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Picture Recognition Memory: A Review of Research and Theory

By: W. Howard Levie
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When you see a picture, how good are you at recognizing whether or not you have seen it before? Quite good, according to the research. Picture recognition has been the focus of hundreds of research studies. The resulting literature is the largest single body of experimental research concerning human response to pictures. The purpose of this article is to provide a concise review of this literature, briefly describing the prominent theoretical positions, the variables that have received attention, and the major reliable findings.

Picture recognition memory experiments have a study phase and a test phase. In the study phase, subjects look at a series of pictures one after the other at a controlled rate. In the test phase, subjects see some of the study pictures mixed in with new pictures (distractors) and are asked to discriminate the study pictures from the distractors. Two kinds of tests are commonly used: forced-choice tests and single-item tests. In forced-choice tests, each test item consists of one study picture paired with one or more distractors. Subjects are asked to indicate which picture they have seen before. In single-item tests, study pictures and distractors are shown singly, and subjects respond "old" or "new" to each item.

The results of early research surprised most researchers. The extent of our ability to recognize when we have seen a picture before is quite remarkable. In a study that attracted wide attention, Shepard (1967) showed subjects a series of 612 color pictures taken from sources such as magazine advertisements. On a two-alternative forced-choice test, subjects picked out the "old" picture with a median accuracy of 98.5%. In another early study, Standing, Conezio, and Haber (1970) showed college students 2,560 color slides over a two or four day period. Recognition accuracy averaged 90%. An even more dramatic demonstration was provided by Standing (1973) who reported recognition accuracy of 83% after showing 10,000 slides! Under optimal conditions, then, picture recognition memory is excellent. It is so good, in fact, that researchers must take precautions to avoid ceiling effects that might mask the effects of the variables they are studying. Nevertheless, as this article will show, a wide range of independent variables have received attention.

This review first considers the relationship found between words and pictures in picture recognition memory research. It looks at the superiority of picture recognition memory over word recognition memory and the effect of accompanying pictures with words. Then, research concerning the effect of pictorial stimulus variables such as meaningfulness, complexity, and color is examined. This is followed by sections covering the effects of the learner's encoding strategy, how research design factors can affect results, and the role of individual differences in recognition tasks. Finally, a few research areas that are closely related to picture recognition memory are considered.

Pictures versus Words

A highly reliable finding in recognition memory experiments is that pictures are remembered better than words. Just a few of the many researchers who have produced this outcome are Bird and Bennett (1974), Borges, Stepnowsky, and Holt (1977), Cobb, Tanhauser, and Johnson (1980), Denis and Colonelli (1976), Durso and O'Sullivan (1983), Emmerich and Ackerman (1979), Gehring, Toglia, and Kimble (1976), Lutz and Scheirer (1974), Nelson, Metzler and Reed (1974), Park (1980), Snodgrass and Burns (1974), and Standing (1973). This finding has been called the "pictorial superiority effect," and the attempt to understand its causes has motivated a good bit of the research on picture recognition memory. In fact, the question of why pictures are remembered better than words could be considered the central issue of the entire research domain.

In some related research elaborating upon the picture superiority effect, Haber and Myers (1982) found that although pictures were recognized better than words, pictograms were recognized even better than pictures (see Figure 1). Dirks and Neisser (1977) found no difference between recognition memory for real objects and pictures of the objects. Finally, it has been shown that visual aspects of words such as type style can play a small but significant role in the recognition of printed words (Brooks, 1977; Hunt & Elliot, 1980; Kirsner, 1973).

Pictures Plus Words

Recognition memory for pictures can be affected by the addition of words. This section considers the results of research using either experimenter-provided or subject-generated words in addition to pictures and then discusses several influential memory models which have been proposed to account for these results.

Experimenter-Provided Words

Does adding printed or spoken labels improve recognition memory for pictures? The answer depends in part upon learner age and the abstractness of the stimuli. Mowbray and Luria (1973) and Wilgosh (1975) found that providing the names of pictures helped young children remember pictures. Nelson and Kosslyn (1976) found that labels helped 5-year-olds more than adults, and that labels were more helpful for abstract than for realistic stimuli (adults performed at ceiling for realistic pictures both with and without labels). With adults, Snodgrass, Volvovitz, and Walfish (1972) found that adding labels did not help

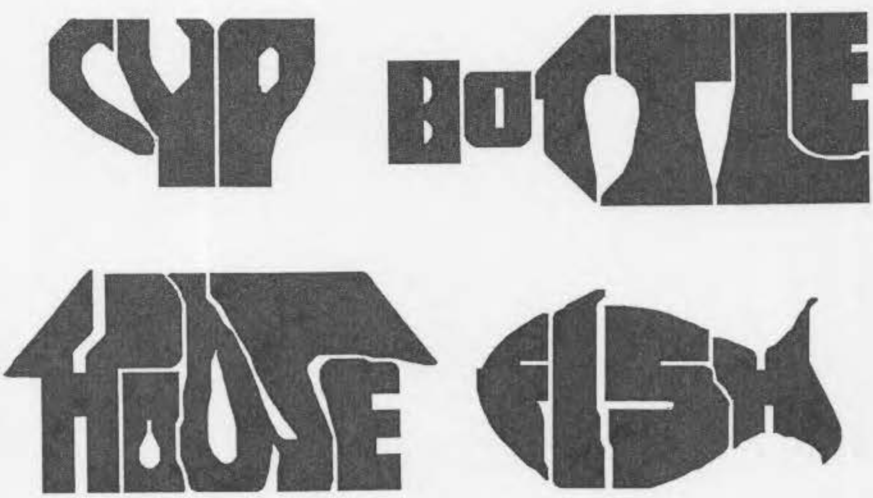

Figure 1. Pictograms

recognition of realistic pictures. However, when an added label increases the meaningfulness of a picture, recognition is improved (Bower, Karlin, & Dueck, 1975; Rafnel & Klatzky, 1978). Providing an inaccurate label depresses picture recognition (Madigan, 1983).

Providing verbal accompaniment that elaborates upon the picture can also improve memory performance. For example, Kerr and Winograd (1982) accompanied pictures of faces with short phrases about the person (e.g., "he's a vegetarian" or "he smokes cigars"). Face recognition was better with the descriptive phrases. Similarly, Standing and Smith (1975) found that the addition of a short spoken description improved recognition of complex pictures. Wiseman, Macleod, and Lootsteen (1985) showed that following the presentation of a picture with elaborating information could improve recognition of the picture. Furthermore, even following pictures with *unrelated* information improved performance over providing no information, although not as much as following the pictures with related information. The amount of information in the sentence (e.g., "This university has an excellent reputation for research," versus "This university has an excellent reputation for biological research in genetic engineering.") had no effect on performance. The authors speculate that the sentences caused subjects to review and further process their mental representation of the picture. This more elaborate representation was then more easily recalled than an unelaborated representation.

Captions can affect how subjects perceive and remember the parts of pictures. Jorg and Hormann (1978) showed that whether a drawing was labelled "a flower" or "a tulip" affected recognition for particular aspects of the picture. They suggest that the specificity of the label alerts the perceiver to a particular level of processing. Similar results were obtained by Gentner and Loftus (1979) who found that the specificity of the verb in a description ("the girl is HIKING down the path" versus "the girl is WALKING down the path") affected memory for pictures. Bacharach, Carr, and Mehner (1976) found that when the label described only a portion of a picture, children's recognition of the described part of the picture was improved, but at the expense of the nondescribed parts.

Subject-Generated Words

Several researchers have shown that naming pictures during study results in improved recognition (Kurtz & Hovland, 1953; Meyer, 1978). Kunen and Duncan (1983) had fourth graders, eighth graders and college students briefly describe what they saw as they viewed pictures. The verbal descriptions increased recognition of the study pictures, but also increased false recognitions of similar distractors. Loftus and Kallman (1979) instructed some subjects to name the details they saw in briefly presented pictures. On a recognition test, subjects who named pictures performed better than subjects who did not, a result that is "consistent with the notion that strengthening a verbal code during initial viewing augments the memorial representation of a picture" (p.209). When, however, distractors on the recognition test are verbally similar to study pictures, the advantage of verbal elaboration during study is reduced (Bartlett, Till, & Levy, 1980; Luszcz & Bacharach, 1980).

Although people probably normally engage in some sort of covert verbalization when they see pictures, some research indicates that the presentation of a picture will not necessarily activate its verbal label (Friedman & Bourne, 1976; Intraub, 1979). Accordingly, instructions to name a picture during study might be required to ensure that verbal encoding, and hence dual-coding (see following section), occurs.

