

## Levels of Processing and Picture Memory: The Physical Superiority Effect

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Six experiments studied the effect of physical orienting questions (e.g., "Is this angular?") and semantic orienting questions (e.g., "Is this edible?") on memory for unrelated pictures at stimulus durations ranging from 125-2,000 ms. Results ran contrary to the semantic superiority "rule of thumb," which is based primarily on verbal memory experiments. Physical questions were associated with better free recall and cued recall of a diverse set of visual scenes (Experiments 1, 2, and 4). This occurred both when general and highly specific semantic questions were used (Experiments 1 and 2). Similar results were obtained when more simplistic visual stimuli—photographs of single objects—were used (Experiments 5 and 6). As in the case of the semantic superiority effect with words, the physical superiority effect for pictures was eliminated or reversed when the same physical questions were repeated throughout the session (Experiments 4 and 6). Conflicts with results of previous levels of processing experiments with words and nonverbal stimuli (e.g., faces) are explained in terms of the sensory-semantic model (Nelson, Reed, & McEvoy, 1977). Implications for picture memory research and the levels of processing viewpoint are discussed.

Consider the following experiment. Subjects are presented with a series of unrelated color photographs, one at a time. Prior to each presentation, the experimenter asks an orienting question to focus attention either on physical characteristics of the picture (e.g., "Is this angular?") or semantic characteristics (e.g., "Is this edible?"). After viewing the entire series, subjects receive an incidental free-recall or cued-recall test in which they report as many pictures as possible. Which type of orienting question, if any, would be expected to result in better memory under these conditions?

The obvious answer to this question, which is based on "Levels of Processing" experiments with words (e.g., Craik & Tulving,

1975) and other visual stimuli (e.g., Bower & Karlin, 1974), is that the semantic orientation will yield superior memory. The levels of processing view of memory (Craik & Lockhart, 1972) and its subsequent revisions (e.g., see Cermak & Craik, 1979) have, of course, had a major influence on memory research and interpretation. Although as a general model, the levels of processing approach have received strong criticism (e.g., Baddeley, 1978; Eysenck, 1979; Nelson, 1977)—primarily because of the lack of an independent measure of *depth* or *spread* of processing—it has been convincingly argued that the conception provides a worthwhile framework for research nevertheless (e.g., Lockhart & Craik, 1979; cf. Cermak & Craik, 1979). A related position is that at the very least, the levels of processing approach has provided a valuable rule of thumb for applied research, regarding the effects of different cognitive orientations on memory (Baddeley & Woodhead, 1982). The present research was conducted with these considerations in mind. The purpose was to apply the use of physical and semantic orienting questions to the study of picture memory and to test the generality of the semantic superiority rule of thumb.

Interestingly, although series of unrelated pictures have typically been used in picture

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memory research, there has been little or no research with this type of stimulus within the levels of processing framework. Color photographs of diverse objects and scenes have been used to study the capacity of picture memory (e.g., Nickerson, 1965; Potter & Levy, 1969; Shepard, 1967; Standing, 1973), the effects of presentation rate and exposure duration on picture memory (e.g., Intraub, 1979, 1980; Loftus, 1972; Potter, 1976; Potter & Levy, 1969; Weaver, 1974), as well as effects of attentional strategies (Graefe & Watkins, 1980; Intraub, 1981a, 1984; Loftus, 1972; Weaver & Stanny, 1978). In contrast, levels of processing experiments conducted with pictorial stimuli have tended to use homogeneous sets of pictures, most notably faces (Baddeley & Woodhead, 1982; Bower & Karlin, 1974; Light, Kayra-Stuart, & Hollander, 1979; Strnad & Mueller, 1977; Warrington & Ackroyd, 1975; Winograd, 1976, 1981) and different arrangements of pieces on chessboards (Goldin, 1978; Lane & Robertson, 1979). For the most part this was done to eliminate ceiling effects (e.g., Bower & Karlin, 1974), although an applied interest in face recognition has also stimulated research (e.g., Baddeley & Woodhead, 1982).

As in the case of words, levels of processing experiments with homogeneous pictures have demonstrated a semantic superiority effect. For example, Bower and Karlin (1974) obtained superior recognition memory when subjects were required to make semantic judgments about faces (likeableness and honesty judgments) as opposed to physical judgments (male or female judgments). It should not be assumed, however, that the results of experiments with homogeneous pictures will generalize to pictures that are rich in distinctive visual detail. This concern is heightened if one considers the implications of the sensory-semantic model of memory that was derived in part from the levels of processing framework (Nelson, Reed, & McEvoy, 1977).

The sensory-semantic model describes memory in terms of sensory (visuo-spatial) and semantic (abstract-conceptual) processes. The model has been successful in accounting for the picture superiority effect (i.e., the tendency for pictures to be remembered better than words; Paivio, Rogers, & Smythe, 1968; Shepard, 1967; Standing, 1973; cf. Paivio,

1971) and predicting conditions under which the effect can be eliminated (Durso & Johnson, 1980; Nelson, Reed, & McEvoy, 1977; Nelson, Reed, & Walling, 1976). The gist of the model is that picture superiority is obtained because of the distinctive sensory codes associated with unrelated pictures. The sensory codes for words cannot compete with the uniqueness of the pictorial sensory codes although the words may elicit similar conceptual codes. The importance of visual distinctiveness was demonstrated by Nelson, Reed, and Walling (1976) when they eliminated the picture superiority effect by presenting subjects with conceptually dissimilar pictures that were drawn to be schematically similar (low visual distinctiveness). This underscores the problem of using faces and other homogeneous pictorial sets to test the generality of the semantic superiority rule because, like words, these stimuli share a finite set of well-defined visual components.

In addition, heterogeneous pictorial stimuli provide a new means of addressing the distinctiveness issue often raised in levels of processing research. This is because pictures have a great potential for both physical and semantic richness. For example, the question of whether semantic codes are by nature more distinctive than physical codes (e.g., Craik, 1979) or if distinctiveness depends primarily on the relation of items within a given set (e.g., Jacoby & Craik, 1979), might be addressed by examining the relative effects of physical and semantic orienting questions on memory for sets of complex pictures that vary in their physical and semantic similarity. But first it is necessary to establish whether orienting questions have an effect on memory for visually heterogeneous sets of pictures.

