of information in increasing the learning of that information seems clearly established. But what is the nature of the phenomenon? Older writers attributed the learning increases to the added kinesthetic cues which the vocalization process introduced. Some tangential support for this view may be found in the experiment of O'Brien (100), who demonstrated that inhibiting subvocal responses in the study by Forster (27), who found that to vocalize information was more effective than to write it. The writer is inclined to the view of Michael and Maccoby (88) that participation is a matter of practice. Under this view the increases in learning are interpreted as the product of repeated reinforcement. This disposes of participation as a multiple channel phenomenon, and places it in the realm of schedules and patterns of reinforcement where it will no longer concern us here.

IV. Synthesis and Discussion

Learning from mass media capable of simultaneously producing an immense number of auditory and visual cues is an extremely complex process. What is perceived by an individual attending to a medium of communication is determined by the sensory limitations, prior associations, and habits, attitudes and motives which he brings to the learning situation. The experimental models which are the bases of our conceptualization of the multiple channel learning process lack the richness of detail and the complexity of organization of real-life communication. The differences between model and reality make extrapolation of experimental results difficult.

Klapper (64) has pointed out that the experiment utilizes subjects highly motivated to attend to the presented communications. The typical listener, viewer, or reader of the mass media is not so motivated. His exposure to the medium is highly selective since many distractions compete for his attention. His interest must be aroused and maintained. He may ignore the compact and logical exposition suited for the motivated student, previously sensitized.

While the incongruities between model and reality must be kept in mind when extrapolation is required, they by no means negate the use of extrapolation. The experimental method is certainly the best if not the

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[23] Abbott (1), Barlow (5), Forster (27), Frankfurther and Thiele (28), Hovland, Lumsdaine and Sheffield (51), Lumsdaine and Gladstone (81), Michael and Maccoby (88), O'Brien (100), and Seibert (113).

[24] Hemmon (44), Kale (56), Pohlman (104), and Roshal (109).

only way that new knowledge can be acquired. The assembled body of facts concerning learning under multiple channel conditions is really a special branch of the experimental literature on learning. It should have the same relation to education, advertising, training, and mental health information communicated through the mass media as does the general experimental literature on learning to the applied areas as a whole. The model derived from experiments should contribute a point of view which is useful in the engineering of human communications. A proposed communication should have a certain lawfulness with respect to the best available model. As discrepancies arise between the model and the reality it describes, experiments must be designed to produce evidence which will permit the alteration or discarding of the model. This is the only way a science of communication can proceed.

The present model may be briefly recapitulated. Its channels of interest are the audio, print, and pictorial. Certain considerations have been added to this basic notion of channels for presenting information. The first consideration is the nature of the elicitation or testing of the learning resulting from the communication. The second consideration is the cognitive relations of the information simultaneously presented in the various channels. The third consideration is the type of learning desired or expected to result from the receipt of the information. The final consideration is the experimental requirement that the recipients of the communication must pay attention.

Generalizations

From the review of the experimental literature certain major generalizations appear valid:

1. Comparing the channels individually as conveyors of information: sufficient information exists for comparison of the audio and print channels, but not for comparisons involving the pictorial channel. It may be concluded that the print channel is more effective than the audio when the information to be presented is difficult or complex and the subjects are reasonably literate. The audio channel is a more efficient communicator than print when the subjects are illiterate, and in many specific instances when less difficult material is used. The audio channel is also considered more attention-demanding when interruption of attendance to visual stimuli is required, but under conditions of continuous simultaneous audio-print presentation of non-redundant information, neither channel has as yet a demonstrable advantage in gaining attention.

2. With regard to the relation between the presentation of a communication and the conditions under which the effectiveness of the communication is tested, the amount of demonstrable learning from the communication increases as the similarity between the testing conditions and the conditions of the original presentation increases. This conclusion may be predicted by extending the stimulus generalization concept of experimental learning theory. Another way of stating the generalization is that cues available when information is learned are of aid only if they are present when the information is tested. Applied to the mul-

tiple channel presentation, this generalization becomes: the learning of information presented in several channels is more likely to be demonstrated if it is tested on several channels. This generalization has been found useful both for discrimination and association learning.

3. Summation of cues, or facilitation--an increase of learning with increasing information provided by multiple channels--will take place under certain conditions: (a) when redundant information is presented simultaneously in print and audio channels, the facilitation of simultaneously hearing and reading a verbal message may be demonstrated in tests on either channel alone--a fact contradictory to the stimulus generalization hypothesis noted above; (b) when the additional cues are also present in the testing of the information (stimulus generalization); (c) when certain associations among information units are facilitated by a cognitive relationship such as the success of a verbal label in improving the learning of an ambiguous drawing. The conditions governing these facilitation relationships, however, are not presently understood.

4. Interference among information simultaneously presented by multiple channels may be expected when (a) the information in the various channels is unrelated and/or the cognitive difficulty or rate of presentation is such that successful alternation of attention among channels is not possible; (b) contradictory cognitive relationships exist among informational units in the various channels.

5. With regard to association learning, it is easier to associate an informational unit to a picture than to a meaningful word. The best available explanation of this is that meaningful words possess contradictory and extraneous associations which interfere with the new attachment.

6. Increases in learning from active vocal reproduction of information by the recipient, involving kinesthetic sensations, are demonstrable but are better explained as a practice rather than a channel effect.

V. Implications for Communicators

Research in the behavioral sciences has been much more successful in the doubts it has cast than in the truths it has averred. Assuming, for the moment, reasonable correspondence between the research model and reality, we may ask several questions concerning the validity of some of the current mass media uses of multiple channels.

