Pictorial and Conceptual Representation of Glimpsed Pictures

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Abstract

Pictures presented in a rapid sequence are remembered briefly, but most are forgotten within a few seconds (Potter, M. C., Staub, A., Rado, J., & O'Connor, D. H., 2002). The present study investigated the pictorial and conceptual components of this fleeting memory by presenting 5 pictured scenes and immediately testing recognition of verbal titles (e.g., "people at a table") or recognition of the pictures themselves, among distractors. Titles were about 80% as effective as pictures in cueing picture memory overall. Both picture recognition and title recognition declined significantly during testing, but initial performance was higher and the decline was steeper when the test stimuli were pictures. In a final experiment using only pictures in the test, 20% of the positive test pictures were replaced by distractors ("decoys") that were conceptually similar to the original picture. False yeses to decoys were significantly higher than to other distractors, but lower than true yeses to old pictures, particularly at the beginning of the test. These results indicate that fleeting memory for glimpsed pictures has a strong conceptual component (conceptual short term memory, CSTM), but show that at the beginning of testing (immediately after viewing 5 pictures) there is additional pictorial memory (pictorial short term memory, PSTM) that is highly volatile and that is not tapped by a gist title or decoy picture.
Pictorial and Conceptual Representation of Glimpsed Pictures

Long term memory for pictured scenes viewed for a few seconds is remarkably good (Nickerson, 1965; Shepard, 1969; & Standing, 1973). However, when such scenes are presented in a rapid sequence for durations between 125 and 333 ms (in the range of normal eye fixations), most of them are forgotten by the time recognition is tested, shortly after presentation (Intraub, 1979, 1980; Potter, 1975, 1976; Potter & Levy, 1969). For example, Potter and Levy found that when each picture was shown for 167 ms (6 pictures per second), only about 25% of the pictures were correctly recognized when tested a minute or two later. Is that because few of the pictures can even be recognized with such a brief presentation? Further experiments in which viewers searched for verbally described targets (e.g., "a picnic") showed that it was relatively easy to spot such targets presented among other pictures at the same rates that were associated with memory failure; for example, at 167 ms/picture a verbally described target--a picture that had never been seen before--was detected on more than 70% of the trials (Potter, 1976). It was even easier to spot the target when the picture itself was shown in advance. Figure 1 shows a typical set of results, contrasting detection with later recognition memory. In a more stringent test in which the target was characterized negatively (e.g., as "not an animal") detection was still substantially higher than later recognition (Intraub, 1981). As none of the pictures had been viewed previously in any of these experiments (except in the picture-target condition), success in picking out the target suggests that these rapidly presented pictures must have been understood at a conceptual level at least momentarily--even though most of the nontarget pictures were soon forgotten.

If scenes can be momentarily understood in a glimpse as short as a sixth of a second, but most are subsequently forgotten, how quickly does the forgetting occur? The phenomenon of change blindness suggests that forgetting of pictorial details occurs almost instantly: after an interruption of only 80 ms between views, participants have difficulty detecting a feature change in a picture (Rensink, O'Regan, & Clark, 1997, 2000). Even after
an 8 s preview of a picture (ample time to encode the picture) a change was difficult to
detect. However, information about the pre-change state may have been encoded but not
immediately compared with the post-change state (Hollingworth, 2003a; Simons, Chabris,
Schnur, & Levin, 2002), so the extent of forgetting in a typical change blindness experiment
is unclear. In change blindness studies, most of the picture remains unchanged and the gist
of the scene is assumed to be retained. In contrast, when a sequence of pictures is
presented rapidly, the whole picture is likely to be forgotten, not just details.

