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Conceptual Masking: The Effects of Subsequent Visual Events on Memory for Pictures

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Three experiments studied the effects of voluntary and involuntary focus of attention on recognition memory for pictures. Experiments 1 and 3 tested the conceptual-masking hypothesis, which holds that a visual event will automatically disrupt processing of a previously glimpsed picture if that event is new and meaningful. Memory for 112-ms pictures was tested under conditions where the to-be-ignored 1.5-s interstimulus interval contained a blank field; a repeating picture; a new picture; a new, nonsense picture; or a new, inverted picture each time. The blank field, repeating picture, and new, nonsense picture did not disrupt memory as much as a new, meaningful picture, supporting the conceptual-masking hypothesis. Experiment 2 studied voluntary attentional control of encoding by instructing subjects to focus attention on the brief pictures, all pictures, or the long pictures in a sequence. Recognition memory for pictures of both durations showed a striking ability of observers to process pictures selectively. The possible role of these effects in visual scanning are discussed.

Stimulus factors such as duration, presentation rate, and visual similarity of stimuli have all been shown to affect memory for pictures (e.g., Intraub, 1979, 1980; Nelson, Reed, & Walling, 1976; Potter, 1976; Weaver & Stanny, 1978). The present research was motivated by questions concerning the observer's control over picture processing and the factors that might limit this control. One potential factor, proposed by Potter (1976), is conceptual masking. The conceptual-masking hypothesis is concerned with the early stages of picture processing, which are initiated during the first eye fixation made on a picture or scene. According to the hypothesis, a picture is rapidly understood and is held for a few hundred milliseconds in a short-term conceptual store while it is consolidated in memory. The information at this stage is very unstable and may be lost if a new picture is quickly presented. This occurs because the new picture itself elicits conceptual processing thus replacing the previous item in the short-term conceptual store.

The hypothesis is based on research in which single fixations and the dynamic, sequential activity of visual scanning are mimicked through the use of tachistoscopic presentation and rapid sequential presentation of pictures. When unrelated pictures are presented at rates that approximate the average fixation frequency of three per second and faster, and recognition memory is tested immediately, subjects can remember very few pictures (e.g., Intraub, 1979, 1980; Potter & Levy, 1969). It was suggested that poor memory for rapidly presented, unrelated pictures may be due to an inability to identify the pictures, perhaps due to visual masking (Rosenblood & Pulton, 1975; Shaffer & Shiffrin, 1972). More recent research, however, rules out the visual-masking hypothesis by demonstrating that recognition memory for a series of briefly glimpsed pictures is very good when pictures are presented with interstimulus intervals (ISIs) that contain a visual noise mask (Potter, 1976) or a familiar picture that repeats throughout the sequence (Intraub, 1980). Furthermore, visual search experiments indicate many more pictures are

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momentarily identified during rapid continuous presentation than are remembered later (Intraub, 1981b; Potter, 1975, 1976).

In one set of experiments a target picture in a rapidly presented sequence was cued by providing the subject either with the picture itself or with a brief verbal title (e.g., "a road with cars"; Potter, 1975, 1976). In another experiment to minimize expectancy effects, the target picture was cued by providing the subject with its superordinate category or a negative cue (e.g., "a picture that does *not* belong to the category 'transportation' "; Intraub, 1981b). In all cases detection accuracy yielded relatively good performance compared with recognition memory for the same pictures. The apparent rapid loss of momentarily held information was attributed to conceptual masking of each picture by the next. According to this view, although many pictures are identified, only those that can be consolidated prior to the onset of the next picture will be remembered at the end of the sequence.

The extent to which conceptual masking is automatic remains unclear. Given that the acquisition of a picture's general concept or "gist" is obtained very rapidly (e.g., Biederman, Rabinowitz, Glass, & Stacy, 1974; Intraub, 1981a, 1981b; Potter, 1975, 1976), the observer may not be able to suppress these processes of identification resulting in conceptual masking if the meaningful visual events are close enough in time. Potter (1976) raised the possibility that an observer would not be able to suppress processing of a new picture in a sequence. The present experiments address this issue. Experiment 1 studies the extent to which selective processing of individually glimpsed pictures can be voluntarily controlled when new pictures are immediately presented. Recent experiments have shown that observers provided with attention instructions can selectively process particular pictures in a series when cued with a warning tone (Weaver & Stanny, 1978) or a postcue (Graefe & Watkins, 1980; Watkins & Graefe, 1981). Those studies, however, used relatively long stimulus durations and conditions in which the to-be-remembered pictures were not immediately followed by new pictures. Experiment 2 examines the effect of selective attention instructions on memory for sequentially presented pictures under conditions in which conceptual masking would be expected. Experiment 3 addresses the issue of whether or not the masking proposed by Potter (1976) is actually *conceptual* in nature, that is, if it is identification of the meaning in a new input that leads to a disruption of memory.