### Experiment 1

Experiment 1 sought to determine if orienting questions would have an effect on memory for heterogeneous sets of pictures or if, as Bower and Karlin (1974) suggested, these pictures would be remembered so well that no differential effect would be obtained. To minimize the likelihood of a ceiling effect, pictures were presented for 250 ms each, and memory was tested by using free recall. The brief stimulus duration also allowed us to

control another possible contaminant of the results. This is the possibility, raised by Winograd (1981), that different orienting questions may have differential effects on visual scanning.

Winograd (1981) argues that the semantic orienting questions used in many of the experiments on face memory (e.g., honesty or likeableness judgments) may have induced the subject to scan the stimulus for several features that would aid in making the decision, whereas the physical orienting questions used (e.g., male-female, large nose, or straight hair judgments) could be answered by fixating on a relatively small portion of the stimulus, thus reducing the likelihood of encoding additional distinctive features. (The suggestion that numerous eye fixations increase the likelihood that a distinctive feature of a visual display will be encoded has also been provided by Loftus, 1972, in experiments using visual scenes as stimuli). Therefore, when viewing durations are sufficient to allow scanning of the stimulus, as has been the case in many experiments (e.g., Bower & Karlin, 1974; Light, Kayra-Stuart, & Hollander, 1979; Strnad & Mueller, 1977; Warrington & Ackroyd, 1975; Winograd, 1976), more extensive feature scanning and the subsequent encoding of additional distinctive features could in some cases account for semantic superiority. By eliminating the observer's ability to make more than one eye fixation per picture, the 250-ms stimulus duration should serve to eliminate the differential scanning problem.

Subjects were presented with equal numbers of different physical and semantic questions to control "uniqueness of encoding" (e.g., Craik & Tulving, 1975; Moscovitch & Craik, 1976; Stein, 1978), and the number of pictures eliciting *yes* and *no* responses to the questions was equated to determine if, as in verbal research, orienting questions eliciting positive responses would result in better memory (e.g., Craik & Tulving, 1975; Moscovitch & Craik, 1976).<sup>1</sup>

## Method

**Subjects.** Subjects were 24 undergraduate volunteers from an introductory psychology course at Bucknell University.

**Apparatus.** Subjects were seated approximately 2.4 m from a rear projection screen. Stimuli were presented

using a Gerbrands Model 1170 two-channel projection tachistoscope. Pictures subtended a visual angle of approximately  $8^\circ \times 10^\circ$ .

**Stimuli.** Stimuli were eighty 35-mm color slides of photographs of diverse indoor and outdoor scenes (from a set of magazine photographs collected and described by Potter & Levy, 1969).

**Selection and pretesting of orienting questions.** Ten semantic and 10 physical orienting questions were constructed on the basis of the following distinction. Physical questions are ones that do not require the subject to consider the picture's meaning. They require attention to visual characteristics and would therefore be applicable to meaningless random patterns as well as to meaningful pictures. Conversely, semantic questions cannot be answered unless the subject considers the picture's meaning. These questions would not apply to meaningless random patterns in the same sense that they apply to meaningful pictures. An attempt was made to make both types of questions equally general or global in nature. The semantic orienting questions included the following:

"Is this (a) animate, (b) inanimate, (c) edible, (d) inedible, (e) manmade, (f) natural, (g) indoor, (h) outdoor, (i) active, and (j) passive?" The physical orienting questions included: "Is this (a) balanced, (b) unbalanced, (c) horizontal, (d) vertical, (e) cluttered, (f) sparse, (g) rounded, (h) angular, (e) red, and (j) yellow?"

Each slide elicited either a *yes* or a *no* response to one semantic and one physical question.

To determine if agreement would be obtained on the classification of stimuli into the particular question-picture pairs selected by the experimenters, *yes-no* responses were collected from 6 subjects, run in groups of 3. The subjects viewed all 80 pictures two times, once preceded by the semantic orienting questions and once by the physical orienting questions. Each individual question was posed with eight pictures, four that were expected to elicit positive responses and four that were expected to elicit negative responses. Half the subjects received the semantic questions first, and the other half received the physical questions first.

The orienting question for each 250-ms picture was asked at the onset of a 2.5-s interval preceding the picture. A 3-s colorful visual noise mask (constructed from randomly scattered bits of colored paper) followed each picture in order to reduce the likelihood of visual persistence. Subjects were instructed to record their responses as quickly as possible during this time. At the offset of the visual noise mask, the 2.5-s blank field again appeared, and the next orienting question was asked. This procedure continued until all 80 pictures had been viewed.

A high degree of intersubject agreement on the classification of pictures was obtained. The mean proportion

<sup>1</sup> It should be noted that in the current design, individual pictures and *yes-no* responses could not be counterbalanced because of other counterbalancing constraints and the nature of the questions. Because of the large number of picture-question pairs (80), however, it was thought that a congruity analysis would still be worthwhile.

of yes-no responses that were in agreement with the experimenters' classification following semantic and physical orienting questions were .94 and .93, respectively. These picture-question pairs were used in the experiment.

*Design and procedure.* The 80 stimulus pictures were arranged into four sets with 40 picture-question pairs in each. Each of the four sets was presented to six independently tested subjects. Each individual picture appeared in two of the sets, once paired with a physical question and once with a semantic question. Within each set, semantic and physical orienting questions were presented in random order with the constraint that there be no more than two consecutive presentations of either type of question. Each question within a set was asked twice so that it elicited one positive and one negative response. Therefore, within each 40 item picture-question set, there were 10 physical and 10 semantic questions eliciting one positive and one negative response each.

Subjects were told that the purpose of the experiment was to collect picture perception data to be used as a baseline measure for future experiments. They were not informed that they would be asked to recall the scenes following the task. After receiving instructions, subjects were familiarized with the task and viewing conditions by answering orienting questions for 10 sample pictures. Immediately following the sample, each subject viewed an experimental set of 40 pictures. The orienting question for each picture was asked at the onset of a 2.5-s interval preceding the picture. The picture was then presented for 250 ms. A 3-s colorful visual noise mask followed each picture to reduce the likelihood of visual persistence. The subject was instructed to say *yes* or *no* as quickly as possible during this time. At the offset of the visual noise mask, the 2.5-s blank field again appeared, and the next orienting question was asked. This procedure continued until all 40 pictures had been viewed. One minute after the task was completed, subjects were allowed 10 min to recall the pictures they had seen. They were instructed to write a brief description (one or two descriptive phrases) for each picture they recalled so that it could be unambiguously identified by the experimenter.