To find out just how quickly pictures are forgotten, Potter, Staub, Rado, and
O'Connor (2002) presented sequences of five pictures (plus a final masking picture that was
regarded as a filler) at a rate of 173 ms (about 6 pictures a second). An immediate
recognition test followed, consisting of the 5 old pictures randomly mixed with 5 new
pictures--distractors. Figure 2 shows the results, as a function of relative serial position in
the test sequence. There was a striking drop in performance over the course of the test, with
a suggestion of an asymptote after 3 or 4 old pictures and 3 or 4 distractors had been
tested.\(^1\),\(^2\)

Surprisingly, unlike the marked effect of serial position in testing, there was no
corresponding evidence for a recency effect in presentation. The only serial position effect
was higher recall for the first picture presented--a primacy effect that we replicated in most
of the experiments in the present study. This primacy effect is probably found because
attention to the first presented picture is immediate, whereas attention to later pictures
requires a switch from processing the previous picture. The flat serial position effect for the
remaining pictures (excluding the final filler picture) suggests that all the masking
interference from a following picture occurs immediately and additional presentation
pictures have no further interfering effect, at least with presentation sequences up to 20
items (Potter et al., 2002).

Our next question was whether the rapid drop in memory over 8 s of testing was
due to decay or to interference. The answer was both. An unfilled delay of 5 s before
beginning the test results in a drop in recognition, but not as great a drop as after 5 s of testing (Potter et al., 2002). In sum, rapidly presented pictures remain in memory for a short time, even when they are slated to be forgotten within a few seconds.

The present study addressed the question, What kind of information is represented in short term memory for scenes? We considered two possible forms of short term memory: visual, pictorial short term memory (PSTM) and conceptual short term memory (CSTM; Potter, 1993, 1999). We hypothesized that the high level of performance seen early in testing reflected both PSTM and CSTM. We proposed that PSTM is lost rapidly, leaving CSTM as the main basis of short term recognition later in testing. By the end of about 8 s of testing both CSTM and PSTM have been lost, and only the subset of pictures that have been consolidated in long term memory (LTM) can still be recognized. To test this hypothesis about the time course of PSTM and CSTM, in the present study we contrasted pictorial and conceptual recognition tests of picture memory: the pictorial test was the usual yes-no recognition test of old pictures mixed with new (distractor) pictures, whereas the conceptual test required participants to use descriptive titles as cues to remember the pictures they had just seen, while rejecting titles of nonpresented pictures (distractors). None of the presented pictures (or the descriptive titles used in testing) had been seen previously. Whereas a test picture provides both visual-pictorial and conceptual information, a descriptive title provides only conceptual information (none of the titles named visual features per se, except indirectly via knowledge of what objects and scenes look like).

We expected that recognition of test pictures would be more accurate than recognition of test titles, inasmuch as the pictures provide full information whereas the descriptive titles provide only abstracted picture gist. Our primary question was whether this expected main effect would interact with serial position in the test. If the superior performance on the first few tested items (see Figure 2) is attributable to visual features which are quickly forgotten, then we would expect tests using titles to have a different profile, starting lower and showing less of an initial decline.
In a final experiment a different method was used to distinguish between visual and conceptual characteristics of remembered pictures: one old picture in each test sequence was replaced by a conceptually similar picture that was visually distinct from the target. If viewers make more false yes responses to such decoys than to other distractors, that would suggest that they retain conceptual information about the original picture but not full perceptual information. Again, our question is whether, if there is a decoy effect, it interacts with serial position on the recognition test: specifically, if viewers initially retain visual information but quickly forget it as the test continues, then the decoy effect should be reduced in early test positions.

In Experiment 1, using two groups of subjects, we established a baseline for performance on the title test relative to the standard picture recognition test under conditions in which most of the pictures are likely to be in LTM because they are shown for 1 s each. Experiment 2 replicated Experiment 1 using a higher rate of presentation (173 ms per picture) at which there is likely to be short-term memory for most of the pictures, but LTM for only a fraction (Potter, 1976; Potter et al., 2002). Experiment 3 combined Experiments 1 and 2 by showing pictures for 173 ms plus a blank interstimulus interval (ISI) totalling 1 s per picture, to test the hypothesis that consolidation time, not viewing time, accounts for the advantage of a 1 s presentation. In Experiment 4 recognition tests with pictures and titles were randomly mixed within the same experiment, to rule out possible strategy effects. In Experiment 5, using only pictures as test items, one of the old pictures in each test sequence was replaced by a conceptually similar but visually distinct decoy picture. The general method used in all of the experiments is described in detail in Experiment 1.