Dual-Code versus Single-Code Memory Models

Research on pictures versus words and pictures plus words has led to rival hypotheses of how these stimuli are processed and stored in human memory. The hypothesis that has dominated the literature is Alan Paivio's dual-code hypothesis. The dual-code model postulates the existence of two symbolic systems: A verbal system specialized for processing and storing linguistic information, and a nonverbal system specialized for spatial information and mental imagery. The two systems can function independently, but they are also richly interconnected so that a person looking at pictures might engage in covert verbalization, or a person receiving words might engage in mental imagery.

When a concept registers in both memory systems it is said to be dual coded. Memory for concepts that are dual coded should be superior to memory for concepts that are entered into only one memory store. Because of our well-established practice of covertly labelling pictures, Paivio argues that it is typical for both codes to be activated when pictures are presented in memory experiments. The presentation of concrete words can result in dual coding if mental imagery is elicited, but the presentation of abstract words is unlikely to result in dual coding because of the difficulty of producing images that are redundant with abstract concepts. Thus, the dual-code model predicts the results of memory experiments: Pictures are remembered better than concrete words, which in turn are remembered better than abstract words (Paivio, 1971, 1986).

Many studies have been conducted for the primary purpose of providing evidence to test various predictions of the dual-code hypothesis. Bleasdale (1983) and Paivio (1978, 1983, 1986), among others, have reviewed this evidence. Paivio (1983) identifies ten major classes of experimental findings which support his model. Among these are (1) studies showing differences in memory for pictures and words, (2) differences found when subjects are instructed to use either verbal or imagery learning strategies, (3)

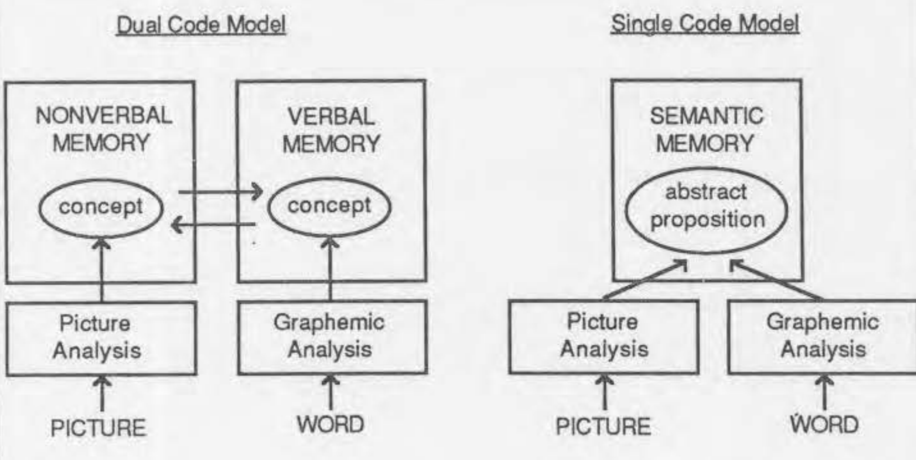

Figure 2. The basic components of the Dual Code Model and the Single Code Model

studies on mental rotations, (4) studies showing differential effects of interference on verbal and nonverbal processes, (5) individual differences in imagery and verbal ability, and (6) functional differences between the cerebral hemispheres of the brain.

Several theorists have spoken out against the dual-code model (e.g., Anderson, 1976; Anderson & Bower, 1973; Chase & Clark, 1972; Kieras, 1978; Norman & Rumelhart, 1975; Palmer, 1977; Pylyshyn, 1973,1981). They contend that all information is represented in memory in a single code. This code underlies our ability to interpret both pictures and words. The initial stages of processing pictures and words may differ, but ultimately both types of information are coded in a common memory store consisting of abstract propositions.

Single-code theorists do not regard experimental data such as the pictorial superiority effect as evidence for separate systems, but only as different activations of a common system. Research that has been considered threatening to the dual-code model includes evidence that in memory retrieval tasks subjects cannot distinguish information that was presented pictorially from that presented verbally (Guenther, 1980), and demonstrations that various interference techniques affect memory for verbal and pictorial material in a similar way (Anderson & Paulson, 1978). Anderson (1978) reviewed the evidence for the two approaches and concluded that neither side holds a clear advantage. In fact, he questions whether it will be possible to settle the issue via behavioral data. For recent evaluations of these models see Kobayashi (1986) and Kolers and Brison (1984).

Snodgrass (1984) proposes a multilevel model in which information from separate verbal and nonverbal systems is passed on to a single propositional store. Other researchers feel that even dual-code models are too narrow. For example, Deffenbacher, Carr, and Leu (1981) provide evidence that human faces constitute a special class of stimuli that might be handled by yet a third memory system. As Kolers and Brison (1984) argue, it is doubtless the case that knowledge can be represented in a variety of ways, depending on the task, the modality, and the mental operations involved.

Summary

The addition of words can affect picture recognition in a variety of ways. Depending upon the circumstances, these effects have been attributed to dual-coding or to the ability of added words to enhance meaningfulness, direct attention to specific aspects of the picture, or stimulate the rehearsal of pictorial information. Although the addition of words can measurably improve picture recognition, the addition of picture-redundant labels will probably result in very little improvement in adults' picture recognition in simple experimental situations.

Pictorial Stimulus Variables

Pictures can be manipulated in a variety of ways. A picture of a landscape, for instance, may be in black-and-white or color, may be very detailed or be a simple line drawing, and may contain many identifiable objects or only a few. This section looks at how these and other characteristics of pictures affect recognition memory. In addition, research on memory for different parts and attributes of pictures is considered.

Distinctiveness

Pictures that are "distinctive" are more memorable than less distinctive pictures. Standing (1973) found better recognition memory for "vivid" pictures (e.g., a picture of a dog holding a pipe in its mouth) than for "normal" pictures (ordinary photographs of dogs). Franken and Rowland (1979) had judges select the 50 "most different" pictures from a set of 1,000 realworld photographs. Recognition memory for these relatively distinctive pictures was superior to memory for a set of pictures selected randomly from the 950 less distinctive pictures. Farley, Cohen, and Sanfeliz (1979) analyzed data relating recognition accuracy to ratings of several aesthetic qualities of pictures, concluding that distinctiveness was the underlying dimension relating recognition and aesthetic quality.

One type of research on distinctiveness uses pictures of human faces as stimuli. Pictures of faces are better recognized if they are rated as being "unusual" (Light, Kayra-Stuart, & Hollander, 1979), "atypical" (Courtois & Mueller, 1981), high or low in "attractiveness" (Shepard & Ellis, 1973), or simply "distinctive" (Cohen & Carr, 1975).

Recognition memory for the different objects shown in a picture may be related to the relative distinctiveness of the objects. For example, Friedman (1979) showed that memory was better for "unexpected" objects that would not normally be found in a scene (e.g., a swimming pool in a livingroom). One explanation of the distinctiveness effect involves the possible difference in subjects' encoding activity for distinctive as compared to common pictures. As Craik (1981) puts it:

> If the stimulus is common or is expected, processing is relatively automatic; few analytic operations need be carried out and the resulting memory trace will be impoverished. Alternatively, if....the material induces extensive elaborate processing, a rich mnemonic record will be formed and this distinctive trace will be highly discriminable at retrieval (p. 384).

The Role of Distinctiveness in Picture-Word Memory Models

Several models of picture-word processing that have been proposed as alternatives to the dual-code hypothesis are concerned with the relative distinctiveness of pictures and words. The Sensory-Semantic Model suggests that the presentation of a picture involves interpreting and storing two aspects of an item: a sensory code that is concerned with the visual appearance of an item, and a semantic code that concerns the meaning of the item (Nelson, 1979; Nelson & Castano, 1984). Whereas the semantic code for a concept presented as a picture or as a word label may be the same, the sensory code for the two stimuli differ, and most importantly, the sensory code for pictures is more distinctive, more differentiating. With words, sensory codes are relatively similar from item to item. That is, one word tends to look more like other words than a particular picture tends to look like other pictures. Thus, with words, there is more interference between items. The pictorial superiority effect, then, is tied to the visual features of pictures. When there is a high schematic similarity between pictures, the usual pictorial superiority effect disappears (Kiphart, Sjogren, & Cross, 1984; Kiphart, Sjogren, Loomis, & Cross, 1985; Nelson, Reed, & McEvoy, 1977; Nelson, Reed & Walling, 1976).