Experiment 1

To determine the effect that immediate presentation of a new picture has on memory for briefly glimpsed pictures in a sequence, pictures were presented for 112 ms each with a 1.5-s ISI that contained a new picture each time. Subjects were instructed to attend to the 112-ms pictures and to remember as many as possible. Memory under this condition was compared with that obtained when the ISI contained a familiar picture that repeated throughout the sequence and when the ISI contained a blank field. If encoding of a glimpsed scene is automatically terminated by the onset of a new scene, then recognition memory should suffer dramatically when the ISI contains a new picture. In principle, it should approach the poor performance obtained following continuous presentation (no ISI). (Note that using pictures from the same stimulus pool as Experiment 1 and a duration of 110 ms per picture, Intraub [1979, 1980] obtained recognition memory scores between 19% and 21% correct for set sizes of 150, 20, and 16 continuously presented pictures.) If processing of new pictures can be suppressed, then recognition memory should equal the condition in which a repeating picture is presented during the ISI.

Method

Subjects. Subjects were 36 Massachusetts Institute of Technology (MIT) undergraduates who were paid for their participation. All reported normal or corrected vision.

Materials and apparatus. The stimuli were color magazine photographs of one or two main objects which were cut out and rephotographed on a plain gray background. They belonged to a diverse range of categories (e.g., people, animals, food, etc.) and were used previously by Intraub (1979, 1980). These were photographed, using single-frame photography, on 16-mm color movie film. The sequences were projected onto a standard movie screen using an L-W variable-speed 16-mm projector at 18 frames per second. For the recognition test, 35-mm slides of the stimuli were presented using a Kodak Carousel projector. The pictures subtended a visual angle of approximately 12° × 12°.

Design and procedure. Twelve subjects took part in each of three conditions and were tested singly or in pairs.

In all conditions, 16 pictures were presented for 112 ms each with a 1.5-s ISI. There were two sets of 16 stimuli, each viewed by half of the subjects in each condition. In the changing-ISI condition, a new picture was presented during the ISI each time. The 112-ms pictures in one version were used as the ISI pictures in the other version, and vice versa. In the repeating-ISI condition, a single picture was repeated during each ISI. Subjects were shown the picture in advance. Two different ISI pictures chosen from the same stimulus pool were used (these pictures were different from the ones used in Intraub's, 1980, previous repeating-ISI conditions). Each was presented to one half of the subjects in the repeating-ISI condition. In the blank-ISI condition, a homogeneous gray field was presented during the ISI.

All subjects were presented with a 6-picture practice sequence and a practice recognition test prior to viewing the experimental sequence. In the repeating-ISI condition subjects viewed the same ISI picture in the sample as they would see in the experimental sequence. Following presentation of the experimental sequence, a 32-item serial recognition test was administered that included the 16 stimuli randomly mixed with 16 distractors (new pictures). The order of presentation of pictures in the test was reversed for half the subjects in each condition. The distractors were from the same pool of pictures but were chosen to avoid those that would be highly confusable with the targets in terms of conceptual content. That is, although both targets and distractors fell into the same superordinate categories (e.g., people or foods), pictures with the same specific object identity were not used (e.g., two cowboys, two apples, etc.).

All subjects were instructed to fixate on the center of the screen at all times during presentation and to pay attention to the briefly presented pictures. The presentation rate was chosen to be fast enough so that subjects would have to remain vigilant not to miss the brief pictures. In the changing- and repeating-ISI conditions, subjects were instructed to try to ignore the ISI pictures. Subjects in all conditions were told to use the ISI to memorize the brief pictures, which would then be presented in a recognition test. The brief duration and rapid rate of presentation made it seem unlikely that subjects would (or even could) adopt a peripheral strategy for ignoring the ISI pictures by closing their eyes quickly enough to avoid seeing the ISI pictures and opening them again in time for the next stimulus. However, to check this possibility the experimenter was positioned so that the subjects' faces could be watched during presentation. This observation, as well as strategy descriptions provided by a subset of subjects in Experiments 1 and 2, indicated that subjects were following instructions. Subjective reports included such terms as "mentally blocking" ISI pictures or "concentrating my thinking" on the brief pictures. For the recognition test, subjects were instructed to write *yes* if they were reasonably sure they had seen a picture before and *no* otherwise.