**Experiment 1**

The purpose of Experiment 1 was to assess whether memory for a pictured scene can be successfully tapped by testing with a verbal title rather than the picture itself. In previous research, memory for line drawings of single objects has been tested by presenting
the object's name in a recognition test, with recognition results that are similar to although often somewhat lower than recognition tests using the pictures themselves (e.g., K. O'Connor & Potter, 2002; Snodgrass & McClure, 1975). The to-be-remembered pictures in those studies consisted of single, readily recognized objects with conventional basic-level names, whereas the scenes in the present study are complex, are being viewed for the first time, and do not have conventional names. It was unclear to what extent a recognition test using titles of such pictures would be a valid index of memory. Therefore, in the first experiment we compared pictures and verbal titles as recognition-memory cues after presenting the pictures for 1 s each, a rate at which most pictures are likely to be in LTM (Potter & Levy, 1969).

Method

Participants. Two groups of 10 volunteers from the MIT community were paid for their participation. All reported normal or corrected vision. No one took part in more than one of the experiments in the present study, and none had participated in earlier studies with pictures in this laboratory.

Materials and apparatus. The pictures were 660 color photographs with widely varied content, chosen from commercially available compact discs. They included pictures of animals, people engaged in various activities, nature scenes, and city scenes. These pictures were stored as PICT files, 300 pixels in width by 200 pixels in height. They were presented on an Apple PowerPC 7500/100 computer with a 17" monitor, set at a resolution of 832x624 pixels and a refresh rate of 75Hz, using MacProbe software (Hunt, 1994). The pictures as displayed were 10.6 by 7.1 cm, subtending approximately 13 degrees of visual angle horizontally and 9 degrees vertically, when viewed from the normal distance of 45 cm. Pictures were shown against a medium gray background, which was present throughout. The room was dimly illuminated.

For the test using descriptive titles, two research assistants working together
constructed a short (1-7 word) descriptive title for each picture in the experiment, both distractors and presented pictures. The titles were generated without knowledge of which pictures were presented pictures and which were distractors. Each title was intended to capture the central theme or gist of the picture as concisely as possible. Explicit references to visual features such as color and shape were prohibited. Examples include: pond with trees, child near shelves, avocado, people standing in a row, hands working on electrical board, football game, short wall with plants, fox. In the recognition test the titles were displayed in palatino bold 20-point font, in the center of the screen.

Design and procedure. There were 60 experimental trials in each group. For the group tested with pictures, each trial consisted of 5 presentation pictures plus a 6th picture that served as a visual and conceptual mask, and 10 test pictures consisting of the 5 presentation pictures and 5 distractors. Pictures were assigned randomly (without replacement) from the full set to each trial and to the role of presentation picture or distractor in that trial. For the title condition it was necessary to switch 20 of the 660 pictures between trials to avoid having conceptually similar pictures (and hence very similar or identical titles) on the same trial, whether as presentation pictures or distractors. The rearrangement was made after the group tested with pictures had already completed the experiment; in all subsequent experiments the rearranged sequences were used.

The serial positions of the five presentation pictures were counterbalanced across subjects so that each picture appeared in each serial position. Half of the 10-item recognition tests (30 trials) began with an old picture, half with a distractor. Of the 30 trials beginning with an old picture, that picture was drawn equally often from each of the 5 serial positions in the presentation sequence. The remaining old and new test pictures were randomly ordered on each trial, with the constraint that no more than two old or two new pictures appeared consecutively. The order of the old and new pictures in each test trial was reversed for half the subjects, counterbalanced with serial position in presentation: the first old picture tested became the fifth tested, the second became the fourth, and so on; and
correspondingly, for the distractors.

Before each trial the word "ready" appeared on the screen, indicating that the participant could press the space bar to begin the trial. The sequence began with a red fixation cross in a black rectangle framed by red edging that was the same size as the pictures. The fixation array was presented for 293 ms, followed by a blank of 200 ms, and 6 pictures in sequence for 1 s each. The sixth picture was regarded as a filler and was not tested for recognition. Immediately following the last picture a white rectangle slightly larger than the pictures was presented for 293 ms, followed by the first test picture. (The purpose of the white rectangle was to signal the end of the presentation sequence and the beginning of the test sequence.)