Durso and associates (Durso & Johnson, 1979, 1980; Durso & O'Sullivan, 1983) offer a "generic-specific hypothesis." In this model, the semantic representations of pictures and words are coded in the same semantic system, but differ primarily in terms of specificity. The semantic information resulting from encoding a pictorial stimulus is tied to specific aspects of the particular picture. Each picture encountered is unique. Words, on the other hand, have been encountered many times before and are not novel stimuli. The semantic information encoded from a word is more general and "generic" to a range of exemplars and contexts in which the word has been encountered. Thus memory representations vary on a dimension from generic to specific. Some representations mixture of generic and specific information. When pictures or their word labels are used as retrieval cues to information stored in long term memory, the specificity of the representation activated will differ.

Yet another model related to distinctiveness that has been invoked to explain the picture superiority effect is frequency theory. Research with verbal material and nonmeaningful shapes shows that subjects can make recognition discriminations based upon their estimates of the relative frequency of test items. Also, rare items are recognized more accurately than common items (Ross, 1972). Ghatala, Levin, and Wilder (1973) showed that pictures are judged to be more novel (less frequent) than words. When the judged frequency of the words and pictures used in a recognition experiment was equated, the usual superiority of pictures disappeared (Levin, Ghatala, & Wilder, 1974).

Meaningfulness

The meaningfulness of the study material is a powerful factor in many types of learning. Generally, information that is low in meaningfulness to the learner is not remembered. Thus the high performance levels found with meaningful pictures drops sharply when stimuli such as nonsense shapes are used (Arnoult, 1956; Clark & Dnoll, 1969; Nagata, 1986). Similarly, Koen (1969) and Nelson (1971) found better memory for representational paintings than for abstract paintings. In experiments manipulating the meaningfulness of pictures, Franzwa (1973) defined meaningfulness in terms of the ease with which pictures of animals could be named by a group of judges. Pictures of animals that were easily named (hence high in meaningfulness) were recognized better than pictures of animals low in meaningfulness. Bower, Karlin, and Dueck (1975) and Rafnel and Klatzky (1978) found that memory for nonsensical pictures was improved when they were accompanied by verbal explanations that made sense out of the picture. (See Figure 3.)

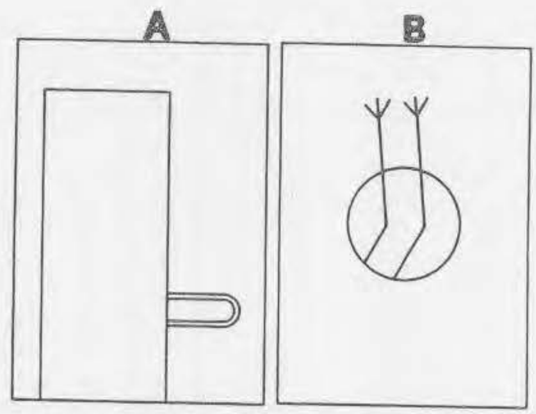

Figure 3. Droodles showing (A) midget playing a trombone in a phone booth and (B) an early bird who caught a very strong worm.

But in an interesting study, MacLeod (1986) used Droodles to show that cross-modal recognition can take place even when meaningful encoding of the pictures does not take place during the study phase of the experiment.

Freedman and Haber (1974) and Wiseman and Neisser (1974) used stimuli like those shown in Figure 4. Subjects were more likely to recognize a stimulus during the test, if they were able to see the face in the stimulus during the study phase. Meaningfulness, then, is a function of the perceiver as well as a property of the stimulus. Perceivers for whom a particular type of stimulus is more meaningful (e.g., expert chess players rather than novices) will show superior ability to accurately recognize stimulus patterns (chess board positions) involving that class of stimuli (Goldin, 1979).

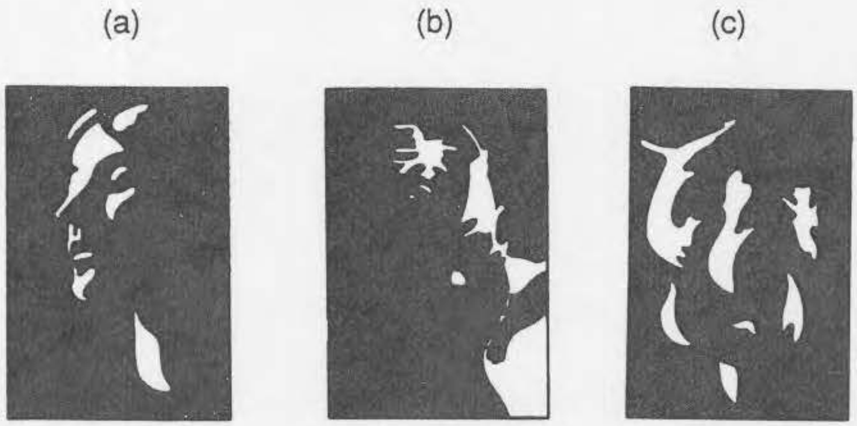

Figure 4. Examples of stimuli used in recognition memory experiment by Freedman and Haber. (1974)

The meaningfulness of a series of pictures has also been studied. Cobb, Tanhauser, and Johnston (1980) showed that when a series of pictures were thematically related, the tendency to judge new distractors as "old" was an increasing function of the degree to which they represented the theme. For further research on the meaningfulness of pictorial organization, see Baggett (1975), Hock, Romanski, Galie, and Williams (1978), and Leibrich and White (1983).

Visual Richness

Visual richness is implicated in yet another attempt to explain the picture superiority effect — the "incidental cue hypothesis." Jenkins, Neale, and Deno (1967) proposed that the advantage of pictures is due to their greater perceptual richness. As compared to their word labels, pictures provide a greater number and variety of "incidental" cues that could be used to form a richer memory trace. If this hypothesis is correct, it would follow that pictures rich in such cues would be remembered better than impoverished pictures. Researchers seeking support for this hypothesis have reported mixed, but generally discouraging results.

Nelson, Metzler, and Reed (1974) produced a set of pictures in three versions: (1) Black and white photographs, (2) detailed line drawings of the same scenes, and (3) simple unembellished line drawings of the main objects in the scenes. College students were shown one of these three versions at a presentation rate of ten seconds per picture. Recognition did not differ for the three versions on both immediate and delayed tests (although a ceiling effect might have masked possible differences on the immediate test). Madigan (1983) produced essentially the same results with similar stimuli. Rock, Halper, and Clayton (1972) demonstrated that "those features of a figure which are immaterial to its over-all, global shape are typically not recognized even immediately afterward." (p. 655)

On the other hand, Loftus and Bell (1975) used the pictures from the Nelson et al. study, but showed them at a very rapid rate (100-500 milliseconds per picture). In their study, photographs were recognized better than drawings. In yet another study using the Nelson et al. stimuli, Pezdek and Chen (1982) compared recognition memory for the detailed drawings versus the simple line drawings. They found no differences in performance for second- and fourth-graders, but found that adults performed better with the simple drawings when the task involved discriminating the simple drawings from the more detailed versions of the pictures.

In studies using other stimuli, King (1986) presented a variety of computer graphics, including simple abstract shapes, simple line drawings, and highly detailed drawings and photographic images, to children and adults. In an immediate recognition test, she found that abstract and highly detailed shapes were recognized better than simple line drawings. However, a week later recognition was best for the simple line drawings in all age groups. Anglin and Levie (1985) tested fourth-graders', eighth-graders', and college students' recognition of color photographs, black-and-white photographs, line drawings, and one-word labels. In a delayed recognition test, each target study item was paired with a distractor that was conceptually related and in the same mode of presentation as the study item (e.g., a color photograph of a chair was paired with a color photograph of a table). The only effect found was that recognition memory for black-and-white photographs was better than that for words. However, Davies, Ellis, and Shepherd (1978) found that photographs of faces were recognized better than detailed line drawings. Other work in this area includes Denis (1976), Peeck, Van Dam, and de Jong (1978), and Peeck, Van Dam, and Uhlenbeck (1977).

Thus, studies of the effects of visual richness on picture recognition have shown mixed results. Although the contribution of embellishments in many situations is probably minimal, there may be a variety of circumstances and types of pictures in which embellishments can make a difference.

Other Pictorial Stimulus Variables

The effects of complexity, color, motion, the figure-ground relationship, and a hodgepodge of other stimulus variables are reviewed in this section.