Results and Discussion

Presentation of a new picture during the ISI disrupts memory for briefly glimpsed pictures more than presentation of a repeating picture, but it does not reduce it to the low level obtained following rapid continuous presentation. The proportion of pictures recognized, the proportion of false alarms, and the proportion recognized corrected for guessing[1] in the blank-, repeating-, and changing-ISI conditions are shown in Table 1. A one-way analysis of variance (ANOVA) on the corrected proportion recognized showed that the conditions differed significantly, $F(2, 33) = 11.02$, $MS_e = .0194$, $p < .001$. Similar to Intraub (1980), only a small memory decrement was obtained when the ISI contained a repeating picture rather than a blank field, showing that visual masking of one picture by the next is not the primary cause of poor performance following rapid continuous presentation. A Dunn post hoc comparison showed that this difference was not significant. Also, memory performance was not differentially affected by the two picture masks used in the experiment (both yielded corrected scores of 80% recognized). A significant drop in performance was obtained when a new picture was presented during the ISI rather than a repeating picture, $p < .05$ (Dunn post hoc comparison). The level of performance, however, remained relatively high (63% correct, corrected for guess-

Table 1
Mean Proportion of Pictures Recognized, of False Alarms (FA), and of Pictures Corrected for Guessing (M_c) in the Three ISI Conditions

ISI condition	M	FA	M_c	SD
Blank	.89	.02	.89	.14
Repeating	.82	.08	.80	.14
Changing	.64	.05	.63	.13

Note. ISI = interstimulus interval.

[1] The formula used to correct for guessing was $Y = (TY - FY)/(1 - FY)$ in which Y is the corrected proportion of yes responses, TY is the proportion of yes responses to old pictures, and FY is the proportion of yes responses to distractors. It should be noted that reliable d' scores cannot be obtained from these data because of the relatively small number of trials (16 targets and 16 distractors) and the fact that with these stimuli many subjects make no false alarms. Group d' scores, however, which can be calculated from these data (see tables for the proportion of false alarms and raw hits in each condition), yield the same pattern of results as the guessing-corrected scores.

ing). Although disrupting processing to some degree, the presentation of a new picture apparently does not terminate encoding or prevent the subject from using the ISI to continue processing a briefly glimpsed picture. Memory did not approach the low level obtained following continuous presentation of pictures from the same pool shown at a similar duration (i.e., approximately 20% remembered; see Intraub, 1979, 1980). Experiment 2 examined the extent to which the observer can voluntarily control encoding to selectively process brief and long pictures in the changing-ISI condition.

Experiment 2

To study the ability to voluntarily control encoding of sequentially presented pictures, subjects were presented with a sequence of alternating 112-ms and 1.5-s pictures (the changing-ISI sequences described in Experiment 1). They received one of three attention instructions: (a) "Attend only to the brief pictures," (b) "attend to all pictures," or (c) "attend only to the long pictures." Expected and incidental recognition memory tests were used to evaluate memory for the 112-ms and 1.5-s pictures following each attention instruction.

Method

Subjects. Subjects were 72 undergraduates from MIT. All reported normal or corrected vision and were paid for their participation.

Materials and apparatus. The apparatus was the same as in Experiment 1. The two changing-ISI sequences described in Experiment 1 were used. The 16 pictures that served as long pictures in one sequence served as brief pictures in the other sequence and vice versa. Each sequence was shown to half the subjects in each of the six conditions described later.

Design and procedure. There were three attention-instruction groups with 24 subjects in each. Depending on the group, subjects received one of three attention instructions concerning which pictures in the sequence to focus their attention on: (a) "Attend to the brief pictures," (b) "attend to all pictures," or (c) "attend to the long pictures." They were told that memory for those pictures would be tested using a serial recognition test.

Each subject viewed a short sample sequence and received a recognition test that always tested memory for the pictures specified in the attention instruction. In the actual experiment two recognition tests were administered. The first test included 16 long or brief pictures (depending on condition) randomly mixed with 16 dissimilar distractors. For half of the subjects in each attention condition, the first tested memory for the long pictures only, regardless

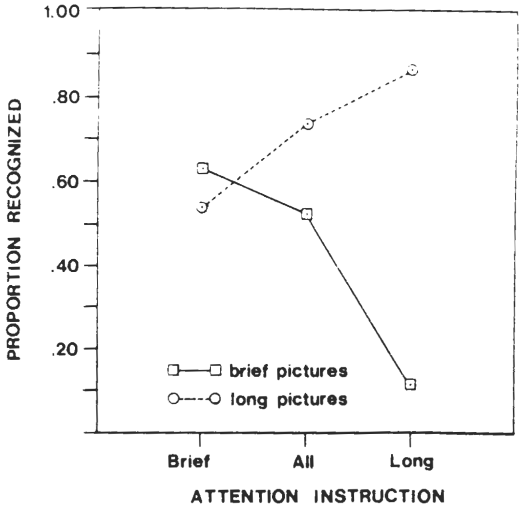

Figure 1. Proportion of long and brief pictures recognized (corrected for guessing) following each attention instruction in the first recognition test.