### Results and Discussion

Physical and semantic orienting questions had a differential effect on memory. The direction of the effect, however, was opposite to that usually obtained in levels of processing research. Superior recall performance was obtained following physical rather than semantic orienting questions. The mean proportion recalled in both conditions is shown in Table 1. A two-way analysis of variance (ANOVA; Type of Question  $\times$  Congruity) indicated that the main effect of Type of Question was significant,  $F(1, 23) = 11.50$ ,  $MS_e = 4.06$ ,  $p < .01$ . The relatively low recall in the semantic condition cannot be attributed to an inability of the subjects to process the pictures semantically. This is supported by the fact that subjects correctly answered the

Table 1

*The Mean Proportion of Pictures Recalled and Standard Deviation as a Function of Orienting Question in Experiment 1 (Global Semantic Questions) and Experiment 2 (Specific Semantic Questions)*

Experiment	Type of orienting question			
	Physical		Semantic	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
1	.52	.16	.38	.11
2	.50	.12	.40	.11

semantic questions on 93% of the trials. Subjects answered the physical questions correctly on 89% of the trials. Out of a total of 24 subjects, 16 showed a physical superiority effect, 7 showed a semantic superiority effect, and 2 performed equally for both types of questions.

Congruity had a significant effect on recall,  $F(1, 23) = 4.34$ ,  $MS_e = 4.03$ ,  $p < .05$ . The proportion of pictures recalled that had been paired with *yes* and *no* questions was .49 ( $SD = .13$ ) and .41 ( $SD = .13$ ). The interaction of congruity and question type approached but did not reach significance,  $F(1, 23) = 3.17$ . The mean proportion of *yes* and *no* pictures recalled in the physical condition was .59 ( $SD = .20$ ) and .45 ( $SD = .23$ ), and in the semantic condition it was .39 ( $SD = .15$ ) and .37 ( $SD = .16$ ).

Physical questions may have resulted in better recall because pictures are rapidly processed to a semantic level under any type of encoding conditions, but physical orienting instructions direct encoding toward additional information that may serve to enhance retrieval. In this case, the additional information provided by physical orienting questions would perhaps lead to a more distinctive sensory code, whereas semantic orienting questions would simply provide information that is redundant with the analysis automatically performed by the subject.

Another explanation for the physical superiority effect concerns the specificity of the orienting question. Although the physical and semantic questions were chosen to be equally broad or global, there is no a priori evidence that the questions are equal in this respect.

Pictures paired with the physical questions may have benefited from greater specificity, which would account for the obtained effect. Because more specific questions would lead to greater congruity and better retrieval, specific category questions were provided in the semantic condition of Experiment 2 to determine if the semantic superiority effect would be obtained under these conditions. As in Experiment 1, the number of pictures per question was held constant.

### Experiment 2

In previous levels of processing research (e.g., Craik & Tulving, 1975; Moscovitch & Craik, 1976), orienting questions that refer to very specific categories were used in the semantic condition (e.g., "Is this an animal? A tool? A piece of furniture?"). In Experiment 2, semantic orienting questions similar to these were used. Physical questions consisted of the same global questions used in Experiment 1. If the physical superiority effect was due to the relative specificity of the two types of questions, with physical questions in some way being more specific or providing more congruent encoding contexts, the physical superiority effect should be diminished or reversed.

### Method

*Subjects.* Twenty-four undergraduate volunteers attending Bucknell University served as subjects.

*Procedure.* The stimuli, apparatus, and design were identical to Experiment 1, except that specific category questions about the scenes were substituted in the semantic condition. The semantic orienting questions included the following:

"Is this (a) a type of weapon, (b) a human being, (c) a kitchen item, (d) an animal, (e) an article of clothing, (f) a type of machinery, (g) a body of water, (h) a type of food, (i) a type of container, (j) a building material, (k) a vacation site, (l) an electric appliance, (m) a type of artwork, (n) a type of food, (o) a type of furniture, (p) a form of architecture, (q) a paper product, (r) a type of flower, (s) a type of liquid, (t) a musical instrument, (u) a sports activity, and (v) a mode of transportation?"

A larger number of semantic questions had to be created than in the previous experiments, because the pictures represented such a wide variety of scenes that they could not be subsumed under only 10 specific categories. All pictures appeared in the same order as in Experiment 1. Again, subjects viewed one of four sets of 40 picture-question pairs, and each picture appeared in two sets, once with a semantic question and once with a physical

question. In each of the four picture-question arrangements, 10 relevant semantic questions from the list just mentioned were presented along with the 10 physical questions used in the previous experiments. Within a set, each question was posed to the subject two times, eliciting one positive and one negative response.

### Results and Discussion

Although specific semantic orienting questions were provided, a physical superiority effect was again obtained. The mean proportion of pictures recalled in each condition is shown in Table 1. A two-way ANOVA (Type of Question  $\times$  Congruity) indicated that the main effect of Type of Question was significant,  $F(1, 23) = 11.34$ ,  $MS_e = 2.21$ ,  $p < .01$ . As in Experiment 1, the relatively low performance in the semantic condition cannot be attributed to the subjects' inability to process pictures semantically because subjects correctly answered the semantic questions on 97% of the trials. Subjects answered the physical questions correctly on 92% of the trials. Eighteen of the 24 subjects recalled more physically encoded pictures than semantically encoded pictures, 5 subjects showed the opposite effect, and the 2 remaining subjects obtained equal levels of recall for both types of encoding.

Congruity again proved to be a significant factor in recall. When pictures elicited a positive response, the mean proportion recalled was .57 ( $SD = .11$ ), whereas when the pictures elicited a negative response, the mean proportion recalled was .34 ( $SD = .12$ ),  $F(1, 23) = 60.98$ ,  $MS_e = 2.10$ ,  $p < .001$ . The mean proportion of *yes* and *no* pictures recalled in the physical condition was .58 ( $SD = .18$ ) and .43 ( $SD = .14$ ), respectively. For pictures in the semantic condition it was .55 ( $SD = .12$ ) and .25 ( $SD = .15$ ), respectively. There was a significant interaction of congruity and question type,  $F(1, 23) = 8.31$ ,  $MS_e = 1.72$ ,  $p < .01$ , reflecting a larger difference in the number of *yes* and *no* pictures recalled in the semantic condition. Congruity was a significant factor in both the physical and semantic conditions,  $F(1, 23) = 28.52$ , and  $F(1, 23) = 66.45$ , respectively, with  $MS_e = 1.72$ ,  $p < .001$ , simple main effects.