A common practice among multiple channel communicators has been to fill the channels, especially the pictorial, with as much information as possible. The obvious expectation is for additional communication to result from the additional information. However, the probability of interference resulting from the additional cues is very high. The hoped-for enhanced communication resulting from a summation of cues occurs only under special conditions. Most of the added cues in the mass media possess a large number of extraeous cognitive associations. The possibility that these associations will interfere with one another is probably greater than that they will facilitate learning.

If there is one principal unit of information that the communicator wishes to get across, every additional cue becomes a potential competitor which can interfere with the prime message. Even though the additional cues have been carefully related to the principal message by the communicator, the associations supplied by the recipients may negate all careful planning, and many of these associations are not presently predictable.

It may be argued that additional cues are excellent attention-gaining devices. So they are, if carefully handled. But a cue which has gained attention is likely to hold it. Too often the attention-getting device is allowed to continue in competition with the major message, or the message is introduced simultaneously with the attention-getting device. Attention may be gained, but communication of the messate may not result.

The greatest interference problem in televised communication probably arises from improper combination of the pictorial and audio channels. The reliance on the verbal audio channel to carry the core of the meaning is much heavier than is generally realized. The pictorial channel often merely illustrates or attracts attention. Unless careful coordination has been provided, there is a tendency to focus attention on the picture, while the significant message has been tucked away in the sound. This focusing of pictorial attention is usually a deliberate effort of the communicator on the assumption that the sound will take care of itself. But experimentation indicates that often sound does not take care of itself, particularly if it is continuous, and not an interjection. There seems to be no reason why the picture cannot be used to set up or emphasize the sound on occasion. A television commercial that began with an audio message and blank screen, instead of vice versa, might have startling effects.

There are several positive implications for the use of audio and pictorial channels which should be re-emphasized here. First a pictorial message is pregnant with meaning but this meaning is often ambiguous and subject to personal interpretation. The use of words (printed and spoken) to structure this ambiguity and fixate attention is essential. The picture needs the word as often as the word needs the picture. Second, audio-print facilitation has strong experimental support, and the combined audio-print presentation of important information should receive wider application. It should be noted, however, that the current practice of exposing large amounts of print well ahead of the introduction of the audio channel puts the reader of the print well ahead of the audio voice; the facilitation effect, consequently, is lost. Third, the audio channel is much more capable of obtaining attention if it is used as an interjection on the pictorial channel rather than being continuously parallel with the pictorial.

A last comment concerning the assessment or testing of the effectiveness of the multiple channel media in producing learning is appropriate. In almost every instance, this assessment has taken the form of a single channel, usually print. The weight of the experimental evidence indicates that this form of testing does not measure an adequate amount of multiple channel learning, and may lead to erroneous results--particularly when the learning of pictorial information is tested by means of verbal descriptions approximate to it.

The purpose of this review is to weld the rather scattered literature on multiple channel learning into a single experimental model capable of generating further research hypotheses. If more questions have been raised than answered, this purpose has been achieved. The problem of interference, in particular, seems deserving of immediate attention, particularly interference from cognitive associations.

The writer has found those experiments performed under stringent laboratory conditions to be the most helpful in drawing conclusions, and it is in the laboratory that multiple channel research should proceed. Field studies provide necessary checks on the extrapolation of experimental findings, but the lack of proper controls necessitates extreme caution in their interpretation. The present literature provides sufficient grounds for questioning some of the procedures currently practiced in the mass media. Research capable of evolving general principles for multiple channel communication should be possible in the near future.

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ON CHANNEL EFFECTIVENESS

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Unless the fundamental differences of information processing (IP) of the different modalities (or channels) is known, a variety of comparisons of different media seems hardly to be valid. Amid many conflicting research results concerning the comparative superiority of mass communications media, i.e., television, radio, newspapers, magazines, motion pictures, etc. which can be seen as basically relying upon the comparative effectiveness of visual (V), auditory (A), and audiovisual (AV) channels, tangible evidence suggests the possibility that when the amount of information to be processed is optimal, the AV channel may be a more effective means of communication than either single channel. The optimization of input of stimuli subjects IP to a number of very restrictive conditions, e.g., the optimization of the ratio of redundancy and entropy (information) in the input for a given person. Any generalization of the comparison of seeing- or hearing-superiority, and of any single-channel or dual-channel supremacy, can be meaningful only if conditions of IP are minutely specified.

The simultaneous AV channel inherits the advantages and disadvantages of both A and V channels, and presumbly has advantages over the A and V only if, for example, its A and V stimuli are closely identical, i.e., there exists nearly perfect between-channel redundancy (BCR) where BCR reaches unity, such that one channel provides cues and clues for the other channel when the number of clues is no more than optimum, or when the sum of information is not in excess of the capacity of the central nervous system (CNS), as additional cues might cause distraction and conflicting responses (36,71).

The differences found in communication efficiency among mass communications media and IP channels and modalities can be traced, either wholly or in part, to lack of specification of the particular conditions where media, channel, or modality differences were found. Since there is a capacity limit for any physical or physiological channel, IP through any medium, channel, or modality has an upper limit, varying in

Reprinted from "On Channel Effectiveness," AV Communication Review, XVI (Fall 1968), 245-267.

accordance with the environmental factors and whether or not these factors are conducive to IP. As the very existence of the capacity limit implies, any information beyond the limit is lost; in information theory this loss is called equivocation. Clearly, equivocation and error are two major factors which hinder IP. Error can never be greater than the amount of information (entropy or uncertainty), but equivocation increasing in proportion to input can reach asymptote.