of which pictures had been specified in the attention instruction. For the other half of the subjects, the first test tested memory for the brief pictures only, regardless of which pictures had been specified in the attention instruction.[2] Just prior to the recognition test, all subjects were informed about which pictures would actually be tested. After this test subjects received a second recognition memory test. This one tested memory for the alternate set of pictures and included 8 of the 16 old pictures as target items and 8 dissimilar distractors. Again, prior to the test subjects were told which pictures (long or brief) to expect. Thus, when a subject's first test was for the long pictures, that subject's second test was for the brief pictures and vice versa. In this way, the effect of each attention instruction could be looked at both across and within subjects. The same testing instructions and procedures were used as in Experiment 1.

Results and Discussion

The results demonstrate a pronounced effect of attention instruction on recognition memory for both the 112-ms and 1.5-s pictures. The scores obtained on the first recognition test, corrected for guessing, are depicted in

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[2] Experiments 1 and 2 were run simultaneously so that the "attend to the brief pictures" condition reported in Experiment 2 (in which brief pictures were tested in the primary recognition test) refers to the same set of data as the changing-ISI "attend to the brief pictures" condition reported in Experiment 1.

Table 2
Mean Proportion of Pictures Recognized and of False Alarms (FA) for Brief and Long Pictures for Each Attention Instruction

	Attention instruction					
	Brief pictures		All pictures		Long pictures	
Type of picture	*M*	FA	*M*	FA	*M*	FA
	First recognition test					
Brief	.64	.05	.62	.15	.15	.06
Long	.58	.07	.76	.08	.88	.02
	Second recognition test					
Brief	.60	.05	.40	.03	.28	.12
Long	.49	.01	.68	.10	.91	.02

Note. Recognition scores corrected for guessing are in Figures 1 and 2.

Figure 1. The raw scores and false-alarm rates for those conditions are shown in Table 2. A two-way ANOVA (Picture Duration × Attention Instruction) on the guessing-corrected scores revealed significant main effects of picture duration (favoring the 1.5-s pictures) and attention instruction, $F(1, 66) = 61.17$, $MS_e = .0252$, $p < .001$, and $F(2, 66) = 4.76$, $MS_e = .0252$, $p < .001$, respectively. A strong interaction of picture duration and attention instruction was obtained, $F(2, 66) = 43.64$, $MS_e = .0252$, $p < .001$. As attention instruction changed from "attend to the brief pictures," to "attend to all pictures," to "attend to the long pictures," memory for the 112-ms pictures decreased and memory for the 1.5-s pictures increased. Independent one-way ANOVAs for the 112-ms pictures and the 1.5-s pictures showed that the effect of attention instruction on memory was significant for pictures of both durations, $F(2, 33) = 36.36$, $MS_e = .0244$, $p < .001$, and $F(2, 33) = 12.80$, $MS_e = 0.261$, $p < .001$, respectively.

The same pattern of scores can be seen in the results of the second recognition test. That is, when the same subjects were tested on the alternate picture set (e.g., brief vs. long), the same effect of attention instruction was obtained. The corrected recognition scores obtained in the secondary test are shown in Figure 2. The raw scores and false-alarm rates are shown in Table 2. A two-way ANOVA again revealed significant main effects of picture duration, $F(1, 33) = 30.00$, $MS_e = .05$, $p < .001$, and a significant interaction, $F(2, 66) = 17.80$, $MS_e = .05$, $p < .001$. There was no main effect of attention instruction ($F < 1$). Independent one-way ANOVAs for the 112-ms and 1.5-s pictures showed significant effects of attention instruction on memory for pictures of both durations, $F(2, 33) = 32.80$, $MS_e = .05$, $p < .001$, and $F(2, 33) = 11.00$, $MS_e = .05$, $p < .001$, respectively.