### Experiment 3

In Experiments 1 and 2, uniqueness of encoding was held constant across the seman-

Table 2  
 Experiment 3: Mean Proportion of Pictures  
 Recalled and Standard Deviation as a Function  
 of Question Type and Distinctiveness

Question type	Condition			
	Semantic distinct		Physical distinct	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Semantic	.47	.12	.28	.10
Physical	.33	.12	.49	.15

tic and physical conditions by equating the number of pictures associated with each type of orienting question. The importance of equating the number of repetitions of physical and semantic orienting questions in assessing their relative impact on memory has been demonstrated for verbal stimuli (e.g., Craik & Tulving, 1975; Stein, 1978). Some experiments with nonverbal stimuli have confounded question type with frequency of repetition, pairing more stimuli with each physical question than with each semantic question (e.g., Bower & Karlin, 1974; D'Agostino, O'Neill, & Paivio, 1977). This would be expected to enhance a semantic superiority effect. In Experiment 3, uniqueness of encoding was varied to examine its effect on memory for pictures and to determine if the semantic superiority effect could be created by increasing the number of physical repetitions.

### Method

*Subjects.* Subjects were 40 undergraduate volunteers from an introductory psychology course at Bucknell University.

*Procedure.* Fifty of the 80 stimulus pictures were selected on the basis of their fit within the categories described later. Viewing conditions were the same as in Experiments 1 and 2. Subjects viewed a set of 40 picture-question pairs in one of two conditions: *semantic distinct* or *physical distinct*. In the semantic distinct condition, each of the 10 global semantic orienting questions used in Experiment 1 was posed to the subject two times, eliciting one positive and one negative response. Only two physical orienting questions were used: "Is this (a) near or (b) far?"<sup>2</sup> Each of these questions was asked 10 times, eliciting five positive and five negative responses. In the physical distinct condition, each of the 10 physical orienting questions from the preceding experiments was

presented two times, eliciting one positive and one negative response. Two semantic orienting questions, "Is this (a) animate or (b) inanimate?", were repeated 10 times each, eliciting five positive and five negative responses. Half the pictures were preceded by semantic orienting questions, and the other half were preceded by physical questions.

The semantic and physical orienting questions were presented in random order with the constraint that there be no more than two consecutive presentations of either type of question. Each picture was associated with a distinct question for one half of the subjects and with a nondistinct question for the other half. A sample set of 10 pictures immediately preceded presentation of the experimental set. All other aspects of the procedure were identical to Experiment 3.

### Results and Discussion

Retention was facilitated by distinctive encoding contexts. The mean proportion of pictures recalled as a function of question type and distinctiveness condition is shown in Table 2. A three-way ANOVA [Distinctiveness Condition (semantic distinct vs. physical distinct)  $\times$  Type of Question  $\times$  Congruity] revealed that the Distinctiveness Condition  $\times$  Type of Question interaction was highly significant,  $F(1, 38) = 71.75$ ,  $MS_e = 1.7072$ ,  $p < .001$ . Inspection of Table 2 shows that retention was a function of the distinctiveness of the orienting questions, regardless of the type of orienting question used. Recall superiority for semantically encoded pictures was obtained in the semantic distinct condition,  $F(1, 38) = 25.69$ ,  $MS_e = 2.9441$ ,  $p < .001$ , simple main effects. In the physical distinct condition, physical encoding resulted in superior recall performance,  $F(1, 38) = 61.35$ ,  $MS_e = 2.9441$ ,  $p < .001$ , simple main effects. No other main effects or interactions were significant ( $F < 3.3$  in all cases).

The bias in recalling distinctively encoded pictures proved to be consistent among subjects in both conditions. In the semantic

<sup>2</sup> For our set of pictures, none of the physical questions used previously could serve as the repeating physical question in the semantic-distinct condition because of the constraints of semantic-physical counterbalancing across pictures and the requirement of an equal number of *yes* and *no* picture-question pairs. This resulted in the introduction of a new physical question. (Only one of the previously used semantic questions met these requirements, and that question was used in the physical distinct condition).

distinct condition, 17 of the 20 subjects recalled more semantically encoded pictures than physically encoded pictures, one subject showed the opposite effect, and the remaining two subjects showed equal levels of recall. In the physical distinct condition, 18 subjects recalled more pictures following physical orienting questions, and the remaining two subjects showed the opposite effect. In the semantic distinct condition, subjects correctly answered the semantic and physical questions on 97% and 93% of the trials, respectively. In the physical distinct condition, the percent correct was 92% and 95% for semantic and physical questions, respectively.

Comparison of the two distinct encoding conditions revealed that equal levels of recall were obtained for distinct semantic and distinct physical encodings,  $F < 1$ , simple main effects. Unlike Experiments 1 and 2, no effect of orienting question was obtained. Inspection of the data (Table 2) shows that performance in the physical condition was the same as in the previous two experiments, whereas performance in the semantic condition was superior to the previous two experiments. Perhaps enhanced performance in the semantic distinct condition, as compared with the previous two experiments, is due to the mixture of distinct and repeated questions. The total number of encoding questions was only 11 as opposed to 20 in the other experiments—making the 10 different semantic questions more salient than those in Experiments 1 and 2.

Contrary to the previous experiments, congruity had no effect on recall in the present experiment,  $F(1, 38) < 1$ . The mean proportion of pictures recalled that had been paired with *yes* and *no* orienting questions was .39 ( $SD = .18$ ) and .40 ( $SD = .17$ ), respectively.

The results clearly demonstrate that uniqueness of encoding affects memory for visual scenes. Repeated use of questions lead to inferior recall of the pictures with which they were paired. The results of the semantic distinct condition may demonstrate that a semantic superiority effect can be artifactually obtained when, as in some early studies, the semantic condition is associated with fewer question repetitions than the physical condition. This particular point regarding semantic

superiority should be viewed as suggestive, however, because the physical question used (near-far), although intended to focus attention on the physical layout of the stimulus, is a relational question that would probably require some semantic processing of the picture as well. Experiment 6 will provide another test of the effect of question repetition on memory, using a different set of pictures that will allow the same physical question to be used in both conditions.