Another factor of fundamental importance in communication is noise which, in a broad sense, is unwanted information, an inevitable occurrence in any IP situation. Error deteriorates IP; however, under certain conditions, purely physical noise has the unexpected effect of altering the receiver to the information task, thereby enhancing communication efficiency. In order to combat equivocation, error, and noise, any communication system usually employs the redundancy principle; for example, the redundancy rate in the English language is 50 percent (90), and the redundant bit called parity check in computer information storage devices.

This review is an attempt to delineate the controversial findings on modality superiority and channel difference, seeking <u>why</u> lack of agreement in experimental findings is so widespread. Indeed, the difficulty of comparing the relative effectiveness of media, modalities or channels has been fully recognized (50). Comparison is possible only after exhaustive categorization of different conditions, and some standardization of testing materials and administration. A number of surveys, mainly concerned with the effectiveness of television as compared with other media (6,34,49,59,64,88,91) have appeared in many journals and books. The one conclusion that can be drawn from nearly a thousand studies surveyed is: no generally conclusive statement can be made.

Controversies on the Superiority of Auditory, Visual and Audiovisual Information Processing

The differences between A and V IP are numerous. In any attempt to determine the performance of A and V modalities or channels, the general characteristics of the A and V channels might be summarized as follows (modification of the summary by McCormick, 67, p. 427):

AUDITORY CHANNEL	VISUAL CHANNEL
Temporal in nature	Spatial in nature, excepting TV and motion pictures which are also temporal
Sequential presentation	Both sequential and simultaneous presentation
Poor referability	Good referability; information can be stored in the display, but TV and motion pictures have poor referability in a normal communication situation

Fewer dimensions in information coding	Numerous dimensions in information coding
Greater flexibility; variation in connotations, nuances and inflection	Restricted flexibility and advance coding
Rate of transmission limited to speaking rate	Much faster rate of transmission
Less versatility	Greater versatility
More attention-demanding	Less attention-demanding
More resistant to fatigue	Less resistant to fatigue

Seeing is Better than Hearing

The battle for supremacy between seeing and hearing has been waged presumably ever since man was endowed with eyes and ears. Wihout exerting much searching effort at all one may easily locate a study favoring any certain IP modality or channel; it is equally true that with the same minimal expenditure of effort one may also find a study in which modality difference was found not to exist. In many old experimental studies, motion picture presentation of novels was found to be superior to, and to produce more understanding than, reading of the same (56). By presenting meaningful words in a serial learning paradigm to lower class Negro elementary school children, it was found that retarded readers learned more rapidly from the V than the A presentation (57). Commenting on the disparity between A and V comprehension, Travers (95) identified several factors in favor of V superiority, and attempted to establish the superior acceleratability, compressibility, and instanteousness of V over A materials. Indeed, the V modality can process much more information than can the A modality (54,55); however, both modalities are subject to the ultimate restriction of the CNS (40,43,87).

Within the V channel comparison itself, one may find that channel effectiveness is to a great extent determined by the stimulus and response materials; for example, May and Lumsdaine (65, pp. 146-147) found that "pictorial representations of objects make better stimulus terms than printed words naming the objects, and that printed words are better than pictures as response terms." Generally, pictorial presentations possess more dimensionality, with more cues and clues, and in the meantime have a greater amount of uncertainty than do printed words. In an idealized situation, both response and stimulus uncertainty (13) should be kept at the optimal level. Deviation from the optimum is likely to produce both facilitation and interference effects in IP. An example of these effects can be found in the study of pictures and various printed titles by Hall (33).

Hearing is Better than Seeing

Defenders of auditory superiority can come up with even more convincing experimental evidence in support of their claims. It is almost a truism that A is better than V for children (16,38). In studies where input was simple and easily understood, A was said to be a more effective channel than V for illiterate and semiliterate subjects (38). The A channel was also found to have superior resistance to interference, as evidenced by a number of studies (41,74). The supremacy of simple-input of A presentation for teaching those below a certain level of literacy can be attested to from the results of a more rapid rate of learning achieved with grade school children, poor readers, and lower ability children (14). It has been claimed that simple-input A presentation makes an extremely significant contribution to early progress in word attack and word recognition skills (24,104). Obviously, simple-input presentation is more suitable for those who have not yet acquired the language-skills which are the principal tools of any intellectual activity. However, when dealing with literate subjects much evidence has been found indicating that regardless of the difficulty level of information, the V presentation showed increasing advantages over A for literate subjects (38). Thus, in considering all studies it must be conceded that there are many factors influencing the relative effectiveness of A and V, and that neither is inherently superior to the other.

Seeing and Hearing are not Different

Based upon the capacity limit theorem (90), the null hypothesis on the A and V channels is at least plausible, since both A and V modalities have to process information through to the ultimate destination, i.e., the CNS. Studies exist in which modality difference was found to be nonexistent (46). Using geometric figures in the study of A and V perception, response time was found to vary linearly with figure complexity and to increase proportionally with the amount of noise; there was no indication as to which modality was really more effective (4).

A series of very interesting experiments was carried out by a Russian psychologist with respect to visual and auditory threshold sensitivity and comparison in the human being. Introducing caffeine as a factor, Nebylitsyn (78) concluded that there was complete lack of coincidence between subjects' rankings for visual sensitivity and auditory acuity. This seems to suggest that the superiority of either A or V can hardly be generalized.

Seeing-Hearing is Better than Seeing or Hearing Only

Since the AV channel is simply a combination of the A and V, it shares the characteristics of both the A and V channels. Precisely because of this, the problem concerning communication efficiency lies in the reinforcing of one channel with the other while concurrently keeping down between-channel interference effects. The maximization of reinforcement of one channel upon another, and the minimization of interference requires, first of all, the optimization of the amount of information; by optimization is meant the combined amount of A and V information approaching the maximum information processing capacity (IPC) of the CNS.