COMPLEXITY. Picture complexity has been operationalized in several ways. The preceding section on pictorial embellishments describes one way. A different technique was used by Pezdek (1978) who defined complexity as the number of figures in a picture. With college students, complexity was used by Pezdek (1978) who defined complexity as the number of figures in a picture. With college students, complexity was positively related to recognition accuracy. On the other hand, Fleming and Sheikhian (1972) found that second graders did better with simple pictures containing one or two figures than with pictures containing four to eight figures. Furthermore, Fleming and Sheikhian found that when defined as the amount of detail, complexity was not related to recognition accuracy, although in one study complex pictures were recognized better at a long presentation duration (four seconds) and simple pictures were better at a briefer presentation duration (two seconds).

Research on the complexity of nonmeaningful shapes has also produced mixed results. Green and Purohit (1976) found better performance with complex stimuli whereas Clark (1965) found that simple stimuli were better. It should also be noted that since complexity has been shown to affect the amount of time people spend looking at a stimulus, complexity may affect picture recognition differently in circumstances in which subjects are free to look as long as they wish, rather than as long as the experimenter wishes--as is the case in the research cited above.

COLOR. Several researchers have compared the recognition accuracy of color versus black and white versions of pictures. Franken (1977) and Madigan (1983) found that color improved recognition memory. Barry (1975) found that non-realistic color as well as realistic color improved recognition memory. On the other hand, Franzwa (1973), Kiphart, Sjogren and Cross (1984) and Anglin and Levie (1985) found no differences between color versus black and white versions. Borges, Stepnowsky and Holt (1977) found that color helped college students, but not elementary school students. In an interesting related study, Watkins and Schiano (1982) showed subjects black and white line drawings and asked them to imagine them filled in with a specified color. On a surprise recognition test, drawings were recognized more accurately if their color was the same as the color imagined during study.

MOTION. Goldstein, Chance, Hoisington and Buescher (1982) compared recognition of moving versus static pictures. Some subjects viewed a motion picture and were tested with eight second film clips from portions of the film. Clips from portions of the film they did not see were used as distractors. Other subjects were presented and tested with a series of still pictures--"freeze frames" taken from the motion picture. Recognition accuracy was better with the moving pictures. Freyd (1983) studied recognition memory for implied motion in still photographs.

FIGURE-GROUND SEPARATION. Franken and Davis (1975) had subjects rank pictures in terms of interestingness, pleasingness, complexity, clarity, and figure-ground relationship. The figure-ground rating was the degree to which the central object "stands out in a lively and impressive manner from the remainder of the picture." These rankings were then related to recognition scores for the pictures. Interestingness and pleasingness rankings did not correlate with recognition accuracy. Rankings of figure-ground clarity, and to lesser degree, complexity, did predict recognition performance. Franken (1977) replicated the finding that pictures high in figure-ground separation are recognized better. In a related study, Mitterer and Rowland (1975) found that alterations in the figure were detected more easily than alterations in the ground.

INTERSTIMULUS SIMILARITY. The degree of similarity among the pictures in the study set can also affect performance. For example, recognition accuracy for individual pictures is very poor if the pictures in the study set are all snowflakes or all inkblots (Goldstein & Chance, 1970) or all mushrooms (Orwig, 1979).

LUMINANCE. Loftus (1985) found that luminance--how brightly or dimly a picture is lighted--affects picture recognition. Using masks on slides in a slide projector to control the brightness of the image on the screen, he found that the brighter the image, the better subjects were able later to recognize the picture.

OTHERS. A variety of rather bizarre stimulus manipulations can make picture recognition more difficult. Such manipulations include blurring the picture (Dallett, Wilcox & D'Andrea, 1968), turning the picture upside down (Phillips & Rawles, 1979; Yarmey, 1971), masking various areas of the picture (Roberts, Mazmanian, & Kraemer, 1987) and presentation as a photographic negative (Galper, 1970).

Memory for Parts and Attributes of Pictures

Research on picture recognition usually treats each picture as a single unit of information; the study and test stimuli are entire, intact pictures. Some researchers, however, have studied memory for parts of pictures or attributes of pictures. They have found that not all aspects of pictures are equally memorable.

Loftus & Bell (1975) proposed that pictures contain two types of information: (1) holistic information—information concerning the overall appearance and meaning of a picture that can be perceived somewhat independent of the picture's details, and (2) specific detail information. Picture recognition can be based upon either kind of information (Loftus & Bell, 1975; Loftus & Kallman, 1979; Loftus, Nelson, & Kallman, 1983), but specific details will act as recognition cues only if they are fixated during the study phase (Nelson & Loftus, 1980). Navon (1977) made a similar distinction between "local features" and "global features" and produced evidence showing that global features are processed prior to local features. Antes and Mann (1984), however, found that the order in which global versus local information is processed may depend on factors such as the size of the image and the semantic relationship between key local features and global meaning.

Eye movement research shows that fixations are most likely to fall upon the "informative areas" of pictures. These areas contain identifiable objects (Antes, Singsaas, & Metzger, 1978) and, in particular, objects that one would not expect to find in the scene portrayed — an octopus in a farm yard scene or a farm tractor in a scene of the ocean floor . On recognition tests, subjects are much more likely to notice changes in these "unexpected" objects than changes in objects which fit in with the rest of the scene schema (Friedman, 1979). When, however, study pictures are presented for very brief durations (250 milliseconds), picture recognition is more likely to be based upon holistic information than on specific detail information (Loftus, Nelson, & Kallman, 1983). People can usually encode holistic information very rapidly, whereas it takes longer to fixate upon more than one critical detail in a picture.

In other research on the recognition of objects in pictures, Ironsmith (1980) devised pictures showing two animals. In each picture one animal was doing something to the other animal (e.g., a duck splashing a frog). Later, the animals shown as "actors" (e.g., the duck) were recognized better than the "objects" (the frog). McKoon (1981) found that when two objects in a picture are shown interacting with each other, the presentation of one of the objects will serve as a particularly effective "prime" for the recognition of the other object. Meyer (1978) found that in pictures consisting of essentially one central figure in a logical context (e.g., a chair in a room), 4- to 5-year-old children based recognition responses on only the central figure, whereas older children were more likely to use all aspects of the picture.

Mandler and her associates (Mandler & Johnson, 1976; Mandler & Parker, 1976; Mandler & Read, 1980; Mandler & Ritchey, 1977; Mandler & Stein, 1974) studied memory for four types of pictorial information: (1) inventory information--the objects a picture contains, (2) descriptive information--what the objects look like, (3) spatial relation information--where the objects are located in relation to each other, and (4) spatial composition information--transformations of pictorial content such as deletions and movements. They found that memory for these different types of information is lost at different rates. For example, in complex pictures, inventory information can be retained over a period of four months whereas descriptive information is lost quite rapidly. Mandler, Seegmiller and Day (1977) and Von Wright, Gebhard and Karttumen (1975) also found substantial memory for the spatial location of objects in pictures. In similar research, Dirks and Neisser (1977) and Newcombe, Rogoff and Kagan (1977) found that recognition was better for objects added to test pictures than for deleted or rearranged objects. Agostinelli, Sherman, Fazio and Hearst (1986) also found that recognition of changes in pictures was better for added objects than deleted objects.

In research on memory for attributes of pictures, it has been shown that subjects can remember the color of objects in pictures (Loftus, 1977; Perlmutter, 1980; Perlmutter & Myers, 1976), although color recognition may be inferior to memory for spatial information (Park, 1980). Subjects in picture recognition studies report that they use color as a cue for trying to remember pictures (Woodhead & Baddeley, 1981).