#### Experiment 4

Experiments 1-3 showed that a physical orientation leads to better memory than a semantic orientation when pictures are presented briefly (250 ms). The purpose of Experiment 4 was to determine if this same pattern of results would hold when subjects have more time to look at the pictures. To this end, memory was tested following stimulus durations of 250 ms, 500 ms, and 2,000 ms. In addition to free recall, a cued-recall task was added (following free recall) to determine if physical superiority could be obtained, when subjects are provided with all the physical and semantic questions at the time of the test.

#### Method

*Subjects.* Subjects were 60 undergraduates from the University of Delaware (36 women and 24 men).

*Apparatus.* Subjects were seated approximately 2 m from a rear projection screen. Stimuli were presented by using a three-channel projection tachistoscope with Uniblitz shutters (projectors and shutters were comparable to those used in Experiments 1-3). Timing and carousel advances were controlled by an Apple II computer. The projected field (17 cm  $\times$  23 cm) subtended a visual angle of approximately  $5^\circ \times 6^\circ$ .

*Stimuli and orienting questions.* The stimuli were 32 pictures taken from the set used in Experiments 1-3. The semantic questions were "Is this (a) animate, (b) inanimate, (c) natural, (d) manmade, (e) edible, (f) inedible, (g) indoors, and (h) outdoors?" The physical questions were "Is this (a) unbalanced, (b) balanced, (c) multicolored, (d) unicolored, (e) horizontal, (f) vertical, (g) rounded, and (h) angular?"

*Design.* There were 20 subjects tested in each of the three stimulus duration conditions. The 32 stimulus pictures were presented in two random orders. Each order had two versions. Half the pictures were paired with semantic questions, and the other half with physical questions in each version. Pictures paired with physical

questions in one version were paired with semantic questions in the other. Each of the 16 questions listed earlier was asked twice and was expected to yield one *yes* response and one *no* response. Unlike the previous experiments, each picture elicited the same response regardless of which question type was asked (i.e., across conditions it elicited either a *yes* response both times or a *no*). This assured that in all cases the only difference between the two conditions was which type of orienting question was asked.

*Procedure.* Subjects took part individually or in pairs. When tested in pairs, subjects were separated by a partition. Following the instructions and presentation of a 6-item practice sequence, subjects were presented with the 32-item experimental sequence. The sequence was organized in the following way. A fixation point was presented for 2.5 s, during which time the question was asked. This was followed by a 2.5-s colorful noise mask and the stimulus, which was presented for 250 ms, 500 ms, or 2,000 ms, depending on the group. A 3-s visual noise mask was then presented, and the cycle repeated, until all pictures were shown.

After presentation, subjects took part in an unexpected free-recall task for 5 min, and then a cued-recall task for 5 min. In the cued-recall task, they were provided with a response sheet on which each of the 16 questions was typed above a space. They were told to read each question and write in the pictures that had been paired with that question in the sequence.

### Results and Discussion

The physical superiority effect occurred regardless of whether memory was tested by using free recall or cued recall, and it clearly was not limited to the 250-ms condition.

*Free recall.* The proportion of pictures recalled as a function of question type and stimulus duration is shown in Table 3. An ANOVA conducted on the number of pictures recalled showed a significant main effect of question type; physical questions resulted in more pictures recalled,  $F(1, 57) = 6.49$ ,  $MS_e = 4.32$ ,  $p < .025$ . A small but significant effect of stimulus duration was obtained,  $F(2, 57) = 3.25$ ,  $MS_e = 5.88$ ,  $p < .05$ , reflecting a slight increase in recall in the longer stimulus duration conditions. There was no interaction of question type and stimulus duration,  $F(2, 57) = 1.83$ . Although the interaction did not approach significance, inspection of Table 3 shows that physical superiority is not evident in the 2,000-ms condition where virtually the same proportion of pictures was recalled in both orienting conditions. This was not due to an increase in the semantic condition, but to a sharp decrease in performance in the

Table 3

*Experiment 4: The Mean Number, Standard Deviation, and Proportion (P) of Pictures Recalled in Free Recall and Cued Recall as a Function of Orienting Question and Stimulus Duration*

Duration	Question type					
	Physical			Semantic		
	<i>M</i>	<i>SD</i>	<i>P</i>	<i>M</i>	<i>SD</i>	<i>P</i>
Free Recall						
250	7.35	2.55	0.46	5.75	2.10	0.34
500	8.60	2.23	0.54	7.25	2.12	0.45
2,000	7.10	2.77	0.44	7.15	1.98	0.45
Cued Recall <sup>a</sup>						
250	4.35	1.42	0.27	2.80	1.51	0.18
500	5.90	2.63	0.37	4.15	2.08	0.26
2,000	5.75	2.05	0.36	3.80	1.74	0.24

<sup>a</sup> Cued-recall scores represent those cases in which the subject recalled the picture with the correct specific question.

physical condition, the reason for which is not apparent. Inspection of Table 3 shows that in cued recall these same subjects showed a physical superiority effect in the 2,000-ms condition, yielding the same pattern of results as subjects in this other two duration conditions.<sup>3</sup>

A congruity effect was not obtained for free recall. The mean number of pictures recalled that had elicited *yes* and *no* responses was 7.45 ( $SD = 2.34$ ) and 6.98 ( $SD = 2.14$ ),  $t(59) = 1.33$ .

*Cued recall.* The mean number of pictures that subjects listed as having been paired with physical or semantic questions was 8.3 ( $SD = 2.51$ ) and 6.3 ( $SD = 2.01$ ), respectively.

<sup>3</sup> The ANOVA for cued recall (reported under the "cued recall" heading) yielded a strong physical superiority effect and no interaction. Because of the concern about the 2,000-ms condition, three dependent *t* tests were performed which revealed that in the cued-recall condition, the difference between the physical and semantic conditions were highly significant at all three durations,  $t(19) = 5.13$ ,  $p < .002$ ;  $t(19) = 3.14$ ,  $p < .01$ ; and  $t(19) = 5.43$ ,  $p < .002$ , for the 2,000-ms, 500-ms, and 240-ms conditions, respectively (two-tailed tests).