The results show that processing of a briefly glimpsed picture can continue during presentation of a new, meaningful picture and that observers have considerable control over the encoding process. Attention instruction had a large effect on recognition memory, not only for briefly presented pictures but also for pictures that had remained in view for 1.5 s. Although the magnitude of the effect is large, Experiment 1 suggests a limit on the voluntary control of encoding during sequential presentation. Under the "attend to the brief pictures" instruction in that experiment, subjects in the changing-ISI condition remembered fewer brief pictures than subjects in the repeating-ISI condition. Apparently the new ISI pictures interfered with processing. A form of the con-

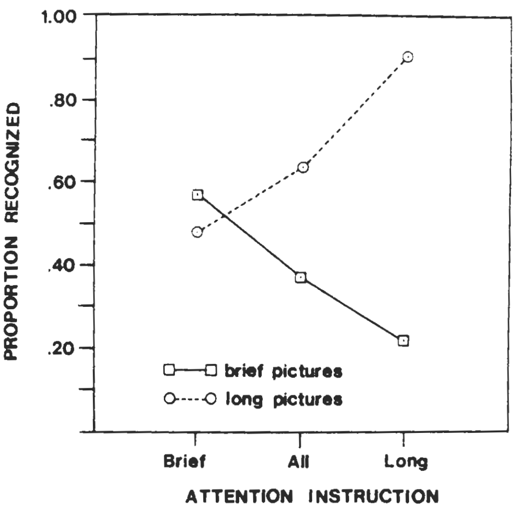

Figure 2. Proportion of long and brief pictures recognized (corrected for guessing) following each attention instruction in the second recognition test.

ceptual-masking hypothesis might account for the difference between these conditions. Experiment 3 tests two alternate explanations for the memory deficit in the changing-ISI condition.

Experiment 3

Contrary to the conceptual-masking hypothesis, one alternate explanation for the decrease in memory in the changing-ISI condition is that it may be an artifact of the number of pictures presented in that condition. Although both repeating- and changing-ISI subjects were presented with 16 briefly presented pictures to remember, and both were instructed to ignore information presented during the ISI, subjects in the changing-ISI condition saw a total of 32 new pictures (including the ISI pictures), whereas the other group saw a total of 17 (including the repeating picture). The lower recognition memory scores in the changing-ISI condition may reflect confusion on the recognition test due to the relatively large set of pictures viewed, rather than to conceptual interference during presentation.

To test this hypothesis, a new step was introduced into the repeating-ISI condition so that subjects in that condition would also view 16 to-be-ignored pictures. Just prior to the experimental sequence, subjects were presented with a monitoring task. They were shown a target picture and were told that it would appear briefly during a sequence of pictures. The continuous sequence contained all 16 ISI pictures from the changing-ISI condition presented for 1.5 s each. They were told to focus attention on remembering the target and to try to prevent the long pictures from distracting them. The target always appeared after the last item in the sequence. This was followed by the repeating-ISI experimental sequence and recognition test. In this way memory could be studied when a set of 16 to-be-ignored pictures was presented immediately prior to the stimulus set and when 16 to-be-ignored pictures were presented so that each one immediately followed a stimulus picture. If the memory deficit in the changing-ISI condition in Experiment 1 was due to the greater number of pictures viewed leading to confusions on the recognition test, then no difference between groups should be obtained with the inclusion of the monitoring task. If the difference was due to interference with encoding caused by presentation of new pictures in the ISIs, the difference in memory performance should be replicated despite presentation of the monitoring task.

If the difference between groups is maintained when repeating-ISI subjects also view the set of 16 to-be-ignored pictures, the conceptual-masking hypothesis would provide one explanation of its cause. An alternate hypothesis, however, is that interference caused by presentation of a new picture during the ISI may not be due to the conceptual attributes of the new picture but to its novelty as an unexpected visual configuration. In Potter's (1976) experiments, the conceptual-masking hypothesis was put forth based on comparisons between conditions of rapid presentation of pictures and conditions in which brief pictures were followed by a single visual noise mask. Besides differing in terms of conceptual content, these items differ in terms of visual novelty and expectancy. That is, unlike a repeating picture or a repeating mask, each new picture provides the subject with an unpredictable new shape so that the changing-ISI sequence can be thought of as a stream of rapidly changing, novel visual events. To determine if the conceptual aspects of the new picture or simply its visual novelty disrupts memory, it would be ideal to obtain two types of visual stimuli to present during the ISI that are equal with respect to visual attributes but differ with respect to conceptual content. Equating the sets for visual attributes would allow for a careful test of the visual novelty hypothesis by removing artifacts that might be introduced if the general visual appearance or complexity of the two sets differed. Two approaches are used in the present experiment to approximate this ideal set of stimuli.

One approach is to compare memory for the brief pictures under conditions in which the ISI contains normal pictures versus meaningless, nonsense pictures that share visual attributes with the normal pictures. In previous picture-memory experiments the types of meaningless masks used have been noisy color masks (e.g., Potter, 1976) or jumbled scenes in which a picture is cut into equal-sized pieces that are then rearranged (e.g., Hulme & Merikle, 1976). Neither type was suitable for the present experiment because the physical characteristics of a random noise mask differ greatly from the objectlike characteristics of a picture, and jumbling a picture might leave too many recognizable, meaningful elements. The nonsense masks in the present experiment were made by tracing the basic shapes of each ISI picture and altering boundaries and coloration to disguise the picture's identity. Because they are meaningless versions of particular pictures, they will be referred to as *nonsense pictures*. The novel visual event hypothesis would be supported if new, nonsense pictures disrupt memory as much as new, meaningful pictures.

