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CONCEPTUAL MASKING OF BRIEFLY GLIMPSED PHOTOGRAPHS

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Conceptual masking is a term used by Potter (1976) to describe a specific type of interference that can occur during the early stages of picture processing. Potter's model and subsequent modifications (Intraub, 1984) have been based primarily upon research in which single fixations and some of the dynamic, sequential characteristics of visual scanning are mimicked through the use of tachistoscopic exposures and rapid sequential presentation of pictures. In addition to testing the early stages of picture processing, this type of research may provide insight into the processes initiated during the first fixation made on a new scene. The major focus of the paper will be the question of whether or not the type of masking discussed by Potter is actually conceptual in nature, or can be attributed either to visual masking or long-term memory effects.

INTRODUCTION

According to Potter's (1976) model of the early stages of picture memory, most pictures of common objects and scenes are rapidly understood -- perhaps within the first 100 msec of viewing. Once identification has occurred, a representation of the briefly glimpsed information is maintained for a few hundred milliseconds in a short-term conceptual memory while processes are initiated to store the information in a more permanent memory. Prior to conceptual identification, the visual information is vulnerable to visual masking. If a complex visual event is presented during this time it is likely that the picture will not be identified. Once identification occurs, however, the information becomes immune to visual masking, but is now vulnerable to conceptual masking caused by the presentation of new information that elicits the same processes (e.g., a new picture). This occurs because by eliciting conceptual processing itself, the new picture competes for space in the short-term conceptual store. Evidence for this view of picture memory comes from search experiments which support the contention that pictures may be momentarily understood and then forgotten and recognition memory experiments which support a distinction between visual and conceptual masking.

Rapid identification of sequentially presented pictures has been demonstrated in several search experiments in which pictures were presented at rates that mimicked or exceeded the average fixation frequency of 3 per second (Intraub, 1981a, 1981b; Potter, 1975, 1976). In these experiments, regardless of whether the target picture was specified in terms of a brief verbal title (e.g., "a road with cars"; Potter, 1975, 1976), a title indicating its superordinate category, or a negative cue (e.g., "report a picture that is not a type of transportation"; Intraub, 1981a, 1981b), subjects were very good at detecting it. Subjects in the detection group could detect and describe more pictures than subjects in the recognition memory group could recognize immediately following presentation of the sequence. For example, at a presentation rate of 258 msec per picture, subjects could detect and describe a target picture based on a negative cue 79% of the time, whereas subjects in the recognition memory condition recognized the same pictures only 58% of the time (Intraub, 1981b). The results of these experiments support Potter's (1976) claim that during rapid sequential presentation of pictures, many pictures are momentarily identified and then lost due to interference caused by the presentation of new pictures. Only those pictures that can be consolidated before the next picture is presented will be retained.

The search experiments suggest that visual masking cannot account for poor memory following rapid presentation because many of the pictures were at least momentarily identified during inspection. More direct evidence that a process other than visual masking is responsible, comes from recognition memory experiments with briefly glimpsed pictures. This research shows that although memory is poor following rapid continuous presentation of pictures, memory for briefly presented pictures is very good when the pictures are presented with interstimulus intervals (ISIs) that contain a colorful visual noise mask (Potter, 1976) or a familiar picture that repeats throughout the sequence (Intraub, 1980, 1984). For example, Intraub (1980) presented 150 color photographs for 110 msec each. In two conditions the interstimulus interval (ISI) was approximately 6 sec in duration. Depending on condition, it contained a blank field or a familiar picture that repeated throughout the sequence. In the remaining condition the pictures were presented continuously with no ISI. In spite of the presentation of a visual event (i.e., a potential visual mask) following each briefly presented picture, recognition memory in the repeating-ISI and blank-ISI conditions did not differ significantly. The proportion recognized was .73 and .77, respectively. When the pictures were presented with no ISI, and each picture was followed by a new picture, the proportion recognized dropped to .21. The argument is that neither a noise mask nor a familiar picture elicits the same identification processes as a new picture.

Consistent with this hypothesis, if a new picture is presented during a to-be-ignored ISI, recognition memory decreases as compared with conditions in which a blank or repeating picture are presented (Intraub, 1981a, 1984). For example, in one experiment, 16 pictures were presented for 112 msec each with a 1.5 sec ISI that contained a repeating picture (repeating-ISI) or a new picture each time (changing-ISI). The probability of recognizing a picture was .80 (SD = .14) and .64 (SD = .13), with false alarm rates of .08 and .05 for the repeating- and changing-ISI conditions, respectively (Intraub, 1984). Clearly, new pictures interfere with memory in some way. The question is whether or not the effect can be attributed to conceptual masking of information in the short-term conceptual store. In the next section we will consider some alternate explanations of the changing-ISI experiments and some other tests of the conceptual masking hypothesis.