Because of between-channel interference, it is not by any means a rule that the AV is always better than the A or V only. A combined AV presentation was found superior to a pictorial only presentation (104); but Sumstine (cited by Hartman, 38) has found the opposite to be true, and Hartman (38) failed to substantiate superior learning from multiple channel presentation. Pohlman (also cited by Hartman, 38), using real objects, found them superior to an auditory-print presentation of the verbal surrogates; but Webb and Wallen (103) sustained the AV superiority over A and V, and Heron and Ziebars (44) found the superiority of A to a live speaker in two studies, indicating that interference might occur in a live presentation. TV lecture was also found superior to live speaker, radio, or printed presentation (31). With simultaneous A and V displays of different numbers presented in series, A was found to induce the best retention; but repetition in either modality was equally effective in retrieval (15).

Due to the limited capacity of man in handling and processing information, impairment in comprehension and retention might occur in the AV presentation when input is sufficiently rapid or complex--that is, when the amount of input is fairly great. Employing a "bisensory discrete matching task" with discrete A and V stimuli to be responded to by each hand, Adams and Creamer (1) were able to support the hypothesis that impairment under AV conditions did occur. Controversial evidence is abundant; in a single study, McCormick, Travers, and their associates (66) using nonsense syllables, words, and words with constraint as stimuli, have found the auditory presentation to be significantly less effective than the V and AV presentations, whereas V and AV presentations were equally effective. After varying exposure time, interval time, channel, and order of presentation, the V group mean was slightly higher than that of the A group, but not statistically significant. Also, in the same study the AV was found inferior as compared with the A and the V groups. The authors pointed out that the relative effectiveness of the A, V, and AV presentations was affected by the number of available dimensions for the coding of information.

Principal Causes for Controversial Findings

Individual differences and preferences for modality may also account for some of the unexpected results. It seems rather unfruitful to compare A with V without specifying the conditions and subjects, both of which contribute to the widely different findings of the superiority of A and V each to the other. The principal causes for all these controversial findings are: first, overlooking of the capacity limit theorem (20,90); second, failure to take into account the between-channel redundancy which specifies the ratio of identical information between the A and V channels; and third, lack of differentiation between error and equivocation, an area long neglected by communication students.

One-Channel Concept versus Redundancy Concept

A host of writers convinced of the superiority of one modality over the other usually cite Broadbent's concept of the one-channel system of man (10,23) that might be inferred further to the psychological refractory period (e.g., Creamer, 22). Herman's (42) studies on subjects' simultaneous performance of an auditory tracing and auditory discrimination task, with each task presented to a separate ear, seemed once more to confirm Broadbent's one-channel theory. However, the disputable point is that interference may occur when unrelated information is simultaneously presented and attention cannot be successfully alternated, thereby increasing the difficulty of IP, and also increasing losses through interference (58).

In an AV presentation, if A and V stimuli are identical (perfect BCR) or highly similar (high BCR), one channel provides cues or clues for the other channel when the number of cues or clues is no greater than optimum. In general, perfect BCR eliminates possible interference effects and reinforces one channel each by the other. If the amount of information is below the maximum capacity of the CNS, no between-channel interference can possibly occur, even if the information via the A and V channels is entirely different (i.e., BCR is zero). Provided that the information is related, auditory cues of various dimensions appreciably decrease the time involved in a visual search task (75). Cues generally bring about facilitation of IP, but when cues increase in number they eventually generate more information than the capacity and thus produce interference as well. When the information transmission rate in the AV presentation is vastly increased, but still borders on the capacity limit, it serves a very practical purpose by providing alternate choices of modality for those who habitually use or are fond of using either the A or V modality. Assuming there exists perfect BCR, i.e., the A and V information is identical and synchronized, it is probably valid to state that under such conditions the AV presentation is superior to either A or V alone. As the amount of information increases, the maximum capacity of the CNS can be reached by either the A or V information. When such is the case, there is little advantage in simultaneous AV presentation.

Capacity, Dimensionality, and Selectivity

As a rule, the V presentation can contain far more information than can the A presentation, since V materials can assume a vastly greater dimensionality than can A stimuli. Take TV for example: what appears on the TV screen [$1.2(10)^7$ bits/sec., 5]' far exceeds the IPC of the V modality [$4.32(10)^6$ bits/sec., 54], which in turn far exceeds the IPC of the A modality (8,000 bits/sec., 55). At this point, input information greatly exceeds that which could be processed by the CNS. Thus, the CNS must select only a portion of this information and discard the rest, so as to avoid overloading (11). "When some information must be discarded, it is not discarded at random" (Broadbent, 1958, p. 34). In other words, the natural adjusting mechanisms of the CNS selectively process only relevant information and discard irrelevant information, thus preventing it from entering and overburdening the nervous system (70).

Generally, if Broadbent's theory that "a nervous system acts to some extent as a single communication channel" (10, p. 297) could be unquestionably established, the AV presentation would yield no more gain in communication than would a single channel presentation. This is hardly the case, however, if the information rate of both A and V is low, e.g., below 2 bits/sec. If Garner's concept that "increased dimensionality leads to increased information transmission" (29, p. 135) can be sustained, AV presentation has definite advantages over A or V, provided that the AV does not too far exceed the IPC. Although both A and V modalities are IP mechanisms, each, of course, performs a different set of functions. No spoken words can adequately describe a picture, whereas no picture can reproduce the tone, inflection, intensity, and duration of the spoken voice. By the nature of dissimilarity in information, and in different IP mechanisms, AV should be expected to introduce interference when A and V information shares no redundancy; this should be particularly true when the amount of information is far above the IPC of the CNS.