The other approach used to determine if the conceptual attributes of a new picture disrupt memory was to present normally oriented ISI pictures in one condition, and the same ISI pictures upside down in the other condition. The rationale was that the visual attributes of the ISI pictures would be virtually the same but that conceptual information would be less accessible in the case of inverted pictures. If the concept is less accessible, then the inverted pictures would be expected to be less effective conceptual masks. If memory for the briefly glimpsed pictures is superior in the inverted-ISI condition, then the conceptual-masking hypothesis would be supported. If the two conditions yield the same memory performance, this would not refute the conceptual-masking hypothesis because both types of ISI pictures contain conceptual information and the assumptions regarding inversion and conceptual accessibility may be incorrect.

Method

Subjects. Subjects were 40 male and 40 female undergraduates from the University of Delaware who took part in the experiment to complete an optional course requirement. Subjects reported normal or corrected vision.

Materials. Thirty-two stimuli from the same pool used in Experiments 1 and 2 were used in the experimental sequences. One set of 16 pictures served as stimuli (brief pictures) in all four conditions. The remaining 16 served as ISI pictures in the changing-ISI and changing-inverted-ISI conditions. The repeating-ISI sequence used 1 of the 2 pictures employed in Experiment 1 to fill the ISI. The nonsense pictures were made with reference to the 16 ISI pictures. As described previously, the pictures were cut out from magazines and photographed on a homogeneous gray background. The cutouts sometimes consisted of an object alone or an object along with some of its original background (e.g., sky or grass). The nonsense pictures were made by tracing the cutouts from 35-mm slides onto acetate. Tracing was accomplished with Staedtler Lumocolor pens. The basic size and global shapes of the cutouts were copied, but boundaries and colors within the general shapes were altered so that the drawings were meaningless, objectlike configurations. The acetates were placed in slide mounts.

The 16-mm sequences were made by photographing the 35-mm slides of pictures and nonsense pictures using single-frame photography. A gray filter was used when photographing the nonsense pictures to approximate the gray background of the meaningful pictures.

Apparatus. A different laboratory was used from that in the previous two experiments. A Visual Instrumentation Corp. variable-speed 16-mm projector was used for rear projection of sequences into a room where the subject was seated. Because rear projection was used, projector noise was minimized. The experimenter was seated in the back of the same room and controlled the projector via a remote control box. Unlike the previous experiments, the recognition test was also photographed on 16-mm film and was presented by advancing the film one frame at a time. The visual angle subtended by the pictures was approximately 13° × 13°.

Design and procedure. The four experimental conditions were repeating-ISI, changing-ISI, inverted-ISI, and nonsense-ISI. There were 20 individually tested subjects (10 male and 10 female) in each condition. The 16 stimulus pictures were presented for 100 ms each with a 1.5-s ISI. In the repeating-ISI condition, the ISI contained a single picture that the subject was familiarized with prior to viewing the sequence. In the changing-ISI and inverted-ISI conditions, the 16 ISI pictures were presented in the same order but were inverted in the latter condition. In the nonsense-ISI condition, the nonsense pictures were presented during the ISI in the same order and orientation as the normal ISI pictures they were based on.

Subjects were informed that the purpose of the experiment was to study attention and memory. They were instructed to focus attention on the briefly presented pictures and to try not to allow the ISI pictures to distract them. All subjects received a five-item sample sequence and recognition test to familiarize them with the task. Following this, subjects were told that they would receive additional practice in focusing attention. Subjects in all conditions except the repeating-ISI condition were again presented with the sample sequence. At this point, subjects in the repeating-ISI condition were presented with the monitoring task.

In the monitoring task, subjects were provided with a target picture to hold in memory while viewing the same 16 ISI pictures used in the changing-ISI condition presented for 1.5 s each in a continuous sequence. Subjects were instructed to respond "now" as soon as the target (presented for 110 ms) appeared on the screen and to try not to allow the long pictures to distract them. The target always appeared at the end of the sequence, and all subjects correctly detected its occurrence. In all conditions, following the sample sequence and practice task, subjects were presented with the experimental sequence and recognition test. The test and procedure were the same as in Experiments 1

Table 3
Mean Proportion of Pictures Recognized and Mean Confidence Ratings (M_{cr}), Proportion of False Alarms (FA) and Mean Confidence Ratings (FA_{cr}), and Proportion of Pictures Recognized Corrected for Guessing (M_c) in Each ISI Condition

ISI condition	M	M_{cr}[a]	FA	FA_{cr}[a]	M_c	*SD*
Changing	.75	1.9	.07	1.3	.73	.21
Repeating	.90	1.9	.05	1.2	.90	.08
Nonsense	.88	1.9	.07	1.6	.87	.11
Inverted	.84	1.9	.11	1.3	.82	.14

Note ISI = interstimulus interval.
[a] Confidence ratings of "sure" and "not sure" were coded as 2 and 1, respectively.

and 2 except that in addition to yes and no responses, subjects were instructed to provide a confidence rating of "sure" or "not sure."