Do people remember the left-right orientation of pictures? Often, subjects' ability to discriminate study pictures from their mirror-images is near chance (Gordon & Gardner, 1974; Dallett, Wilcox & D'Andrea, 1968; Kraft & Jenkins, 1977; Kiphart, Sjogren & Cross, 1984). However, when left-right orientation is meaningful, as in slides from a sequence in which left-right movement made a coherent story, subjects recognized orientation in test pictures with high accuracy. Several researchers have shown that when subjects are instructed to disregard orientation in making judgements about whether or not they have seen a picture before, they are more likely to classify pictures with the same orientation as the study pictures as old than to classify their left-right reversals as old (Bartlett, Gernsbacher & Till, 1987; Intraub, 1980; McKelvie, 1983, 1985). Furthermore, when asked to indicate whether a picture labelled "old" had the same orientation as the study item, subjects were much more likely to make correct "same" classifications of identical items than to make correct "different" classifications of left-right-reversed items. In other words, there appears to be a bias, under these

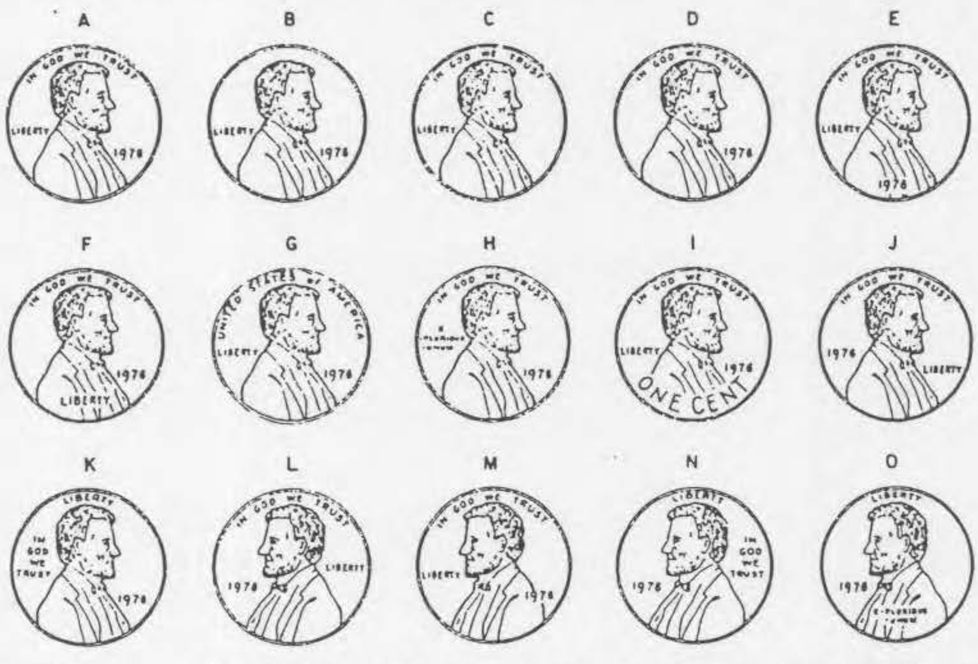

Figure 5. Stimuli used by Nickerson and Adams (1979)

conditions, to respond that an item has the same orientation as the studied picture (Bartlett, Gernsbacher & Till, 1987; Klatzky & Forrest, 1984; McKelvie, 1983).

Finally, Nickerson and Adams (1979) studied memory for attributes of an object you should be very familiar with—the head of a penny. Does Lincoln face toward the left or the right? In Figure 5 only one of the 15 drawings is accurate. Which one? Just 42% of the subjects in the Nickerson and Adams study were able to pick out the correct drawing.

Summary

Studies of pictorial stimulus variables suggest that high distinctiveness, high meaningfulness, motion, good figure-ground separation, and high illumination help subjects remember pictures. Studies of the effects of visual richness, complexity and color have yielded mixed results, whereas a high degree of similarity between pictures in the study set diminishes recognition accuracy.

Subjects can recognize a picture based upon (1) its overall appearance or meaning or (2) specific parts or details. Subjects are unlikely to remember parts of a picture unless they are unexpected, distinctive, or central to the meaning of the picture. Among the attributes of pictures, subjects are most likely to retain color information and spatial information.

Encoding Strategy

So far this review has focused on the contributions of stimulus variables in recognition memory. This section focuses on the perceiver's mental activities. When we look at a picture our state of perceptual readiness influences what we see. Similarly, what we remember is influenced by the kinds and amounts of mental processing activated. Researchers have attempted to control subjects' encoding strategies by techniques such as requiring them to verbalize about the objects shown in pictures, directing them to attend to specified aspects of the stimuli, leading them to anticipate certain kinds of tests, and asking them to perform interfering tasks during the study phase.

Level of Processing

Researchers studying the effects of encoding strategy on picture memory have often attempted to manipulate subjects' level or depth of processing. The basic distinction in depth of processing is between "deep" semantic processing and "shallow" nonsemantic processing. It is predicted that information processed at a semantic level will be remembered better than information processed at the sensory surface level. Miller, Mueller, Goldstein and Potter (1978) asked subjects to make judgements about photographs of landscapes that would result in either deep processing (judging whether the scene is in the United States) or shallow processing (judging the colorfulness of the scene). Deep processing resulted in better performance.

The degree of elaboration of the mental image formed by the viewer is an important variable. Kunen, Green and Waterman (1979) presented pictures like those shown in Figure 6. Pictures of the kind shown in the middle two columns were recognized better than those at the ends. Why? Briefly, the explanation concerns the amounts and kinds of processing apparently required by the four types of pictures. The middle two pictures "present subjects with a level of problem difficulty that promoted the maximally beneficial amount of perceptual elaboration, and consequently those subjects' visual memories profited the most." (p. 583)

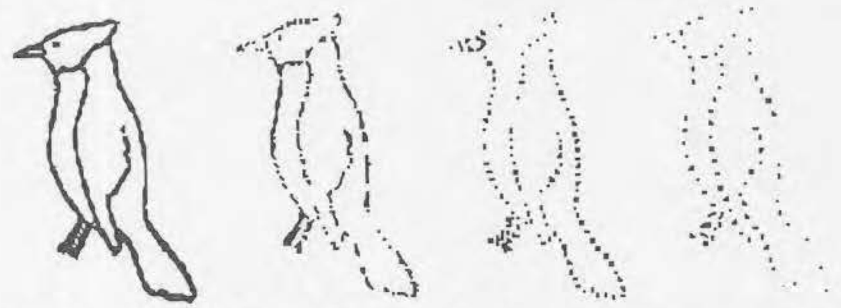

Figure 6. Stimuli used by Kunen, Green & Waterman (1979).

Stanny and Weaver (1985) had subjects use a variety of strategies in studying pictures. They found that instructing subjects to attend to colors in the picture led to least accurate recognition, instructing subjects to search for large forms or use multi-sensory imagery to supplement visual information produced intermediate levels of recognition, and instructing subjects to attend to details in the picture led to most accurate recognition. Subjects who were told simply to "try to remember" the pictures and to rate them according to expected ease of recognition performed almost as well as subjects instructed to attend to details.

Human faces have been used as stimuli in other research of this kind. When subjects were instructed to make judgements about character traits such as honesty or friendliness during study, recognition accuracy was better than when subjects attended to the general physical features of faces (Bower & Karlin, 1974; McKelvie, 1985; Mueller, Courtois & Bailis, 1981; Mueller & Wherry, 1980; Warrington & Ackroyd, 1975; Wells & Hryciw, 1984). It was assumed that classifying faces along an abstract dimension resulted in deeper encoding. However, Parkin and Goodwin (1983), Parkin and Hayward (1983) and Winograd (1978, 1981) found that when subjects were given tasks that required them to focus upon the most distinctive features of each face, recognition was as good as under trait judgement instructions. It was argued that it is the degree of elaboration rather than the depth of processing that distinguishes successful encoding strategies.

Several other aspects of encoding strategy have been studied. Researchers have manipulated distinctiveness of encoding (Parkin & Hayward, 1983), spread of encoding (Kunen, Green, & Waterman, 1979), and encoding effort (Kellogg, Conklin, & Bourne, 1982). Hampson and Cutting (1985) found that college students are good at judging the relative effectiveness of a range of strategies for remembering pictures and Justice (1985) found developmental improvement in elementary school children's ability to judge the value of picture memory strategies.

Test-Related Encoding

If subjects encode a stimulus in a way that anticipates the type of test, performance should be facilitated. Some studies that have demonstrated this principle are quite complex. Emmerich and Ackerman (1979) asked subjects to respond to questions about pictures during the study phase. These questions were designed to encourage (1) conceptual encoding--questions about how the object in the picture functions, (2) schematic encoding--questions about the shape of the object; (3) acoustic encoding--whether or not the name of the object rhymes with another given word, or (4) a control condition in which no questions were asked. On the recognition test, distractors for study pictures were devised to correspond with each of the encoding strategies. For example, a study picture showing a nail was paired with distractors showing (1) a hammer--a conceptually similar object, (2) a pencil--a schematically similar object, (3) a whale--an acoustically similar object, or (4) an object that was dissimilar to the study picture in each of the aforementioned respects. The results were that conceptual encoding was best, schematic next best, and acoustic encoding and the control condition poorest. Also, distractor types produced interference with encoding strategy (e.g., acoustically similar distractors reduced performance under acoustic encoding conditions).