Each test picture was presented for 400 ms, followed by a blank screen until the participant responded by pressing a yes or a no key on the keyboard. The reason for the relatively short duration of the test picture was to encourage the viewer to make a rapid decision and to minimize the elapsed time during the test. The participant's response was followed by a 107 ms delay before the next test picture appeared, and the cycle repeated for the 10 test pictures. Participants were instructed to view the presentation sequence and then respond to the test pictures as rapidly as they could, consistent with accuracy. They were told that they did not need to be absolutely sure that a picture was an old picture in order to press yes. They were not given any information about how many of the test pictures in each trial were old pictures. Between trials there was a brief interval while the computer loaded the pictures for the next trial, after which the word "ready" appeared on the screen. There were four practice trials, using a different set of pictures. No picture was repeated in the experiment, except as an old test picture.

The procedure for the group tested with titles of the pictures was identical to that of the picture group, except for the following. Titles replaced the pictures in the recognition test. The titles appeared for 800 ms, rather than 400 ms, to allow sufficient time to read them. Participants were instructed to press yes if a title corresponded to a picture that had
appeared in the presentation sequence, and otherwise to press no.

**Data analyses.** In this and the following experiments we analyzed the data using three measures, calculated separately for each subject in each cell of the design. The first measure was the proportion of yes responses, separately for true yeses (TY) and false yeses (FY): this analysis allowed us to look at serial position in both presentation and test. Second, we used a high-threshold guessing correction that is often used in studies of picture memory: \( P(Y_{corr}) = \frac{P(TY) - P(FY)}{1 - P(FY)} \), where \( P \) is proportion.

Third, we used \( A' \), which is an alternative to \( d' \) that can be calculated even when the false alarm rate is zero for a given participant in a given condition (Donaldson, 1993; Grier, 1971; Macmillan & Creelman, 1991; Pollack & Norman, 1964; Snodgrass & Corwin, 1988). As the results from the \( Y_{corr} \) analyses and the \( A' \) analyses were in most cases similar, we report only \( P(Y_{corr}) \) except when only one of the two analyses was significant at the .05 level or better; in that case, we specify which analysis was significant and which was not. Because we were particularly interested in serial position effects in testing, we calculated \( P(Y_{corr}) \) for each subject at each of the five relative serial positions of the old versus the new pictures in the test. For analyses of serial position effects in the presentation sequence, uncorrected \( P(TY) \) was used (unlike test serial position, there is no measure of false yeses that corresponds to each serial position in presentation).

**Results and Discussion**

As expected, the group given the picture recognition test performed very well: Overall, they correctly recognized 89% of the old pictures, and falsely recognized only 4% of the distractors. The group tested with titles did less well, although performance was surprisingly good: Overall, 75% of the titles of old pictures were correctly recognized and 14% of distractor titles were falsely recognized. Figure 3 shows \( P(Y_{corr}) \) for the two groups as a function of serial position in the test. An ANOVA revealed a significant difference between the groups, \( F(1, 18) = 13.82, p < .01 \), and a significant effect of test position, \( F(4, \)
Trend analyses were carried out separately for pictures and titles. The linear trend was significant for both groups: pictures, $F(1, 9) = 11.89, p < .01$, and titles, $F(1, 9) = 5.93, p < .05$.

An analysis was carried out on correct yeses, in order to evaluate the effects of serial position in the presentation sequence. Both serial position in presentation and in testing were variables, as well as test type. As before, there was a significant main effect of pictures versus titles and of test position, but no main effect of presentation position. The only significant interaction was between test type and presentation position, $F(4, 72) = 3.24, p < .05$. Inspection indicated that there was a first-item primacy advantage for pictures only, whereas for titles there was a slight recency effect. Neither effect was significant, however.