Results and Discussion

The results provide strong support for the conceptual-masking hypothesis. The mean proportion of brief pictures recognized (corrected for guessing), the mean proportion of hits, the mean proportion of false alarms, and the mean confidence ratings for hits and false alarms in each of the four ISI conditions are presented in Table 3. Because the changing-ISI condition is the control condition for each of the other three, three a priori comparisons were conducted.

Contrary to the hypothesis that the number of pictures caused the poor performance in the changing-ISI condition (Experiment 1), in the present experiment the repeating-ISI condition (with the monitoring task) still yielded significantly superior memory performance than that obtained in the changing-ISI condition, $F(1, 76) = 14.00$, $p < .001$, (MS_e for all the comparisons = .02). Apparently it is not the presentation of numerous to-be-ignored pictures per se that reduces recognition memory for the brief pictures in the changing-ISI sequence but the placement of the to-be-ignored pictures within the sequence. What disrupts memory for the brief pictures in the changing-ISI condition may be the conceptual identification processes elicited by new, unexpected pictures. The repeating picture apparently does not elicit the same processes or the same amount of processing as a new picture. Although the nature of the difference cannot be determined from these data, two possible explanations are (a) the repeating picture can be conceptually identified much more rapidly than a new picture, or (b) because it has already been conceptually identified, it need not undergo any conceptual processing but need only be recognized as it reappears (perhaps based on a match with a representation held in the subject's working memory).

Comparison of the changing-ISI condition with the nonsense-ISI and inverted-ISI conditions suggests that the disruptive effect of the ISI pictures is not due to their novelty as visual events but to their conceptual attributes. Presentation of a new, nonsense picture during the ISI yielded significantly better memory performance than presentation of a new, meaningful picture, $F(1, 76) = 9.00$, $p < .005$. In fact, performance in the nonsense-ISI condition was quite similar to that obtained in the repeating-ISI condition. Although more pictures were remembered in the inverted condition than in the changing-ISI condition, this difference did not reach significance, $F(1, 76) = 3.5$, $p < .10$. As mentioned previously, since both inverted and upright pictures contain conceptual information, a finding of no difference would not refute the conceptual-masking hypothesis because assumptions regarding the effect of inversion on concept availability are speculative. The direction of the effect is encouraging, however, and future research may explore this issue by following each stimulus with an inverted or normal ISI picture of brief duration (i.e., confined to the initial part of the ISI). By decreasing duration, the effect of inversion of concept availability may be increased, and inverted pictures may then prove to be significantly less effective conceptual masks.

Confidence ratings (see Table 3) showed that although fewer pictures were recognized in the changing-ISI condition, when subjects did recognize old items they expressed as much confidence in their decisions as subjects in the other conditions. The average rating in each of the four conditions was 1.9 (2.0 would be the highest mean possible), showing that subjects were very confident when they responded yes to an old picture. The lower ratings obtained for false alarms suggest that subjects were equivocal about those yes responses.

General Discussion

Potter (1976) proposed that encoding of each briefly glimpsed picture in a sequence is terminated by the onset of the next new, meaningful picture because of the elicitation of cognitive processes associated with extraction of the new picture's concept. This process, referred to as conceptual masking, was held to be the cause of the poor recognition memory performance obtained following rapid continuous presentation of pictures (e.g., Intraub, 1980; Potter & Levy, 1969). Experiments 1–3 support some aspects of the proposed process but at the same time suggest modification of the original formulation.

Experiments 1 and 3 support the hypothesis that the interference referred to by Potter (1976) is indeed conceptual. Experiment 1 showed that memory for briefly glimpsed pictures is disrupted when a new picture, as opposed to a familiar, repeating picture, is presented during the ISI. Experiment 3 showed that the inferior performance obtained when a new picture appears in the ISI is not due to the greater number of pictures viewed by subjects in that condition. When the number of to-be-remembered and to-be-ignored pictures was equated, memory was still superior when a familiar picture was repeated during the ISI. Experiment 3 demonstrated that the disruptive effect of a new picture in the ISI cannot be attributed to its visual novelty or unexpectedness. Nonsense pictures, created by tracing and distorting each ISI picture, were presented during the ISI and did not disrupt memory as much as the meaningful pictures they had been copied from, although like the meaningful pictures they were novel, objectlike visual configurations. Memory performance in the nonsense-picture condition was, in fact, quite similar to that obtained in the repeating-ISI condition. Inverting the ISI picture did not significantly enhance memory for the brief stimuli, but the direction of the results suggests that inverting a picture may reduce the accessibility of conceptual information, thus creating a less effective conceptual mask while holding visual characteristics virtually constant. Additional research to explore this possibility was discussed in Experiment 3.