A similar study involving the use of ten different orienting tasks in the recognition of words and pictures was reported by Durso and Johnson (1980). Their instructions were designed to orient subjects to the concept as (1) a verbal item--what is the last letter of the name?, (2) an image--how long would it take an artist to draw a picture of the object?, or (3) the underlying referential information associated with the concept--is the object artificial (i.e., man-made) or naturally occurring? One outcome of this study was that when subjects were oriented to consider the concepts as images, performance on the recognition test was better for words than pictures.

Interference Tasks

Encoding strategies have also been studied by requiring subjects to engage in tasks that interfere with their ability to encode the study pictures in an effective manner. In one kind of study, subjects are asked to shadow verbal material (i.e., repeat aloud words being presented auditorily) while attempting to study picture or word stimuli (Kroll, Kellicut & Parks, 1975; Levie & Levie, 1975; Rollins & Thibadeau, 1973; Rowe & Rogers, 1975). It is assumed that requiring subjects to shadow words will tie up the verbal processing system so that verbal elaboration while learning pictures and words will be reduced. The results generally showed that the verbal interference task had a less damaging impact upon the recognition of pictures than words.

Summary

In order to study how pictures are processed in memory, researchers have instructed subjects to use a variety of encoding strategies. These studies suggest that, in general, strategies that lead to deeper or more elaborate encoding improve performance on subsequent recognition tasks. It has also been shown that different distractor types produce varying amounts of interference depending on the type of encoding strategy used. Finally, verbal interference tasks are more detrimental to the recognition of words than of pictures.

Research Design Factors

A variety of research design factors affect picture recognition memory. Several factors concern time intervals--presentation duration, interstimulus interval, and test delay. Other factors concern the type of test--using a forced-choice versus single-item recognition test, the degree of similarity between test items, and the relationship between the study modality and test modality.

Time Intervals

During the study phase of recognition experiments two time intervals are important: (1) the length of time each picture is in view, and (2) the length of the interval between pictures. Another important interval is the length of the delay between the study phase and the test.

PRESENTATION DURATION. Increasing the amount of time a picture is in view results in higher recognition accuracy (e.g., Gaffan, 1978; Hulme & Merikle, 1976; Loftus & Kallman, 1979; Read, 1979; Tversky & Sherman, 1975; Weaver & Stanny, 1978). Picture recognition memory is so good, however, that a ceiling is often reached with very brief presentation rates. In experiments using a heterogeneous set of simple representational pictures, recognition is nearly perfect with a presentation rate of only two seconds. Presentations lasting only one second produce recognition accuracy in the 80% to 90% range (e.g., Lutz & Scheirer, 1974; Potter & Levy, 1969; Rosenblood & Pulton, 1975; Standing, Conezio & Haber, 1970). Presentation rates so brief as to allow for only a single eye fixation still result in recognition substantially above chance (Intraub, 1979, 1980). On the other hand, in experiments in which the task requires encoding detailed aspects of complex pictures, a ceiling effect will likely not occur at a two second presentation duration, and performance will continue to improve with further increases in viewing time (e.g., research by Mandler and associates).

INTERSTIMULUS INTERVAL: VISUAL REHEARSAL? What about the time interval between pictures? In learning verbal material, the provision of a "rehearsal period" following stimulus presentation improves performance. Some early research seemed to show that such is not the case with pictures (Cohen, 1973; Hintzman & Rogers, 1973; Shaffer & Shiffrin, 1972). Most subsequent researchers, however, have found that increasing the blank period between pictures does improve recognition accuracy (e.g., Hulme & Merikle, 1976; Kallman, 1984; Intraub, 1979; Lutz & Scheirer, 1974; Tversky & Sherman, 1975; Weaver & Stanny, 1978--but c.f. Bird & Cook, 1979).

Although it is by no means clear just what mental operations are going on during the interval between picture presentations, the usual interpretation is that some sort of rehearsal is involved. Evidence that retention is better if subjects are instructed to "rehearse" pictures after they have been removed from view supports this contention (Watkins & Graefe, 1981; Watkins, Peynircioglu & Brems, 1984). In one experiment, Graefe and Watkins (1980) showed subjects pairs of pictures side-by-side, and then, after the pictures were removed from view, cued subjects to "imagine, visualize, or otherwise think about" only one of the pictures during the between-picture interval. Later, subjects were better at recognizing the cued picture, suggesting that "the control exerted by the subject over the beneficial effects of postpresentation interval provides an adequate demonstration that pictures can be effectively "rehearsed" (p. 156). Levin, Ghatala, DeRose and Makoid (1977) demonstrated use of a remarkably effective rehearsal strategy in discrimination learning. After looking at an item, subjects were instructed to turn their heads to one side and trace the imagined outline of the to-be-remembered picture in the air with their fingers.

Thus, it is now clear that people can continue to process pictorial information for several seconds after the picture has been removed from view. Even without instructions, rehearsal of some sort often appears to occur. Furthermore, this process seems not to be just a matter of implicit naming of the objects pictured (Intraub, 1979) or the selection of specific detail information for additional processing (Weaver & Stanny, 1984). What, however, is the nature of this process?

Proctor (1983) and Nagata (1986) showed that when the duration of the intervals between study pictures was varied randomly, pictures followed by longer time periods did not show the expected advantage in a recognition test. Proctor suggested that rehearsal is a voluntary process and that subjects did not make use of a blank interval following the picture when they were not sure how long they would be able to rehearse. Watkins (1985) disputes this interpretation, suggesting that a more reasonable explanation is to assume that subjects distribute rehearsal over several items at a time. He offers some evidence that when subjects are persuaded by the task or by instructions to rehearse only the previously presented picture, then longer postpresentation intervals do lead to improved performance even when the intervals between pictures are of random duration.

Another way of studying such issues involves following the presentation of to-be-remembered pictures by masks which are design to disrupt perceptual or conceptual processing (Intraub, 1980, 1984; Loftus and Ginn, 1984). Results suggest that rehearsal processing (Intraub, 1980, 1984; Loftus and Ginn, 1984). Results suggest that rehearsal can continue when a perceptual mask, such as a repeating to-be-ignored picture is used, but not when a conceptual mask, such as a novel stimulus is used. This indicates that rehearsal involves more than looking at a "mentally-held image" or at a perceptual afterimage. In addition, high recognition rates have been produced under conditions that would seem to discourage verbal encoding processes during rehearsal (Graefe & Watkins, 1980; Read, 1979; Tversky & Sherman, 1975; Weaver, 1974).

TEST DELAY. Another time variable is test delay. Numerous researchers have found that performance is poorer on delayed as compared to immediate tests (Bird, 1975; Dallett, Wilcox & D'Andrea, 1968; Franken & Rowland, 1979; Krouse, 1981; Morrison, Haith & Kagan, 1980; Nelson, Metzler & Reed, 1974; Nickerson, 1968; and Scapinello & Yarmey, 1970). Even so, performance can still be quite good on delayed tests. On a two-alternative forced-choice test using a heterogeneous set of 150 representational pictures, Franken & Rowland (1979) report 80% accuracy after a one week delay. Under nearly identical learning conditions, Nelson, Metzler & Reed (1974) found rates of 85-90% after a seven week delay. Gehring, Toglia and Kimble (1976) found that pictures maintained about the same relative advantage over words for delays of 10 minutes, one hour, one day, one week, one month, and three months. In an extreme example, Zusne and Zusne (1986) found that a subject recognized 100 well-learned random polygons with 92% accuracy after an 11-year delay!

Mandler and Read (1980) suggest caution in using a repeated measures design rather than a between-groups design in studies which compare recognition memory after delays of various lengths of time. If different old items and distractor items are not used on each test, learning of old or new items can take place, influencing performance on future tests.

Factors Related to the Form of the Dependent Measure

TEST-FORM: FORCES-CHOICE VERSUS SINGLE-ITEM METHODS. As mentioned in the introduction, picture recognition is usually tested by one of two basic techniques: (1) the two-alternative forced-choice method in which each test item consists of a pair of pictures--an old picture from the study set and a distractor picture, and (2) the single-item method in which old pictures and distractors are shown singly, and subjects respond "old" or "new" to each picture. Single-item tests are more difficult than two alternative forced-choice tests (Deffenbacher, Leu & Brown, 1981; Franken & Rowland, 1979). On the two-alternative forced-choice test subjects can answer an item correctly for two reasons: either by accurately recognizing the old picture or by recognizing that the distractor was not among the study set and thus inferring that the alternative is the old

Figure 7. Illustrations of eight types of similarity.