Erroneous responses (those not corresponding unambiguously to any of the stimuli) accounted for 4% and 6% of those responses, respectively. Considering only those responses that actually referred to stimuli, less than 3% were reported as having occurred with the wrong question type (i.e., physical vs. semantic). An average of 7.6 pictures were correctly associated with the proper physical question pair (e.g., angular-rounded), and an average of 5.3 pictures with the proper semantic question pair (e.g., edible-inedible). Subjects correctly identified which specific question was asked (e.g., "Is this *edible*?" or "Is this *inedible*?") for an average of 5.4 pictures and 3.6 pictures in the physical and semantic conditions, respectively.

The number of pictures recalled in association with the specific question in cued recall is shown in Table 3. An ANOVA yielded results similar to those obtained in the free-recall analysis. A significant main effect of question type showed that under conditions of cued recall, physical orienting questions lead to better memory than semantic questions,  $F(1, 57) = 46.4$ ,  $MS_e = 1.979$ ,  $p < .001$ . There was a small significant effect of stimulus duration on recall, with longer durations yielding better recall,  $F(2, 57) = 4.278$ ,  $MS_e = 5.62$ ,  $p < .02$ . There was no interaction of question type and stimulus duration,  $F(2, 57) < 1$ . The same results were obtained when less conservative scoring was used that included all responses made to the correct question pair.

A congruity effect was obtained for cued recall. The mean number of pictures recalled that had elicited *yes* and *no* responses was 5.12 ( $SD = 2.60$ ) and 3.82 ( $SD = 2.01$ ),  $t(59) = 3.35$ ,  $p < .001$ , two-tailed test.

### Experiment 5

The pictures used in Experiments 1-4 were color photographs of scenes. Because of this, the semantic questions in some cases referred to a particular object within the scene (e.g., edible-inedible, or animate-inanimate), whereas the physical questions referred to the scene taken as a whole (with the exception of the question referring to red and yellow in Experiments 1-3). In Experi-

ment 2, all the semantic questions referred to an object in the scene. Experiment 5 sought to determine if the physical superiority effect is an artifact of the allocation of attention to a part of the picture rather than to the whole picture. If this is the case, then the physical superiority effect should be eliminated or reversed when the semantic and physical questions both refer to the picture as a whole.

To this end, an experiment similar to Experiment 4 was conducted in which photographs of single objects, rather than photographs of scenes, were presented. Single, unrelated objects, like scenes, are commonly used in picture memory experiments. They are particularly appropriate in the current context, because both types of questions would make reference to each picture as a whole. Because these stimuli are in some sense less complex than scenes, a shorter stimulus duration was included, in case of ceiling effects. Stimulus durations tested in this experiment were 125 ms, 250 ms, and 2,000 ms.

### Method

*Subjects.* Subjects were 60 undergraduates from the University of Delaware (women and men).

*Apparatus.* The apparatus was the same as in Experiment 4.

*Stimuli and orienting questions.* The stimuli were magazine photographs of animals, food, people, and objects that were cut out and rephotographed on a gray background. There were 6 pictures for the practice sequence, and 32 pictures for the experimental sequences. The pictures were chosen from a set that was first described by Intraub (1979) and was used in several experiments. The orienting questions were the same as in Experiment 4 except in one case. The physical question pair regarding balance ("Is this (a) balanced or (b) unbalanced?"), applied well to scenes, but not to single objects. A new, somewhat related question pair was substituted that asked "Is this (a) symmetrical or (b) asymmetrical?"

*Design and procedure.* The design and procedure were the same as in Experiment 4, except that the 500-ms condition was replaced with a 125-ms condition.

### Results and Discussion

Changing the stimuli to pictures of objects did not eliminate the physical superiority effect. Physical questions led to better memory in both the free-recall and the cued-recall

Table 4  
*Experiment 5: The Mean Number, Standard Deviation, and Proportion (P) of Pictures Recalled in Free Recall and Cued Recall as a Function of Orienting Question and Stimulus Duration*

Duration	Question type					
	Physical			Semantic		
	M	SD	P	M	SD	P
Free recall						
125	6.65	1.57	0.42	5.65	1.60	0.35
250	7.60	1.90	0.48	5.70	1.90	0.35
2,000	7.75	2.43	0.48	6.40	2.11	0.40
Cued recall <sup>a</sup>						
125	4.50	1.85	0.28	2.70	1.81	0.17
250	4.70	1.87	0.29	4.00	1.92	0.25
2,000	5.40	2.44	0.34	3.75	2.17	0.23

<sup>a</sup> Cued-recall scores represent those cases in which the subject recalled the picture with the correct specific question.

tasks when stimuli were presented for 125 ms, 250 ms, and 2,000 ms.

*Free recall.* The proportion of pictures recalled as a function of question type and stimulus duration is shown in Table 4. An ANOVA conducted on the number of pictures recalled in each condition showed a significant main effect of question type; physical questions resulted in superior recall,  $F(1, 57) = 19.37$ ,  $MS_e = 3.11$ ,  $p < .001$ . Unlike the previous experiment, the slight difference in recall associated with stimulus duration was not significant,  $F(2, 57) = 1.94$ . The results of these two experiments (using two different sets of pictures) suggests that the well-established relation between recognition memory performance and stimulus duration may not apply to free recall. There was no interaction of question type and stimulus duration,  $F(2, 57) < 1$ .

A significant congruity effect was obtained,  $t(59) = 2.53$ ,  $p < .02$ , two-tailed test. The mean number of *yes* and *no* pictures recalled was 7.07 ( $SD = 1.91$ ) and 6.18 ( $SD = 2.10$ ), respectively.

*Cued recall.* The mean number of pictures that subjects listed as having been paired with physical and semantic questions was 8.07 ( $SD = 2.02$ ) and 6.07 ( $SD = 1.80$ ), respectively. Erroneous or ambiguous responses accounted for .09 and .06 of those responses, respectively. Considering only unambiguous responses, .05 responses in each condition were reported as having occurred with the wrong question type. An average of 6.9 and 4.5 pictures were reported as occurring with the proper physical and semantic question pair, respectively. Subjects correctly identified the specific question for an average of 4.9 ( $SD = 2.07$ ) and 3.6 ( $SD = 2.01$ ) pictures, in the physical and semantic conditions, respectively.