Although the masking discussed by Potter (1976) seems to be conceptual, its role in rapid continuous presentation of pictures, and by extension, in visual scanning, is probably different from the initial formulation suggested. According to that formulation, once a picture has been identified (which it was estimated occurs within about 100 ms), additional processing is required to encode the newly identified picture into memory. Potter (1976) proposed that the newly identified picture is held in a short-term conceptual store for a few hundred milliseconds, during which time it is vulnerable to conceptual masking. Because the store can hold only one scene at a time, conceptual identification of a new picture terminates encoding of the picture currently held in the store. For this reason Potter suggested that in visual scanning the average fixation frequency of three per second represents a compromise between the need for rapid identification of the environment and the need for an uninterrupted interval to allow the observer to store some portion of what has been seen.

The present research suggests some changes in this view of the conceptual short-term store and conceptual masking. Experiments 1 and 3 showed that although presentation of a new ISI picture was more disruptive than presentation of a familiar, repeating picture or a nonsense picture during the ISI (presumably because of the conceptual processing it elicits), memory for the brief pictures was still relatively good, with 63% and 73% remembered in the two experiments, respectively. Memory did not approach the low level obtained following rapid continuous presentation. This indicates that encoding of a briefly glimpsed picture can proceed in spite of the onset of a new, meaningful visual event. Presentation of a subsequent picture alone is not sufficient to terminate encoding (see also, Erdelyi & Blumenthal, 1973). Consistent with this observation is recent research in which 24 briefly shown pictures were presented in a sequence in which a blank interval was presented after each picture or after each group of 2, 3, or 4 pictures. The effect these groupings had on recognition memory suggested that the very short-term buffer associated with rapid serial visual presentation of pictures or words (see Forster, 1970; Potter, 1976) may hold up to 3 complex visual scenes concurrently (Intraub & Nicklos, 1981). Encoding of a briefly glimpsed picture apparently is not limited to the time between its onset and onset of the new picture.

Selective Attention Instructions and Picture Memory

In addition to this point, Experiment 2 showed that to a large degree the observer can voluntarily control the extent to which encoding will proceed for particular pictures in a sequence. In that experiment, although subjects viewed the same experimental sequence, memory for the 16 brief pictures increased from 12% remembered, to 54% remembered, and then to 63% remembered, as attention instruction changed emphasis from the long pictures, to all pictures, and then to the brief pictures, respectively (first recognition test, corrected for guessing). The effect of attention instruction on memory was not limited to the briefly presented pictures. The high level of recognition memory usually obtained with pictures having durations of 1 s or more (e.g., Standing, 1973) decreased dramatically from 89% remembered to 54% remembered as attention instructions shifted focus away from the long pictures to the brief pictures. The same pattern of results was obtained in the subjects' secondary recognition test. Simply watching pictures does not ensure good recognition memory. This is consistent with other research on the effects of intentional strategy on pictorial encoding (Graefe & Watkins, 1980; Weaver & Stanny, 1978) and extends this effect to conditions using continuous pictorial presentation, as well as brief pictorial presentation. The results are also similar to those obtained using audibly presented sequences of alphanumeric stimuli (Hamilton & Hockey, 1974).

Conclusion

The present research indicates that while presentation of a new, meaningful visual input disrupts encoding of briefly glimpsed pictures, it does not necessarily terminate encoding. Contrary to the initial formulation of the conceptual-masking hypothesis, it is unlikely that each picture in a rapid continuous sequence abruptly interrupts processing of the picture that precedes it. Instead, by drawing attention away from the previous picture, it interferes with ongoing encoding or rehearsal processes. The question of automaticity in relation to the disruptive effects of new, meaningful visual events still remains open. In the present experiments, subjects received only minimal practice viewing the sequences and were presented with a single experimental sequence. Clearly under these conditions subjects seemed unable to suppress processing of the new, meaningful inputs. Whether or not highly trained subjects would be able to increase their recognition memory performance in a changing-ISI condition to match that obtained in conditions where the ISI contains a repeating picture or a new, nonsense picture is a question to be addressed in future research.

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