Only rarely do subjects judge that a distractor item was among the study pictures. That is, we are better at knowing when we have *not* seen a picture before than knowing when we *have* seen it.

SIMILARITY OF TEST ITEMS. Recognition performance can be affected dramatically by varying the degree of similarity between study pictures and distractor pictures. When a study picture is paired with a highly similar distractor, performance will be poor. Luszcz and Bacharach (1980) found that performance was poorer when a distractor had the same general name as the old picture. In fact, target-distracter similarities of several kinds can reduce performance. Figure 7 shows eight types of distractor similarity used in an experiment by Scarborough (1977). The "different view" distractor produced the greatest number of errors. On the other hand, using distractors that are highly dissimilar or highly unlikely will result in high performance (see Figure 8).

picture. On the single-item test, subjects must base their judgements on one picture only.

Franken and Rowland (1979) compared performance on the two types of tests under four conditions: Immediate and delayed recognition of small (150) and large (1,000) sets of pictures. Scores on the single-item tests were from five to ten percent lower than on the two-alternative forced-choice tests. In both types of tests, performance levels can be lowered by increasing the number of distractors—using more than one distractor per item in forced-choice tests, and adding more distractors to the series in single-item tests (Davies, Shepherd & Ellis, 1979; Hoffman & Dick, 1976; Kintsch, 1968; Snodgrass, Volvovitz & Walfish, 1972; Standing, 1973).

An interesting phenomenon in single-item tests is that most errors are the result of failing to recognize that an "old" item in the test series was among the study pictures.

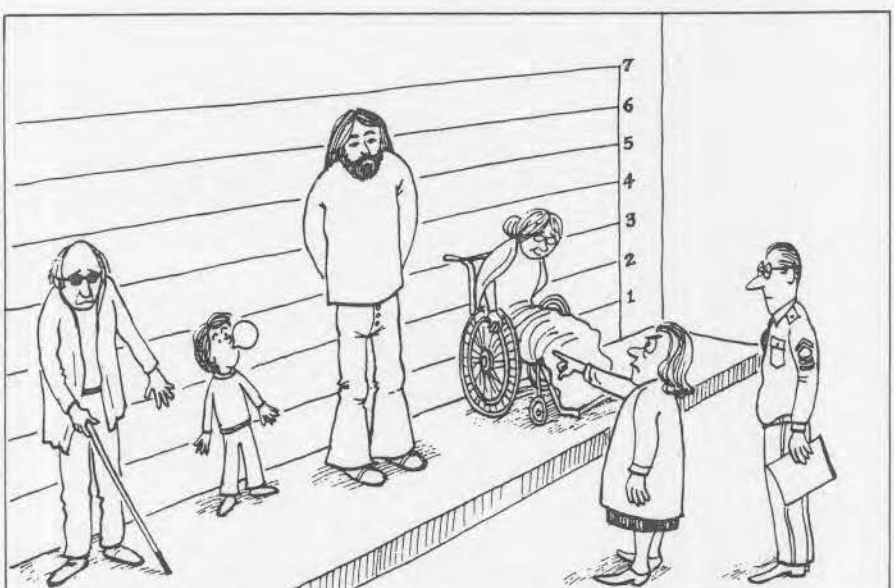

Figure 8. From *Human Memory:The Processing of Information* by G. R. Loftus and E. F. Loftus

Kirasic and Siegel (1975) found an interaction between the degree of distractor similarity and an individual difference measure. The Matching Familiar Figures test (Kagan, Rossman, Albert & Phillips, 1964) was used to identify reflective and impulsive college students. Reflective individuals react slowly and make few mistakes whereas impulsive individuals react quickly and make more mistakes. When, on a picture recognition task, distractors were very similar to the study pictures (thus requiring detailed feature analysis), both groups of subjects performed more poorly than when distractors were dissimilar, but reflective students performed better than impulsive students. With dissimilar distractors, the two groups performed equally well. Siegel, Babich and Kirasic (1974) produced similar results with fifth-graders.

Bird (1975) devised a very sensitive test of recognition memory by producing a set of 15 distractors for each study picture. One distractor differed from the study picture in just one minor detail, another differed in two details, another in three details, and so forth, up to 15 differences. In recognition testing, the number of differences between an accurately rejected distractor and the study picture was progressively greater and greater as test delay was increased by one, two, seven and 60 days.

Finally, Tulving (1981) reports an ingenious study in which the distractor in a two-alternative forced-choice test was either (1) highly similar to the study picture or (2) dissimilar to the study picture shown, but highly similar to some other picture in the original study set. Performance was better in the first condition, thereby reversing the usual effect of distractor similarity.

STUDY MODALITY AND TEST MODALITY. Recognition memory for pictures or their word labels can be tested in the same or in the opposite symbolic modality. There are four possible combinations: study pictures--test with pictures (PP), study pictures--test with words (PW), study words--test with pictures (WP), and study words--test with words (WW).

The reliable findings of this research are that (1) pictures are better than words as study stimuli, and (2) testing in the same modality is better than testing in the opposite modality (Denis & Colonelli, 1976; Emmerich & Ackerman, 1979; Haber & Myers, 1982; Jenkins, Neale & Deno, 1967; Magne & Parknas, 1962; Park, 1980; Peeck, Van Dam & de Jong, 1978; Standing & Smith, 1975). The first finding confirms the pictorial superiority effect and the second finding is consistent with the encoding specificity principle (Tulving & Thompson, 1973) that performance is enhanced by using similar study and test stimuli. Overall, performance in the PP condition is best, the PW and WW are about equal, and WP condition results in the poorest performance. Haber and Myers (1982) found that pictograms used as study and test items performed in similar fashion. For additional relevant research, see Brimer & Mueller (1979), Snodgrass and Asiaghi (1977) and Snodgrass, Wasser, Finkelstein and Goldberg, (1974).

Individual Differences

Except for infants and individuals with severe handicaps, all people perform remarkably well on picture recognition tasks. Researchers have identified, however, several modest individual differences in performance. Age, cognitive style, aptitude, ability, and experience with the kinds of stimuli pictured can affect picture recognition memory.

Age Differences

Not too long ago it was generally thought that picture recognition memory does not develop appreciably with age (Brown, 1975; Piaget & Inhelder, 1973). Although young children's ability to recognize pictures is very good, numerous researchers have now documented improvement in performance with age (Bird & Bennett, 1974; Dirks & Neisser, 1977; Hock, Romanski, Galie & Williams, 1978; Hoffman & Dick, 1976; Kirasic, Siegel & Allen, 1980; Mandler & Robinson, 1978; Morrison, Haith & Kagan, 1980; Nelson & Kosslyn, 1976; Newcombe, Rogoff & Kagan, 1977; Sophian & Stigler, 1981). This improvement has been attributed by some researchers to increasing ability to use scene schema in recognition tasks (Kirasic, Siegel & Allen, 1980; Mandler & Robinson, 1978; Meyer, 1978). But there are a doubtless variety of other causes. For example, it may be that young children are less likely to label, and hence dual-code, pictures (Mowbray & Luria, 1973).

Another age difference was demonstrated by Morrison, Haith and Kagan (1980) who showed that on two-alternative forced-choice tests, younger subjects were less likely than older subjects to identify the old picture by inference—that is, infer that the alternative to the distractor is the old picture because they are certain they had not seen the distractor before.

Infants have some recognition capability. In fact, recognition for forms has been found in infants just a few days after birth (Slater, Morrison & Rose, 1982). The usual technique for research with infants involves studying habituation to novel and familiar stimuli. When novel and familiar pictures are shown side by side, infants tend to look more at the novel picture. Rose and Wallace (1985) found that the proportion of time that 6-month-old premature infants spent looking at novel as opposed to familiar pictures was highly correlated with their scores on tests of cognitive ability up to at least the age of six.

Some researchers have studied the picture recognition capabilities of younger versus older adults (Harker and Riege, 1985; Park and Puglisi, 1985; Rabinowitz, 1984). These studies indicate that although recognition memory for words declines with age, recognition memory for pictures does not. The decline in recognition that occurs with delayed testing appears to be slightly greater for the aged (Park, Puglisi, & Smith, 1986). There is some evidence, however, that older adults have more difficulty than young adults in remembering facial expressions and other details of photographs of faces (Bartlett & Leslie, 1986).