A tentative assertion can be entertained at this stage: if the combined amount of information of A and V stimuli exceeds the upper limit of the CNS capacity, then both selection processes and interference take place; yet so long as neither A nor V stimuli reach the limit of the CNS, an AV presentation is generally a more efficient method of presenting communication materials. Since man's IPC is known under specified conditions (3,63,69,85), i.e., between 2 to 4 bits/sec. of information, the theoretical optimal rate of AV presentation can be ascertained. Thus, it appears that the superiority of AV over A or V almost entirely depends upon the amounts of transmitted information, i.e., input.

Empirical Evidence on Human Information Processing Capacity

Man's empirical IPC has been extensively reviewed by many authors (3,20,63,69,79,85). Since there is no single universally accepted communications theory in existence, the logical approach to communications study would be first of all the examination of the empirical and practical human capacity in processing information. The difficulties encountered by psychologists are conceivably far greater than those faced by computer scientists who, in most cases, know precisely what happens in their black box, namely, the computer. A communications student or psychologist at best can only control the stimulus and examine the response, or more mechanically, manipulate the input and observe the output data; in this manner, some reasonable inference can be made. A number of psychologists, using information theory principles, have examined amounts of transmitted and received information in relation to IPC and redundancy (51) from which a distinct pattern in IP seems to have emerged.

Various methods have been devised to determine the rate of IP from which the IPC of the CNS is inferred: Hick (45) and Hyman (53) have worked on disconjunctive reaction time; and Pollack's studies (82,83) on the absolute judgment of the pitch of pure tone verified Hick's conclusion that there exists a limit beyond which no gain would result from additional transmitted information. Similar findings have been obtained from a number of other studies: Hake and Garner (32) asked subjects to identify various positions of a pointer between two endmarks (0-1000) on a linear scale, with the experimental variable being the number of alternative positions. Hayes (39) linked vocabulary size with memory; his testing materials including binary digits, decimal digits, letters of the alphabet plus decimal digits, and 1,000 monosyllabic words.

Other studies took into account redundancy and dimensionality in addition to the examination of IPC. For example, Sumby and Pollack (92), using twelve different word-order approximations of 50 word-passages in English, asked subjects to reproduce the verbal material by writing, typing, and oral reading. The results are familiar to us now: the IP rate increases and average reaction time decreases as the order of approximation increases. Hartman's (35) experiments with the pitch of pure tones and the use of A stimuli by Pollack and Fick (83) confirmed the general principle that transmitted information increases with the number of stimulus aspects or dimensions. Garner (28), and Erikson and Hake (26) studied the absolute judgment of loudness and of the relation between stimulus range and the number of stimulus and response categories, using loudness and squareness as variables.

Proliferation of Information Theory

Russian psychologists, judging from the number of their publications, seem to be making energetic efforts in informational psychology. For instance, Tonkonogii and Tsukkerman (94) have used an information theory approach to the study of perceptual abnormality; Ukraintsev (97), among others, has studied the qualitative nature of the concept of information and control from the point of view of reflection, which is defined as the reproduction of the features of one system in the features of another. Usov (99) has investigated the optimization of the channel of information transmission. Ukraintsev (97) has even tried to incorporate information theory into the dialectical materialistic processes.

Attempts have also been made to associate information loading with concept and meaning (93). Probability learning is now a well known methodology in information theory (18,21). Many informational models have also been proposed (19,30). A treasury of model-based propositions can be found in both Hunt (52) and Garner (29). A number of studies have sustained what common sense would predict: for example, the "Bon Depart" (Good Start) method of learning to read and write, based on drawing, rhythm, and singing (9) is but a variation of the elementary redundancy principle. Following the work of Leonard (61), Egorov (25) has studied the relation between the IPC and task complexity in 20 flight training sessions. Each of these studies found that if the information needed to be processed is of very low amount and is repeated frequently enough, then learning will result. It has been found, for example, in the Egorov study and in Smith's Ebbinghausian study (69) that the effects of practice and training usually increase learning but not necessarily improve the capacity for learning, indicating a necessary distinction between the IPC and IP rate. Napalkow and Bobneva (77) have discovered a chain of behavior formed by successively adding links, pointing out that a subject is usually able to perfect his performance by trial and error; this demonstrates the importance of sequential redundancy (29).

Other Determinants in Information Processing

The IP rate is, to a certain extent, determined by psychological and physiological factors of the individual. Motivation increases the IP rate, and monetary incentive tends to facilitate IP (47), as does an emergency situation (62). But motivation, incentive, desire, and aspiration can in no way increase the IPC. A not too surprising fact concerning the daily experience of listening and looking is that no A or V stimuli are ever entirely processed and absorbed, i.e., heard or seen. It has been suggested that man is not motivated toward hearing or seeing all stimuli surrounding him; he either subconsciously refuses to process all the information--his defensive mechanism in IP performs homeostatic functions to fend off excessive information--or he selects only that information which has "surprise value," or "predictive value" (20), or is essential for his survival. The other possible explanation lies in the fact that when the system is overloaded, as is usually the case, the total amount of information simply exceeds the IPC of the CNS.

Optimal Information Loading

Morrisett and Hovland (73) have expounded the importance of optimal loading in a learning situation. They have found that an experimental group loaded with optimal information proved to be superior to low and high loaded groups. This study seems to have reconciled the opposite viewpoints on the relation of information amount and learning as to whether or not maximum information input would result in maximum information transfer, by indicating that there exists an optimal level between the two extremes.