IS THE INTERFERENCE "CONCEPTUAL"?

One alternate explanation of the relatively poor performance in the changing-ISI condition is a traditional explanation that focuses on long-term memory. Although subjects in the repeating- and changing-ISI conditions were faced with the task of remembering the same 16 briefly presented pictures, and were both instructed to ignore information presented during the ISI, subjects in the changing-ISI condition saw a total of 32 pictures (including the ISI pictures), whereas the other subjects saw a total of 17 pictures (including the ISI picture). The lower scores in the changing-

ISI condition may have been due to relatively greater difficulty in discriminating old from new pictures in the recognition test because these subjects had just seen a relatively large number of pictures. That is, the poor performance may not have been due to interference with the contents of a short-term buffer, but to interference with later recognition processes.

To test this hypothesis, a new step was added to the repeating-ISI condition so that like subjects in the changing-ISI condition, in addition to the 16 target pictures, these subjects would see 16 to-be-ignored pictures for 1.5 sec each. Immediately preceding the repeating-ISI condition, subjects were presented with a monitoring task. They were shown a picture and were told that it would appear briefly at some time during presentation of a continuous series of 16 pictures. The continuous series contained the 16 ISI pictures used in the changing-ISI condition, presented for 1.5 sec each. Subjects were instructed to think about the picture they were to search for while watching the sequence and to report its appearance. The picture they were searching for always appeared at the end of the continuous sequence. In this way, like the subjects in the changing-ISI condition, these subjects watched the 1.5 sec ISI-pictures while focusing attention on another task. The monitoring task was followed by the repeating-ISI condition, where subjects were instructed to focus attention on the briefly presented pictures in preparation for a recognition test.

A comparison of memory for the 16 briefly presented target pictures in the new repeating-ISI condition with memory for the same pictures in the changing-ISI condition, supported the conceptual masking hypothesis. Subjects in the new repeating-ISI condition recognized .90 (SD = .08) of the briefly presented pictures whereas subjects in the changing-ISI condition only recognized .73 (SD = .21) of the pictures (Intraub, 1984). The false alarm rates did not differ between the two conditions (they were .05 and .07, respectively). Apparently it is not the presentation of numerous to-be-ignored pictures per se that disrupts recognition memory for briefly presented pictures, but the placement of the to-be-ignored pictures within the sequence. Conceptual identification of a new picture may be automatic, occurring even when the subject tries to ignore the picture (e.g., Smith & Magee, 1980). If a briefly glimpsed target picture is in the short-term conceptual store when the ISI picture is presented, identification of that ISI picture will disrupt processing of the store's contents. If the same ISI picture is identified prior to viewing the brief target picture (as in the monitoring task condition), it will have no effect on processing of the target. The disruptive effect of conceptual identification may be due to its attentional demand. Indeed, if the status of the ISI pictures in the changing-ISI condition is changed from "pictures-to-be-ignored" to "pictures-to-be-remembered," this increases their disruptive effect. The next experiment was concerned with testing the hypothesis that automatic conceptual identification is the cause of poor memory in the changing-ISI condition.

The control conditions for experiments testing the conceptual masking hypothesis have been ones in which briefly presented pictures are followed by a single noise mask (Potter, 1976), a repeating gray field (Intraub, 1980), or a repeating familiar picture (Intraub, 1980, 1984). Besides differing from new pictures in terms of the necessity for new conceptual analysis, these items differ with respect to visual novelty and expectancy. Unlike a repeating picture or a repeating meaningless noise mask, each new ISI picture provides the subject with an unpredictable visual event. Maybe any novel stimulus, regardless of its conceptual content, would disrupt the contents of the unstable short-term store by drawing attention.

To test this hypothesis, a new changing-ISI condition was constructed and compared with the changing-ISI condition described above. In this case the pictures presented during the ISI were nonsense pictures. These were created by tracing the basic shapes of each of the ISI pictures used in the changing-ISI condition, and altering coloration and boundaries within the shape to disguise the picture's identity. Like the ISI pictures, the nonsense pictures provide a novel, unpredictable visual event following each target picture. They are object-like in that they present a colored shape against a gray background, just as the pictures do. The major difference between the two types of visual displays is that the nonsense pictures are not meaningful (i.e., do not readily map onto pre-existing concepts). If the conceptual masking hypothesis is correct, then presenting a new, nonsense picture during the ISI should not lead to as poor performance as presenting a new, meaningful picture. If, however, the memory disruption is the result of attention being drawn by any new visual stimulus, then nonsense pictures should disrupt memory as much as meaningful pictures.