Style, Aptitude, and Ability

In studies of learner differences in style and aptitude, Chatterjea and Paul (1981) found field dependent subjects were better at recognizing faces, whereas field independent subjects were better at recognizing geometric figures. Blevins and Moore (1987) found no difference in field dependent and field independent subjects' abilities to recognize picture details in a learning task presented by television. McKelvie and Demers (1979) found imagery ability was unrelated to picture recognition ability. MacLeod (1986) also found that performance was unrelated to imagery ability in a cross-modal recognition task. As mentioned in the section on test distractor similarity, Kirasic and Siegel (1975) and Siegel, Babich and Kirasic (1974) found differences in recognition performance of impulsive and reflective subjects.

Are some individuals reliably better than others at recognizing pictures? To answer this question, Chance and Goldstein (1979) attempted to identify college students who were either consistently good or consistently poor on repeated tests of face recognition. Overall, students showed only modest consistency over trials. On the other hand, Woodhead and Baddeley (1981) identified groups of subjects who had done extremely well or relatively poorly on face recognition experiments, and then tested them for recognition of another set of faces, paintings and words. The "good recognizers" performed much better with faces, somewhat better with paintings, and equally well with words. Chance, Turner and Goldstein (1982) found that female college students were better than males at recognizing faces.

Experience with the Class of Stimuli

The amount of experience subjects have had with the kind of stimulus used in a recognition experiment can affect their performance level. Several researchers have found that people are better at recognizing pictures of faces from their own racial group than faces from another racial group (Brigham & Barkowitz, 1978; Ellis & Deregowski, 1981; Goldstein & Chance, 1978, 1980). Chance, Turner and Goldstein (1982) showed that this effect increases with age (young children recognized own-race and other-race faces equally well), and hence may be due to the development of an own-race facial schema that is acquired with increasing experience. Chance, Goldstein, and Andersen (1986) found that adults who had some experience with infants were better able to recognize pictures of infants and Goldstein and Chance (1985) improved poor recognition memory of Japanese faces by intensively training subjects to learn Japanese face-digit pairs. Similar improvement in recognition accuracy with increasing experience has been documented with other kinds of stimuli (Goldin, 1979).

Some Closely Related Research Areas

The boundaries of research on picture recognition memory are indistinct. The selection of topics and variables that are relevant is a matter of judgment. For example, a good argument could be made for including research on recognition memory for verbal material in this review. Understanding how a given variable such as meaningfulness affects the recognition of words could contribute to understanding how it affects picture recognition. Although brief reference is made to this research throughout the review, a comprehensive treatment of this large research area was not undertaken. However, a few bodies of research dealing with particular classes of visual nonverbal stimuli do seem particularly pertinent.

Face Recognition

Many researchers have used pictures of human faces as stimuli in recognition experiments. In some cases, researchers were not interested in the phenomenon of face recognition but used pictures of faces only because they constitute a convenient, relatively homogeneous set of stimuli that can be used to study many aspects of picture recognition. Such research is not covered in this section. This section deals only with studies in which researchers were interested in face recognition per se.

The common assertion that "I never forget a face" is generally corroborated by research. Bahrick, Bahrick and Wittlinger (1975) found that even after several decades people can recognize yearbook portraits of their high school classmates. Recognition memory for pictures of strangers is also good (Davies, Ellis & Shepherd, 1981). Even changing the pose and expression of faces from presentation to test produces very little drop in recognition performance (Bruce, 1982; Walker-Smith, 1980), although major changes--"disguises" such as wigs and glasses--or inverting the face can reduce performance substantially (McKelvie, 1985; Patterson & Baddeley, 1977). Baddeley and Woodhead (1982) report on several unsuccessful attempts to devise techniques for training people to improve their ability to recognize faces.

Attempts have been made to determine what aspects of faces are most memorable (Ellis, Shepherd & Davies, 1979). Familiarity and distinctiveness have been identified as two independent characteristics which influence face recognition (Bartlett, Hurry & Thorley, 1984; Valentine & Bruce, 1986). Kennedy, Scannapieco, Mills and Carr (1985) and McKelvie (1987) found that subjects were better able to recognize faces when shown only the left half of the face on a recognition test than when shown only the right half. In studies of the effects of visual richness on face recognition, Davies (1983), Hagen and Perkins (1983), and Tversky and Baratz (1985) found that photographs of faces were more accurately recognized than either realistic drawings or caricatures. Furthermore, training with one kind of representation and testing with another kind yielded poor recognition scores.

The question of whether or not faces constitute a special class of stimuli that are handled in special ways has been much debated. Ellis (1975), in a review of research, could find no unambiguous evidence that faces are processed differently than other pictorial stimuli, whereas Deffenbacher, Carr and Leu (1981) feel that a special memory system for faces might exist. Diamond and Carey (1986) showed that photographs of dogs seem to be processed like photographs of faces when dog experts are used as subjects. They speculate that recognition of an object will behave like face recognition when three conditions are met: (1) the members of a class share the same basic configuration, (2) it is possible to distinguish one member of the class from another on the basis of second-order features, and (3) subjects have the expertise to pick out and exploit such features in recognition. For other recent research see Bruce and Valentine (1985), Bruce and Young (1986), Kennedy, Beard and Carr (1982), Kerr and Winograd (1982), Klatzky, Martin and Kane (1982), Parkin and Hayward (1983), Parkin and Goodwin (1983), and Seamon (1982).

Eye Witness Research

In eye witness research, subjects are exposed to a staged or filmed incident such as a mock purse snatching and are later asked to identify the criminal in a lineup or set of photographs. Performance in these experiments is often little better than chance (Buckout, 1980). False identifications can range from 36% to 72% (Warnick & Sanders, 1980). Furthermore, no correlation has been found between subjects' performance and confidence. Subjects who are sure they are right do no better than those who are less certain of their judgements (Brown, Deffenbacher & Sturgill, 1977; Lindsay, Wells & Rumpel, 1981). Error rates can be influenced by a variety of variables such as encouraging witnesses to make a guess. When witnesses are allowed "no choice" or "I don't know" options, false identifications are reduced without decreasing correct identifications (Malpass & Devine, 1981; Warnick & Sanders, 1980). Such research has obvious implications for police practice (Baddeley, 1979). For further research in this area, see Loftus (1979a) and Yarmey (1979).

Some related research concerns the Photofit, Identi-kit, and sketch artist techniques used by police to reconstruct the appearance of faces from eyewitness descriptions (Davies & Christie, 1982; Ellis, Davies & McMurran, 1979; Laughery & Fowler, 1980). Another line of related research shows how memory for events can be distorted by information presented after the event took place (Greene, Flynn & Loftus, 1982; Loftus, 1977, 1979b; Loftus, Miller & Burns, 1978). For other research on this topic see Bekerian and Bowers (1983), Boice, Hanley, Shaughnessy and Gansler (1982), Hosch and Cooper (1982), Shaughnessy and Mand (1982), and Weinberg, Wadsworth and Baron (1983).

Recognition of Environmental Scenes

A few researchers have ventured outside the confines of the experimental laboratory and studied the recognition of objects in natural environments. Such research includes the recognition of objects in a museum (Barnard, Loomis & Cross, 1980), the objects to be seen while walking down a corridor in a university building (Baroni, Job, Peron & Salmaso, 1980), the furniture and other objects in an office (Brewer & Treyens, 1981; Salmaso, Baroni, Job & Peron, 1983), small objects lying on a table (Barnard, Breeding & Cross, 1984), and the sights in a suburban area as seen from an automobile (Ezinga & Rowland, 1972).

Final Comment

Before 1970, meaningful pictures were rarely used in memory research. But during the seventies a sizable literature was produced, and many of the stimulus factors that affect picture recognition memory were identified—both sensory factors such as distinctiveness, and semantic factors such as meaningfulness. With the transition from behaviorism to cognitive psychology, increased attention was devoted to the mental processes involved in picture recognition, and research on encoding and retrieval strategies predominated. Hypotheses and memory models became more complex and diverse, and researchers sought patterns of interactions among stimulus, subject and contextual variables. Today, although a great many questions remain, the domain might now be said to be "mature."

An examination of the topics appearing in recent psychology journals suggests that research activity in picture recognition memory may have diminished somewhat in the past few years. Perhaps this trend will continue as psychologists increasingly turn their attention to the study of higher cognitive processes. Or, perhaps the area will find an infusion of new interest from sources such as neuropsychology or computer vision. In any event, the literature on picture recognition memory as it now stands provides a substantial, reliable data base concerning a fundamental psychological process—a process that holds implications for those interested in many aspects of visual literacy.

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