Minor (72) has investigated the rate of speech with a simulated speech output device at 45, 60, and 75 characters/min. Subjects were required to write an alphanumeric response message during message transmission. The rate of 60 c.p.m. was found to be the most favorable in terms of accuracy and preference. Results seemed to indicate that when information needed to be processed is kept at a minimum, this information is operationally easier to process (86), and fewer errors are likely to be made.

Implicitly, the existence of an optimal level of information indicates the capacity limit theorem, which consequently implies equivocation; there equivocation exists, any information beyond the human capacity limit is lot, and whatever is lost is not incidentally a random phenomenon, but involves a highly developed information selection mechanism. Man's selection processes are determined by a host of factors such as information uncertainty, redundancy, and noise, but only the limitation of the IPC seems to have been firmly established (76).

A Principal Cause of Equivocation: Information Overloading

A major cause of equivocation is information overloading, with noise as a contributing factor. If difficulty is equated with loading, and forgetting with equivocation, the findings of Posner and Rossman (84), indicating that the greater the difficulty of a transformation the more forgetting will result from it, adequately describe the overloading effect. It seems that the most efficient means of learning or communication is to treat the receiver, in a very unsophisticated analogy, as an ulcer patient, feeding him the optimal amount of information as frequently as feasible.

Generally, communications tend to either underestimate or overestimate the IPC of receivers, which is not surprising as they lack a uniform measurement whereby to determine it precisely. To substantiate his "overloading theory" as being applicable to all organisms and organizations, J. G. Miller (78) conducted a series of researches on five levels of organization: cellular, organic, individual, group, and social. His results show similar phenomena at all levels: when the maximum channel capacity rate was reached, omission and filtering of information were prevalent. Queuing (information lined up to be processed in the short-term memory storage) occurred below the maximum rate. Urmer (98) similarly has reported that a sharp decline was registered at the information loading saturation point in a simulated military display system.

Multi-modality IP seems to reach the information overloading point faster than does IP under single modality conditions, particularly when BCR is low. When nonsense syllables, words, and words with constraint were presented through either one or both modalities, the results generally showed no advantage of AV presentation over a presentation involving only A or V. At a faster speed, however, a significant decrement was found in the AV, as if the use of two modalities resulted in interference of one transmission with the other (101). Travers and Jester (96) reported that under the AV condition subjects tended to block one channel by closing the eyes or covering the ears.

Redundancy, Equivocation and Error

Whenever there is constraint upon any phenomenon, event, system, or language, there is law. Constraint is the prerequisite of any law, and "every law is a constraint" (2). Every constraint constitutes redundancy. Redundancy in information theory is conventionally defined as one minus the relative entropy (relative information), which is the ratio of the actual to hypothetical maximum entropy (maximum information or uncertainty). It would be ideal if redundancy could be eliminated and IP within any physical channel could be maximized, thereby minimizing the effort and cost involved in IP.

Redundancy as defined is concerned with the sign or symbol system processed by one or more modalities, but there also exists internal redundancy. Internal redundancy is redundancy between stored information within the memory system and the information being processed. This differs from Brown's (12) concept, "Assuming that when a memory trace is established, it usually has some internal redundancy. In other words, the trace is established with more features than are necessary to represent the information which the trace is required to store." This redundancy, Brown argued, takes up memory storage space, but "the trace system can often supply some of the information lost through decay of an individual trace." But, "sensory information has to be transmitted from place to place in the central nervous system and the reduction of redundancy before this is done would enable the number of internal connecting fibres to be reduced" (5). Optimal coding to arrive at an optimal ratio of redundancy and information seems, therefore, to be a most important task for communications.

BCR has been discussed in some detail, and within-channel redundancy (WCR) has been extensively treated by Garner (29). In whatever form redundancy may appear or may be classified, it supposedly has the effect of increasing efficiency in IP, with the following capabilities: (1) reducing to a tolerable level errors in the encoding process and checking out errors in the decoding process by means of its built-in constraint system; (2) combating and perhaps reducing to an optimal level the effects of noise, interference and distortion in both internal and external channels--internal channel refers to the physiological channel; and (3) facilitating association and discrimination, and establishing memory trace in the organism's CNS as well as helping to prevent the organism from forgetting. These capabilities exist if and only if redundancy does not overreach the optimal ratio between information and redundancy.

Intrinsic Objective of Communication

Any purposeful communication has an intrinsic objective: it is what Weaver calls "the effectiveness problem" (90, p. 56). Its prerequisite is, however, Weaver's "technical problem," to obtain maximum communication efficiency and dependability; the former indicates minimum equivocation (information loss), and the latter signifies minimum error in information transfer from sender to receiver. Perfect information transmission and reception (perfect communication) is only theoretically possible; by perfect communication is meant that in which the information being transmitted, processed, and fed back sustains no equivocation of error.

In any information transfer, particularly in human communication, principally because of man's limited capacity in IP together with other physio-psychological factors, both equivocation and error are inevitable. The inevitability of the occurrence of equivocation and error necessarily demands a remedial action; redundancy is probably the most effective communication device man has found to cope with equivocation and error, or at least to reduce equivocation and error in IP. However, the introduction of redundancy into sign and channel systems invariably raises the cost of IP in terms of time and capacity, as redundancy necessarily takes up information space and/or time. In order to reduce equivocation and error, it is necessary to increase redundancy; but to increase redundancy is to decrease information. This is the communication theorist's perfect dilemma.

The very existence of equivocation and error renders perfect communication impossible; however, by manipulating redundancy in a message and/or channels, it is possible to achieve relative maximum information transfer by maintaining an optimal ratio between redundancy and information in order to keep both equivocation and error at the relative minimum. The maintenance of an optimal ratio between information and redundancy is of fundamental importance not only in communication theory, but in practical usage as well. Before the optimal ratio can be ascertained, the distinction between equivocation and error must be made, as equivocation and error are the two predominant factors in determining the optimal ratio.