The nonsense-ISI condition was conducted at the same time as the new repeating-ISI and changing-ISI conditions described above and will be compared to those conditions. The results supported the conceptual masking hypothesis. Memory for target pictures in the nonsense-ISI condition was significantly better than that obtained in the changing-ISI condition. Subjects in the nonsense-ISI condition recognized .87 (SD = .11) of the target pictures, with a false alarm rate of .07 (Intraub, 1984). This score was comparable to that obtained in the repeating-ISI condition (with the monitoring task) showing that subjects could ignore the colorful nonsense pictures about as easily as they could a familiar repeating picture. Presentation of a new, unpredictable visual mask did not disrupt memory as much as a new, meaningful picture. The good performance obtained when repeating pictures, noise masks, and nonsense pictures are presented during the ISI, argues against visual masking as the cause of poor memory following rapid presentation. Other converging evidence regarding this point has been reported by Loftus and Ginn (in press).

Loftus and Ginn (in press) tested the conceptual masking hypothesis by directly contrasting visual masking and conceptual masking. They presented target pictures for 50 msec, a briefer duration than that typically used in the recognition memory experiments described above. According to Potter's model, this would make the pictures susceptible to visual masking, because conceptual identification might not yet be complete. Depending on condition, subjects were presented with one of two types of masks (a meaningless visual noise mask or a new picture) at one of two levels of illumination. They postulated that if the mask was presented immediately at stimulus offset, the target picture would be subject to visual masking. This being the case, luminance would be expected to affect the power of the mask, but meaningful masks would not be expected to be any more effective than a meaningless noise mask. If the mask presentation was delayed for 300 msec, they predicted that luminance would have no effect on the effectiveness of the mask, but that meaningful pictures would be more effective masks than the visual noise mask. This is because by the time 300 msec has elapsed, subjects would be expected to have identified the picture. The picture at this stage would no longer be susceptible to visual masking but would be susceptible to conceptual masking.

The dependent measure in their experiment was the number of details subjects could report about a picture following the mask. The results followed the predictions, thus providing converging evidence for the contention that conceptual masking is a process that differs from visual masking and involves the conceptual content of the mask. Also, by showing an effect of mask type when memory for each picture is tested immediately following the mask, their results corroborate those obtained in the monitoring task/repeating-ISI condition, in showing that conceptual masking is not due to confusion in long-term memory.

INVERTED PICTURES AS CONCEPTUAL MASKS

One of the experiments in Intraub (1984) lead to the suggestion that inverting a picture might lessen its effectiveness as a conceptual mask by making the picture's concept less available. If this were the case, it was argued, inverted pictures would provide an excellent means of testing the conceptual masking hypothesis because the visual characteristics of inverted and upright pictures would be very similar, but their conceptual accessibility would differ. Research testing the effects of inverted versus upright ISI pictures, however, did not show any effect of this manipulation on recognition memory for target pictures. For example, in one experiment using the same pictures as Intraub (1984), target pictures were presented for 112 msec with a 1.5 sec ISI that contained a 250 msec ISI picture followed by a colorful visual noise mask. Subjects were instructed to focus attention on the target pictures which would be presented again in the recognition test. The proportion of pictures recognized in the upright and inverted ISI conditions respectively was .60 (SD = .21) and .65 (SD = .18). Similar experiments were conducted using more complex pictures (visual scenes), which might be expected to be more difficult to understand when inverted. These ISI pictures were presented for as little as 125 msec. Inverted pictures continued to disrupt memory as much as upright pictures.

Using a visual duration threshold method with the complex visual scenes, a pilot study has indicated that even at very brief durations (e.g., 30 msec), when subjects were capable of reporting something about the picture, although they could not provide a detailed description, they seemed to be able to report very general conceptual information about a scene regardless of whether it was inverted or upright. For example, subjects might not be able to report that the scene contained men and women folk dancers in traditional costumes, but they could report that the scene contained people. These results suggest that inverting a scene does not necessarily significantly retard or prevent conceptual identification. Extraction of this very general conceptual information is apparently enough to cause conceptual masking.

CAPACITY OF THE SHORT-TERM CONCEPTUAL STORE

According to Potter's (1976) original formulation of the conceptual short-term store, the buffer could hold one picture at a time. During rapid presentation, if a picture in the buffer could not be consolidated in memory before the onset of a new picture, it would be lost. Although memory in the changing ISI conditions described previously is worse than in conditions in which a blank field or repeating picture is presented during the ISI, memory does not approach the low level obtained during continuous rapid presentation where there is no ISI(e.g., Intraub, 1980, 1981b; Potter & Levy, 1969). This suggests that presentation of a new picture disrupts processing but may not necessarily terminate it. It seemed possible that the buffer might be able to hold more than one picture at a time.