In sum, when a sequence of six pictures is displayed at a rate of 1 s per picture, most test pictures are presumably consolidated in LTM so that they are readily recognized and there is little or no forgetting during the test period. Corrected for false yeses, .88 of the pictures were remembered. These results are consistent with previous findings demonstrating the high level of recognition when the duration of each picture is 1 s or more; Potter and Levy (1969) found that about .82 of the pictures in their study were recognized when presented at 1/s, with little memory loss over a 32-item recognition test (see also Hollingworth, 2003b, and Intraub, 1980). In the title condition in the present experiment the overall level of performance was lower than for the picture condition: after correction for false yeses, .70 of the titles successfully cued recall of the corresponding picture.

These results suggest that when a series of pictures is presented at the rate of 1 per second, viewers are not only able to remember the visual features of these pictures, but are also able to encode and remember the meanings of the pictures in some detail. Both perceptual and conceptual information is retained for at least 14 seconds (the approximate duration of the presentation and test periods), and probably considerably longer. The titles do not cue memory for the pictures as successfully as the pictures themselves because titles provide only gist, not the full pictorial and conceptual detail that is encoded and consolidated.
in 1 s. However, the titles clearly capture some important aspects of the information in memory.

**Experiment 2**

Experiment 2 tested the hypothesis that the fleeting memory for rapidly presented pictures observed by Potter et al. (2002; see Figure 2) depends on visual-pictorial rather than solely on conceptual information. Having shown in Experiment 1 that descriptive titles can tap LTM for pictures, in Experiment 2 we used the same contrast between picture and title tests to examine fleeting memory--PSTM or CSTM--when pictures are presented at a high rate, almost 6 pictures/s (173 ms/picture).

**Method**

The method was like that of Experiment 1, except that the sequence was presented for 173 ms per picture. Due to a programming error, the test pictures in the picture group were presented to four participants for 800 ms each, rather than 400 ms; these subjects performed similarly to other subjects. There were 20 participants in each group.

**Results and Discussion**

As expected, performance was much lower in Experiment 2 than in Experiment 1. As in Experiment 1, the group tested with pictures did better, overall, than the group tested with titles. Both groups, however, showed a decline in performance over the test, as seen in Figure 4. Importantly, the benefit of testing early in the sequence was greater for the group tested with pictures, showing that features of the presented picture not represented in the title--presumably visual features--were available early in testing but were quickly lost.

In the group tested with pictures, 51% of the old pictures were recognized and 14% of the distractors were falsely recognized; in the group tested with picture titles, 48% and 18% were recognized, respectively. The guessing-corrected scores, $P(Y_{corr})$, are shown in
Figure 4 as a function of test serial position. In the analysis of $P(Y_{corr})$ the picture group was more accurate than the title group, $F(1, 38) = 8.20, p < .01$; the effect of test position was significant, $F(4, 152) = 75.41, p < .001$; and the interaction between group and test position was also significant, $F(4, 152) = 6.68, p < .001$. Separate analyses of the two groups showed a significant effect of serial position in each group. For the picture group, $F(4, 76) = 86.66, p < .001$; a trend analysis showed significant linear and quadratic components, each $p < .001$. For the title group, $F(4, 76) = 16.82, p < .001$; there was a significant linear trend, $p < .001$, but the quadratic trend was not significant, $p = .08$.

In an analysis of the yes responses to old pictures in which both presentation serial position and test serial position were variables, the main effect of test serial position and the interactions between this effect and test group were highly significant, as in the analysis of $P(Y_{corr})$. The serial position of presentation had a significant effect, $F(4, 152) = 19.33, p < .001$, consisting of a primacy benefit for the first presented picture. There was no recency effect (but note that the very last picture in presentation was treated as a filler). There was no interaction between serial position in presentation and group (pictures versus titles); none between serial position in presentation and in test; and there was no triple interaction with group (all $F$s were less than 1.0).\(^5\)

The performance with pictures versus titles supports the hypothesis that the fleeting early benefit in the recognition test is primarily due to short-lived visual-pictorial information, PSTM, that is not tapped by a title. The relative similarity of performance with pictures and titles in the later part of the test suggests that the more durable short-term memory for a picture is primarily conceptual, when pictures are presented at about 6/s. Test pictures and titles tap the same type of information except right at the beginning of the test, when the picture test evidently taps considerably more information that is quickly lost if testing comes a little later. However, the finding that performance showed a significant decline throughout testing not only in the picture test but also in the title test suggests that conceptual information, CSTM, is also being forgotten over the approximately 8 s of testing,
although at a slower rate than PSTM.