The number of pictures recalled in association with the correct specific question as a function of question type and stimulus duration is shown in Table 4. An ANOVA revealed the same pattern of results as the analysis of the free-recall responses. There was a significant physical superiority effect,  $F(1, 57) = 23.72$ ,  $MS_e = 2.42$ ,  $p < .001$ , no effect of stimulus duration,  $F(2, 57) = 1.80$ , and no interaction of question type and stimulus duration. The same results were obtained when less conservative scoring was used that included all responses made to the correct question pair.

A significant congruity effect was obtained,  $t(59) = 4.04$ ,  $p < .001$ , two-tailed test. The mean number of pictures recalled that had been paired with *yes* and *no* questions was 4.88 ( $SD = 1.89$ ) and 3.37 ( $SD = 2.41$ ), respectively.

### Experiment 6

The purpose of Experiment 6 was to determine if the physical superiority effect obtained with pictures of single objects could be eliminated by repeatedly presenting the same physical questions, so that only in the semantic condition would pictures have unique encoding contexts (i.e., a unique combination of a specific question and a *yes* or *no* response). If the effect of orienting questions on memory for pictures is similar to that obtained for words (e.g., Craik & Tulving, 1975; Stein, 1978), then this should be the case.

It will be recalled that Experiment 3 tested this prediction by using the visual scenes as stimuli and provided tentative support. The problem with the experiment was that none of the previously used physical questions applied to all of the stimuli; therefore, a new physical question had to be introduced. The pictures of objects (used in Experiment 5) were more flexible with respect to the physical questions and with a subset of 16 of those pictures we were able to circumvent that problem. For each subject, eight pictures were paired with semantic questions, and eight were paired with physical questions. In the semantic condition, each picture was paired with a different specific question. In the physical condition, four pictures were paired with one specific question ("Is this rounded?") and four were paired with the other specific question ("Is this angular?"). The rounded-angular question pair was selected because it yielded the highest memory performance of all the physical questions, and it would therefore provide the most conservative test of the hypothesis.

### Method

*Subjects.* The subjects were 22 undergraduates from the University of Delaware (10 women and 12 men).

*Apparatus.* The apparatus was the same as in Experiments 4 and 5.

*Stimuli and orienting questions.* The same eight semantic orienting questions were used as in Experiment 4. The physical condition required a question pair that could be applied to all the stimuli (half yielding *yes* responses, and half yielding *no* responses). The question pair used was "Is this (a) angular or (b) rounded?" This question pair had yielded the best memory performance in cued recall in Experiment 5 (physical condition). Using this question pair provided the strictest test of the hypothesis.

Sixteen stimuli fit the requirements of the present experiment. There were an equal number of *yes* and *no* pictures for each of the two physical questions, and the same stimuli also provided an equal number of *yes* and *no* pictures for the semantic condition.

*Procedure.* The experiment followed the same basic procedure as Experiment 5 except that a single stimulus duration was used (250 ms) and there was one random order of the 16 picture-question pairs. Those pictures that were paired with physical questions in one version were paired with semantic questions in the other version. For a given subject, each of the eight semantic questions was asked once, and each of the two physical questions was asked four times. There were an equal number of *yes* and *no* responses.

### Results and Discussion

The results show that like the semantic superiority effect for words, the physical superiority effect for pictures will be affected by reducing the "uniqueness of encoding" (i.e., repeating the same question for several different stimuli). The results are consistent with those obtained in Experiment 3. In the present experiment, the physical superiority effect for pictures of objects was eliminated both in the free-recall and cued-recall conditions.

The number of pictures recalled in the physical condition was 4.0 ( $SD = 1.73$ ), and in the semantic condition it was 3.8 ( $SD = 1.59$ ),  $t(21) < 1$ . The number of pictures recalled with the correct specific question in cued recall was 2.00 ( $SD = 1.75$ ) and 1.95 ( $SD = 1.17$ ) in the physical and semantic conditions, respectively.

### General Discussion

Orienting questions of the type used in levels of processing research affected free recall and cued recall of color photographs (naturalistic scenes and single objects). The direction of the effect, however, was opposite to that typically obtained with words (e.g., Craik & Tulving, 1975; Moscovitch & Craik, 1976). Physical orienting questions (e.g., "Is this angular?") resulted in a higher proportion of pictures recalled than did semantic questions. This occurred regardless of whether the semantic questions were global (e.g., "Is this an outdoor scene?", Experiments 1 and 4) or relatively specific (e.g., "Does this scene contain furniture?"; Experiment 2). It should be noted that although this reversal was obtained, some similarities to recall patterns obtained with words suggest that the same general mechanisms may be at work regardless of which question type is most beneficial for a particular set of stimuli.

Just as "uniqueness of encoding" has been shown to influence the semantic superiority effect associated with words (Craik & Tulving, 1975; Moscovitch & Craik, 1976; Stein, 1978), the physical superiority effect was eliminated or reversed when the same physical questions were paired with several pictures (Experiments

3 and 6). As with words, congruity affected memory for pictures in most of the conditions. That is, pictures that had elicited *yes* responses to questions tended to be recalled more frequently than pictures that had elicited *no* responses. Because the general pattern of results is the same as that obtained with words, the next question to ask is why a physical superiority effect rather than a semantic superiority effect was obtained with these pictures.

Two explanations of the physical superiority effect that would relegate it to the status of an artifact are that (a) subjects did not process the pictures semantically in the semantic condition and (b) that the specific physical and semantic questions used had differential effects on how much of the scene was attended to and encoded. Clearly the first possibility cannot be the case because in all the experiments subjects responded correctly to the semantic questions, making very few errors, and in no case was accuracy in the physical condition superior. Furthermore, subjects' response show that in all cases, remembered pictures had been identified and understood regardless of orientation. For example, there were no responses made describing a scene as "an angular, greenish picture with many lines." Descriptions of scenes and objects always included reference to the picture's meaning (e.g., "girl sitting in tall grass"). Semantic processing certainly took place; it simply did not result in superior recall.