To test this possibility, the capacity of the buffer was explored by comparing memory for 24 briefly presented visual scenes under conditions in which they were shown in groups of 1, 2, 3, or 4 pictures. In all conditions the same 24 pictures were used and the intergroup intervals (which contained a colorful visual noise mask) were adjusted so that the length of time from the beginning of each sequence to the test was the same. All pictures were presented for 250 msec each. The intergroup intervals for the single, double, triple, and quadruple grouping conditions was 1625, 3250, 4875, and 6500 msec, respectively. The control condition presented all 24 items in a continuous sequence followed by a 39 sec mask filled interval so that the time from the beginning of the sequence to the test was the same as in the other conditions. If the buffer can hold only one picture at a time, then memory in the double, triple and quadruple condition should be no better than memory following continuous presentation of all 24 pictures. Of course, to make the comparison it is necessary to disqualify the final picture in each grouping because this picture is the only one never followed by a conceptual mask. Only in the single picture condition, where each picture is immediately followed by a mask filled interval, should memory be superior to the continuous condition.

The results show that the buffer must hold more than one picture at a

time. Recognition memory (excluding the final picture in each group) was superior to that obtained following rapid presentation in all but the quadruple grouping condition. The proportion recognized was .54, .56, and .37 in the double, triple, and quadruple conditions, respectively. The proportion of pictures recognized in the continuous condition was .29. In the single condition where no conceptual masking should have taken place, the proportion recognized was .90. Although presentation of additional conceptual masks causes more disruption of memory, the buffer can apparently hold up to three complex visual scenes.

SUMMARY AND IMPLICATIONS

These experiments provide support for a model of the early stages of picture processing proposed by Potter (1976). According to this view, pictures of objects and scenes are rapidly understood and stored in a short-term conceptual memory where they are no longer vulnerable to visual masking, but may have their processing disrupted by a conceptual mask. Conceptual masking is thought to occur when new conceptual information competes for space in the short-term conceptual store. The argument that conceptual processing rather than visual processing of a new stimulus is responsible for disruption of memory at this stage is supported by experiments showing that nonsense pictures and repeating pictures do not disrupt memory for briefly presented pictures as much as new pictures do (Intraub, 1984). The distinction between visual and conceptual masking was also supported in research showing differential effects of meaningless and meaningful masks on memory for a picture's details as a function of delay (Loftus & Ginn, in press).

Modifications of Potter's model have been based on experiments showing that, contrary to the initial formulation, the short-term conceptual buffer can maintain more than one picture at a time (Intraub, 1984; and the grouping experiment discussed above). As the buffer fills to its capacity of approximately three pictures, memory performance decreases as more attention is drawn by incoming information. Regarding attention and conceptual masking, there is a possible distinction that should be drawn. Experiments testing selective attention for pictures have shown that picture memory is affected by attention instruction (Graefe & Watkins, 1980; Intraub, 1980, 1981a, 1984; Weaver & Stanny, 1978). Some of the processes required to store a picture in a more stable memory are certainly under the subject's control. However, it may be the case that other processes are not. The research described here suggests that conceptual identification of a new picture may be automatic (see also, Smith & Magee, 1980), in the sense that the subject cannot terminate or bypass the process. Identification, however, may require allocation of attentional resources. For example, recall that memory for pictures dropped dramatically when each of the 16 briefly presented pictures was followed by a new ISI picture as compared with a colorful nonsense picture that retained the basic shape of each of the ISI pictures. When the subject is familiar with a picture through repeated exposure or if the picture does not contain meaningful features that readily map onto a concept, the identification processes either proceed rapidly (requiring little attention) or, in the latter case, may be terminated by the observer. This protects the contents of the short-term store, allowing the observer to process it further and store it in a more stable memory.

The implications of these processes for visual scanning (in which the average fixation frequency is no more than about three per second) are that the visual/cognitive system of the observer is set up to allow rapid comprehension of complex visual information. This information is stored briefly while decisions are made about further processing. New naturalistic information cannot be ignored and will impinge on processing. This latter point is quite reasonable when one considers that unlike the present experiments, during visual scanning, most fixations are probably highly redundant. The results of the experiments discussed, suggest that during normal visual activity subjects can rapidly assess the contents of each "scene" and adjust the extent of encoding and perhaps the location of the next fixation. These overlapping processes of identification and storage may also play a role in the integration of successive fixations during scanning.

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