The results of the group tested with titles show that information about the pictures' semantic contents is often remembered well enough for participants to match verbal titles to these memories, even when the pictures were presented for only 173 ms each. Indeed, a comparison of the two groups in Experiment 2 (Figure 4) indicates that titles were almost as recognizable as pictures, apart from the beginning of the test. This result is surprising and is strong support for the claim that conceptual gist is extracted very early in viewing a picture. Potter (1975, 1976) and Intraub (1981) showed that participants can readily pick out a picture target when given a descriptive title in advance of viewing a rapid sequence of pictures--although they do still better when shown the target picture itself, in advance (see Figure 1). However, this is the first time that the reverse has been shown: that a title is an effective memory retrieval cue for a previously glimpsed picture.

Not surprisingly, performance was lower overall in Experiment 2 (with pictures presented for 173 ms) than in Experiment 1 (with pictures presented for 1 s). Interestingly, however, at the higher rate of presentation titles were more nearly equivalent to picture tests. This outcome is what one might expect if gist information (corresponding to the title) is encoded early in processing a picture (e.g., in the first 173 ms), whereas more detailed visual or conceptual information is acquired later. In Experiment 2 relatively little extra detail could be encoded and consolidated in the 173 ms of presentation, reducing the difference between picture and title tests.

In one important respect, however, the results support the assumption that picture details (beyond gist) play a significant role in the recognition test, even with a 173 ms presentation (Experiment 2). The picture test was markedly better than the title test in the early part of the recognition test, specifically for the first old picture tested. This outcome is most readily explained by assuming that non-gist pictorial information (PSTM) was available if the picture was tested early. Later in the test, however, there was a reliance on gist information (CSTM), putting titles and pictures more nearly on par. As both kinds of
information--PSTM and CSTM--had ample time to be consolidated into LTM at the slow rate of presentation in Experiment 1, a test picture conveyed more useful information than a title, and this difference was stable throughout the test.

Experiment 3

One question about the comparison between Experiments 1 and 2 is whether the benefit from 1 s rather than 173 ms of viewing comes from the extra time to inspect the pictures, or from extra time to consolidate the information. Intraub (1980) presented pictures sequentially for 110 ms with blank ISIs ranging from 0 to 5.9 s; memory performance improved markedly as the ISI increased from 20% with 0 ISI to 84% with an ISI of 1.5 s (see also Potter, 1976, Experiment 3). This finding suggests that the main benefit of a long presentation duration is to allow consolidation of information extracted early in viewing. To test this hypothesis, in Experiment 3 we presented each picture for 173 ms followed by a blank ISI of 827 ms, so the stimulus onset asynchrony (SOA) was 1 s as in Experiment 1 but the presentation duration of each picture was 173 ms, as in Experiment 2.8

Method

The method was like that of Experiments 1 and 2, except that each picture in the sequence was presented for 173 ms, followed by a blank ISI of 827 ms, for a total SOA of 1000 ms. The blank ISI was a medium gray, the same as the background. There were 10 participants in each group.

Results and Discussion

The results of Experiment 3, corrected for guessing, are shown in Figure 5 as a function of test serial position. Despite the brief exposure duration of each picture,
performance was little different from that in Experiment 1 in which pictures were viewed for the full 1 s SOA (Figure 3), and much better than in Experiment 2, when pictures followed each other with no ISI (Figure 4). As in Experiment 1, the group tested with pictures did better, overall, than the group tested with titles. Only the picture group showed a significant (although small) decline in performance over the test, as seen in Figure 4.