The Imperative of Differentiation between Error and Equivocation

Evidence in support of the capacity limit suggests that output information is a linear function of input up to a point beyond which output remains constant (51); all information beyond the IPC becomes equivocation. Equivocation is "error by omission," usually compounded in the general term error (error by commission or projection). Error has the IPC as its upper limit; however, equivocation can, as is the case with input, reach asymptote. In addition to other minor causes attributable to noise, the principal cause of equivocation is, as described previously, information overloading, whereas error is subject to a host of factors. In a study using output, error, equivocation, and shared information as dependent variables, Hsia (51) was able to determine the channel differences by differentiating equivocation and error. The superiority of AV was established beyond any reasonable doubt when input information was optimal in relation to IPC. AV was found to be with much less error and equivocation, and consequently with a much higher efficiency and dependability rate. However, channel distinction in terms of effectiveness was no longer in evidence when input was either extremely high or very low with respect to IPC. It may be inferred that when input is much greater than the IPC, equivocation eliminates the differences, and that when input is much less than the IPC, both error and equivocation are unlikely to take place, therefore there are no channel differences.

The notion that V can process more information than A is, to a great extent, unfounded, in spite of the fact that the physiological capacity of V is much greater than that of A, as both A and V must feed information to the CNS. In the Hsia study (51), it was found that the V channel was more dependable than the A channel, whereas the A channel was more efficient than the V channel. In other words, the V channel made less error but in the meantime processed less information than did the A. The crucial evidence is that there was no significant difference in recalled information (shared information, Attneave, 3) between A and V. If a verdict has to be given, then the A and V channels can be said to be equally effective in recalled information only.

The theoretical question raised regarding man's IPC being a "single communication channel" or being capable of processing information supplied by two channels seems to have been solved. So long as information is not beyond his IPC, man is capable of processing information through both channels. It seems that Broadbent's position on the "single communication channel" and Garner's position that "increased dimensionality of information increases information transmission" are not, after all, irreconcilable.

Summary

Many discrepancies exist in studies on the comparative effectiveness of A, V, and AV presentations. A major cause for the controversial findings seems to be the failure of taking into account the capacity limit theorem and redundancy. Redundancy, in most cases, causes the IP rate to fluctuate. Communication efficiency could be increased by ascertaining the optimal ratio of redundancy and information, taking into consideration individual IPC and environmental differences and whether they facilitate or interfere with IP. The second major cause for conflicting evidence on the superiority of A, V, and AV seems to be the nondifferentiation of error and equivocation. As they are of entirely different natures, only when error and equivocation are distinguished can the effectiveness of IP be accurately determined, and channel comparison made meaningful. Equivocation can almost solely be attributed to information overloading, i.e., input information in excess of the capacity limit. Obviously, then, the reduction of equivocation can be accomplished by decreasing input information in accordance with the IPC. Error can be eliminated or reduced by the manipulation of redundancy to the optimal level where maximum information transfer would be made possible.

Examination of channel differences could also be conducted by categorizing the different forms of redundancy to precisely determine the rates of input, output, error, equivocation, and shared information in attempts to ascertain the communication phenomena under a variety of conditions and stimulus materials. It would then be possible, once and for all, to solve the controversies on the effectiveness of different channels, modalities, and probably also of stimulus materials in the forms of verbal statements, pictorial representations, printed words, etc.

Only after the IP rate of each modality and channel processing different stimulus materials is determined can the "semantic" and "effectiveness" problems as expounded by Weaver (90) be wrestled with, for both "semantic" and "effectiveness" problems of a communication are dependent upon solution of the "technical" problem (90) and arise only when a communication has been successfully received or processed. This paper has dealt only with problems entirely within the technical realm, but the writer entertains the hope that a series of full attacks upon semantic and effectiveness problems might be launched when the technical problem is sufficiently understood.

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CHANNEL VERSUS MODALITY

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* * *

A most significant conceptual inadequacy in this area is represented in the apparent confusion between "modalities" and "channels." That is, there is no consistent distinction drawn between the sensory modality involved in the communication of information and the coding system which characterizes the information presentation.

It is said, for example, that information may be presented through the print channel or the audio channel. No attempt is made to distinguish the two in that the former involves the visual modality, and the latter, the auditory modality, while it is verbal coding of information that is common to both. However, if one maintains the distinction between coding systems and sensory modalities, it must logically be concluded that the simultaneous presentation of a picture of a cow and the printed word "cow" is a combination of coding systems, employing a single sensory modality. But, the simultaneous presentation of a picture of a cow and the spoken word "cow" is both a combination of coding systems and sensory modalities. From the unexplicated channel point of view, both presentations would be conceived of as two-channel combinations whose comparison in a given experiment would be put forward as the basis for an ambiguous conclusion regarding multiple-channel communication of the same information.

The failure to make necessary conceptual distinctions not only leads to ambiguous treatment comparisons both within and across separate studies, but it seems also to have blinded researchers to the existence of significant presentation conditions. Thus, to continue the present example, a picture of a cow or the printed word "cow" in conjunction with the sound of a cow illustrates a treatment condition that has been overlooked by researchers in this problem area. Such omissions are understandable if one sees in them the failure to confront the more general problem of conceptual explication noted above. In this regard, the work

Excerpted from "Multiple-Sensory Modality Communication and the Problem of Sign Types," AV Communication Review, XV (Winter 1967), 371-383.

of Knowlton (1) is pertinent. Knowlton has attempted to provide a logical framework for what has here been called coding systems.