The second explanation described earlier is that because some semantic questions referred to a particular object within a scene (e.g., "Is this animate?"), whereas physical questions tended to refer to the scene as a whole (e.g., "Is this balanced?"), *physical* superiority may actually have been an artifact of *part* versus *whole* picture encoding. Some evidence against this hypothesis is that the verbal titles subjects provided during recall did not suggest that they had only encoded the object and not the scene (e.g., if a dog was the *animate* object in a suburban scene, subjects did not report *dog* but reported *dog in suburban scene*). It could be argued, however, that subjects simply did not report a picture if they could not remember the whole scene. More direct evidence against the hy-

pothesis is that when photographs of single objects on gray backgrounds were used instead of scenes, the physical superiority effect persisted in both free recall and cued recall (Experiment 5). In this case, all the questions referred to each picture as a whole. The physical questions may have enhanced memory for pictures by yielding more distinctive codes or by requiring more effortful processing than did the semantic questions. We will now consider how this might be the case.

Object detection and search experiments have demonstrated that even briefly presented pictures (e.g., 100–300 ms) are rapidly understood (Biederman, Glass, Rabinowitz, & Stacy, 1974; Intraub, 1981a, 1981b; Potter, 1975, 1976). There is evidence that this conceptual processing may be automatic (e.g., Intraub, 1984; Smith & Magee, 1980). If this is the case, then semantic questions that ask for category or identity information about a picture may evoke processing that is redundant with automatically initiated processes. The physical questions, on the other hand, may direct attention to additional characteristics of the scene that the subject would not normally focus on. (For example, consider the effort spent in art courses trying to teach students to attend to the composition and other visual characteristics of a painting rather than simply identifying what object is depicted.) Once attention is directed to these attributes, the physical questions may enhance memory for visually rich stimuli by resulting in a more detailed and distinctive code. Another possibility is that because the physical questions are not tapping into an automatic process, they may elicit more effortful processing, thereby enhancing the probability of recall (see Craik, 1981).

With these considerations in mind, it is not surprising that previous research with nonverbal stimuli supported the semantic superiority rule of thumb. Most pictorial stimuli in those experiments, like words, shared the same small set of visual characteristics and comprised a visually homogeneous group. They included pictures of faces (e.g., Bower & Karlin, 1974; Light, Kayra-Stuart, & Hollander, 1979; Strnad & Mueller, 1977; Warrington & Ackroyd, 1975; Winograd, 1976; 1981) and different arrangements

of pieces on chessboards (Goldin, 1978; Lane & Robertson, 1979). The sensory-semantic model of Nelson, Reed, & McEvoy (1977) has demonstrated the importance of distinctive visual codes in picture memory. Recall that the higher memorability of pictures as compared with words was reduced or eliminated when conceptually dissimilar pictures were drawn to be schematically similar (Nelson, Reed, & Walling, 1976).

It follows that if pictures are very similar on a sensory dimension, biasing the subject to attend to semantic characteristics may make their traces more distinctive. For example, asking for capital letter-small letter judgments about words, or large nose-small nose judgments about yearbook faces, would not be expected to lead to as discriminable encodings as asking about word meaning or speculation about the pictured person's character (e.g., honest-dishonest dimension). When, as in the present experiments, visually distinctive pictures are used, which may differ conceptually as well as physically, a different pattern of results emerges. In this case, because the objects and scenes depict fairly common concepts, having attention drawn to their unique visual characteristics may lead to a more distinctive or elaborate trace than having attention drawn to their semantic attributes.

The physical superiority effect raises some interesting possibilities for future research with pictures. Although many experiments have studied the effects of stimulus variables (such as stimulus duration, interstimulus interval, series length, picture similarity, and mask types) on picture memory, there are relatively few that have been concerned with the effects of cognitive variables such as attentional strategy (Graefe & Watkins, 1980; Intraub, 1980, 1981a, 1984; Loftus, 1972; Weaver & Stanny, 1978). These experiments have all used selective attention instructions that require the subjects to focus on some pictures at the expense of others. In contrast, orienting questions shift the focus of attention to different aspects of the same picture. Using orienting questions in conjunction with memory tests that are more sensitive to the detail contained in a memory representation [e.g., drawing tasks, detail description tests

(e.g., Intraub, 1980), and recognition tests] should indicate whether question superiority effects are due to storage of a more detailed representation in memory or to more diffuse factors such as variation in the expenditure of effort. Different tests would also provide different retrieval contexts for the same code. Finally, as discussed previously, the possibility of independently varying conceptual and physical characteristics, make pictures an interesting tool with which to study the effects of distinctiveness on memory.

One caution should be considered in conducting and comparing levels of processing experiments that test memory for pictures. It involves the choice of questions and their designation as *physical* or *semantic*. In Experiment 1, we offered a guideline for making this decision. We suggested that to be considered a physical question, a question must not require reference to the picture's meaning. For example, questions about angularity, balance, and color could be applied to random pattern of lines as well as to meaningful scenes. Semantic questions, on the other hand, require reference to the picture's meaning and would not readily apply to random patterns (e.g., "Is this indoors?").

This distinction does not hold for some of the experiments with faces where the nature of the stimulus makes question selection difficult. For example, making a "big nose-small nose" decision about a face was considered a physical question in some experiments but is problematic because to make the decision one must make use of knowledge about noses and process the picture in terms of a meaningful unit (a nose). This is the same problem we found with the near-far question used in Experiment 3. We suggest the use of our guideline in future research, because it seems to capture what was intended in the initial levels of processing experiments with words where physical questions (e.g., capital-small letters, number of consonants) could be answered without reference to a word's meaning and in fact could readily be answered for nonwords.

With respect to the levels of processing view of memory, these experiments make two important points: (a) that the rule of thumb regarding the superiority of semantic

processing does not necessarily hold for pictorial stimuli and (b) that, as has been suggested previously (e.g., Jacoby & Craik, 1979; Nelson, Reed, and Walling, 1976), it is very important to take into account not only the nature of the individual stimulus, but also the nature of the whole inspection series in interpreting memory phenomena. The relation of each object to other members of the to-be-remembered series is important in determining the type of encoding that will make the memory distinctive. Jacoby and Craik (1979), in discussing distinctiveness and word meaning, point out that distinctiveness requires a contrastive assessment of an item with respect to the context or background in which it is presented. This same view should be taken with pictures, with equal focus being placed on the conceptual and physical dimensions.

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