In the group tested with pictures, 90% of the old pictures were recognized and 7% of the distractors were falsely recognized; in the group tested with picture titles, 72% and 16% were recognized, respectively. In the analysis of $P(Y_{corr})$ the picture group was more accurate than the title group, $F(1, 18) = 50.23, p < .001$; the effect of test position was significant, $F(4, 72) = 2.89, p < .05$; but the interaction between group and test position was not significant, $F < 1.0$. Separate planned analyses of the two groups showed a significant effect of test position in the picture group, $F(4, 36) = 3.24, p < .05$; a linear trend analysis was not significant ($p < .10$). For the title group neither test position nor linear trend was significant.

In an analysis of the yes responses to old pictures in which both presentation serial position and test serial position were variables there was a significant main effect of pictures versus titles ($p < .001$) and of test position ($p < .05$), but no main effect of presentation position and no interactions. These results are consistent with those of Experiment 1.

Analyses comparing Experiments 1 and 3 were carried out separately for the picture and title groups, on $P(Y_{corr})$. For the picture groups there was no significant difference between the two experiments, the effect of test position was significant ($p < .001$), and there was no interaction. For the title groups there was again no significant difference between the experiments ($p = .24$), test position was marginally significant ($p = .05$), and there was no interaction.

Overall, the comparison between Experiments 1 and 3 shows that, when there is an SOA of 1 s between pictures, having the picture in view for only 173 ms of that interval is little different from being able to view the picture for the full 1 s, and that in both cases
performance is much better than when pictures are presented for 173 ms with no ISI (Experiment 2). The opportunity in Experiment 1 to make two or three eye movements to different parts of a picture did not give a significant memory advantage. This suggests that the major benefit of a slower rate of presentation is not in the extra time to inspect the picture, but the extra time to consolidate information picked up in the initial 173 ms of viewing. This conclusion is consistent with results of Intraub (1980), described earlier.

Experiment 4

In Experiment 4 we tested an alternate interpretation of Experiments 1-3. It seems possible that participants adopt two different encoding strategies when they are tested with pictures versus titles. Perhaps performance in the title condition was relatively good because subjects were able strategically to encode the pictures in a verbal or propositional form, even when they were presented at 6 a second in Experiment 2. To test this hypothesis, in Experiment 4 the two types of trials were randomly intermixed within subjects, so that participants did not know until the test began whether they would be seeing pictures or titles. If the nearly equivalent level of performance in Experiment 2's two groups was the result of task-specific encoding strategies, performance would be expected to decline in one, the other, or both conditions, in Experiment 4. As in Experiment 2, pictures were presented for 173 ms with no ISI.

Method

The method was the same as that in Experiment 2, except that type of recognition test was a within-subjects variable. Of the 60 trials, half were tested with titles and half with pictures, counterbalanced between subjects. Serial position in presentation and serial position in test were counterbalanced with type of test. Trials were randomized, so that participants did not know until the recognition test began whether it would consist of pictures or titles. There were 20 participants.
Results and discussion

Overall, the results of Experiment 4 with titles and pictures as a within-subject variable were similar to those for Experiment 2 with a between-subjects design. If anything, however, the advantage of a picture test early in testing was more marked in Experiment 4.

In the picture test condition, 56% of the old pictures were recognized and 18% of the distractors were falsely recognized; in the title condition, 47% and 24% were recognized, respectively. The guessing-corrected scores, $P(Y_{corr})$, are shown in Figure 6 as a function of test serial position. In the analysis of $P(Y_{corr})$ the picture condition was more accurate than the title condition, $F(1, 19) = 8.59, p < .01$; the effect of test position was significant, $F(4, 76) = 15.80, p < .001$; and the interaction between condition and test position was also significant, $F(4, 76) = 10.08, p < .001$. Separate analyses of the two test conditions showed a significant effect of serial position in each condition. For the picture condition, $F(4, 76) = 22.25, p < .001$; a trend analysis showed significant linear and quadratic components, $p < .001$ and $p < .01$, respectively. For the title condition, $F(4, 76) = 7.33, p < .001$; there were significant linear and quadratic components, $p < .001$ and $p < .05$, respectively.