Knowlton distinguishes between the sensory modalities through which information is received and the types of sign vehicles that are employed in the presentation. Sign vehicles may be of two types, iconic or digital. What is most important to note in this context is that both types of sign vehicles may be employed in auditory and in visual presentations. Such an approach permits the specification of treatment conditions that have appeared in previous research and, in addition, allows the identification of possible combinations which researchers have ignored. The following paradigm illustrates this: viz., that four physically distinct sign vehicles have the potential for evoking the same response disposition or concept (cow) in a given individual.

		Sensory Modality	
		Auditory	Visual
Sign Type	Iconic	the sound "moo"	line drawing of a cow
	Digital	the spoken word "cow"	the printed word "cow"

In the light of this explication, the relationships of information in so-called multiple-channel presentations are seen to be labels applied to rather specific combinations of sign vehicle types and sensory modalities. The combination of digital-auditory "cow" and iconic-visual drawing of a cow is said to be "related" information. So also would the combination of visual-only iconic and digital signs. The combination of digital-auditory "cow" and digital-visual "cow" is said to be "redundant" information. Beyond this particular specification of what is exemplified by the redundant and related cases, these labels have no other explicit conceptual meaning.

On further analysis of actual experimental practice, however, it is clear that a distinction is implicitly made between the way pictures and words function in communication. Pictures "relate" to words in that the pictures can be reduced to or transformed to some referential function equivalent to or identical with the words with which they are paired. Further, it is the transformation of a picture to a specific linguistic response that is the crucial expectation. As noted earlier, this expectation is never empirically verified in research; rather, it is implicitly assumed in the investigator's choice of appropriate pictorial material.

* * *

At this point it will be necessary to reiterate the distinction between sensory modalities and sign types made earlier in order to further clarify the status of the redundant and related cases. Employing that distinction, it will follow that comparisons of a redundant presentation against either of the two components which make it up focus on a conclusion pertaining to the efficiency of combined-versus single-sensory modality presentations. Hence, in the following treatment paradigm, it is the sign types that are constant while the number and nature of the sensory modalities vary.

Auditory		Visual	
Digital	+	Digital	"redundant pair"
	vs		
_______		Digital	
	vs		
Digital		_______	

In effect, the above paradigm represents the presentation conditions examined in the Van Mondfrans and Travers study (8) and permits a conclusion regarding the advantages of using two sensory modalities over one in the learning of specific material.

Following the logic of the modality/sign type distinction, the related case may be shown to focus on a separate problem. In the following paradign, it is the sensory modality that is constant while the number and nature of the sign types vary.

Visual		Visual	
Iconic	+	Digital	"related" pair
	vs		
______		Digital	
	vs		
Iconic		_______	

The conclusion that such a paradigm justifies clearly has little to do with combined versus single modalities, but deals with the advantages of using two sign types over one. If by multiple-channel presentation it is intended to signify a combination of sign types, then only the above paradigm is appropriate for determining whether multiple-channel communications are superior to single-channel communications. However, as has been noted, it is simply not the case that the channel conception is so clearly formulated.

In sum, it appears that the failure to take cognizance of modality and sign type differences in redundant and related combinations permits an ambiguity that may be carried over into the interpretation of experimental results. Analysis of the combined presentation issue indicates that it encompasses two distinct questions that are likely to be confounded in experimental investigation, i.e.:

a. Is a presentation combination of two sensory modalities more efficient than either one of the modalities used alone for the learning of specified material?

b. Is a presentation combination of two signs more efficient than using either one of the sign types alone for the learning of specified material?

A consistent finding in the studies of Van Mondfrans and Travers and Severin is that there is no advantage in using two sensory modalities over one in the learning of meaningful material. Hence, the first of those questions has, in part, been answered. However, the second question remains unanswered and this omission is critical, given that combined presentations in research may confound both the modalities and sign types in the same treatment condition.

It would appear necessary that future research begin to examine this question from a more rigorous logical and conceptual base. It may well be that the answer to question b above is a positive one under specific conditions that are still to be elaborated. Yet, given current specification of what constitutes a related information combination, the answer may be identical to that found in the sensory modality comparisons.

Further explication of the relation between redundant and related presentations may be suggestive in this regard. Current use of the concept of redundancy (especially by Van Mondfrans and Travers) is ambiguous but not entirely uninterpretable. It seems apparent that what is intended by its use is not the physical or stimulus similarity of the component materials in a combined presentation, but rather the overlap in interpreted referential function of signs in combination. The pairing, for example, of the spoken word "cat" and the printed word "cat" is clearly nonredundant in physical terms. It is almost certain, however, that both signs make reference in the same way for a given individual, and the combination in this sense can be highly redundant.

It would appear that not physical similarity but equivalence in referential function is the defining criterion for "redundancy." It should follow, therefore, that the combination of two different sign types, whether they are presented in the same or in different sense modalities, defines a redundant presentation provided that they both evoke the same concept. Thus, the pairing of a picture of a cat and the printed word "cat" can be regarded as a condition of redundancy provided that the picture does indeed evoke the concept "cat" for a given individual. Hence, what has usually been defined as a related presentation can here be interpreted as a further instance of what is intended by recourse to the notion of redundancy. But, the present example involves presentation of information through a single sensory modality. It would now clearly involve some considerable strain to subsume the learning of such a pair within, for example, the single-channel model of information processing.

The crucial issue that the above interpretation brings to light is the failure to recognize and make explicit the built-in assumptions about sign learning which underlie certain operational procedures manifestly adopted to distinguish between pictorial and verbal stimuli. It is long overdue, but clearly in order, that we now systematically begin to make such assumptions the focus of research attention.