In an analysis of correct yeses in which test condition was crossed with serial position in presentation and in test, our main interest as before was in serial position in presentation, and its possible interaction with test condition and with test serial position. There was a significant main effect of presentation position, $F(4, 76) = 10.85, p < .001$, with the usual primacy effect and no recency effect; there was no significant interaction with test position, with test condition (pictures versus titles), and no triple interaction. This pattern of results was highly similar to that in Experiment 2.

In sum, intermixing trials with picture tests and title tests changed performance only minimally, compared with Experiment 2 in which the two test conditions were presented to different groups. It seems unlikely, on the basis of this result, that success in recognizing titles depends on strategic encoding of the pictures in verbal or propositional form. To the
contrary, the evidence we have presented suggests that viewers standardly encode the meanings of pictures, so that a title is an effective match to that meaning in many cases. The evidence suggests, however, that in addition to a picture's overall meaning or gist, for a brief time viewers maintain enough detailed visual information to make recognition of the first old test item much better when it is a picture than when it is a title.

**Experiment 5**

In Experiment 5 we evaluated the conceptual basis of memory in another way, by including in the recognition test occasional pictures that matched the title--the gist--of one of the old pictures. We called such a picture a *decoy*; two examples are shown in Figure 7. The decoy was visually different from the old picture it replaced: side by side, it was easy to tell that the pictures were not the same. If viewers rely on a visual match early in the test, then they should not be susceptible to the decoys; to the extent that they rely on a conceptual or gist representation of the presented pictures, however, they should make false yes responses more often to decoys than to new distractors that are not conceptually similar to any of the pictures they have just seen. Moreover, if viewers rely in part on CSTM (as Experiments 2 and 4 suggest), then one would expect a fall-off in response to decoys in the course of the test like that for responses to old pictures.

**Method**

There were 20 participants. The method was the same as that in Experiment 2's picture group, except for the following. A decoy picture replaced one of the 5 old pictures in each recognition test. The decoy was selected so as to satisfy the same short (1-7 word) conceptual title that was assigned to the corresponding presentation picture in Experiments 1-4; if a presentation picture was assigned the title "skiers on a mountain" this would also be the main theme of the corresponding decoy. However, the decoy was always selected so as to be visually dissimilar to the corresponding presentation picture. A minimal criterion
was that the two pictures should be sufficiently dissimilar that they would be easily
discriminable if presented beside each other. The pairs varied in their degree of
dissimilarity: some did share some visual features, such as dominant colors, but most were
alike at only an abstract level. Figure 7 shows examples of pairs of decoy and old pictures.
Like the original set of pictures, the decoy pictures were gathered from various sources,
including commercially-available CDs and the internet.

The serial positions of the decoy pictures were counterbalanced, so that for each
participant the decoys appeared equally often in the place of the first-tested old picture, the
second-tested, and so on. The position of the presentation picture that was replaced by the
deco was similarly counterbalanced: for each subject the first-presented picture was
replaced in the test sequence exactly as often as the second-presented, and so on. As in the
previous experiments, the position of a given picture in the presentation sequence was
counterbalanced across subjects. Test position was counterbalanced over subjects in the
same way as in Experiment 1 and subsequent experiments.

In sum, each test sequence consisted of five new pictures (the standard distractors),
four old pictures, and one decoy picture, which occupied the test position vacated by one of
the old pictures. Participants were not informed that there would be decoys: they were
instructed as before to press yes only if they were reasonably confident that they had seen
that picture in the preceding sequence. Thus, the correct response to the decoys was no.

Test of ability to distinguish decoys from old pictures. To test the discriminability of
old pictures and decoys, a separate group of 7 participants made same-different judgments
of sequentially presented pairs of pictures preceded and followed by visual masks
consisting of other pictures cut up into small squares that were reassembled randomly. On
120 of the 240 trials, the two pictures were identical. On 60 trials, the two pictures were
unrelated. On the remaining 60 trials, the two pictures were the old picture and decoy, in that
order. The trials were intermixed randomly. Each trial began with a fixation plus for 307 ms
followed by a blank for 200 ms, then a mask (for 173 ms), the first picture, a second mask,
the second picture, and a third mask. The participant responded by pressing one of two keys to indicate "same" or "different." For the identical pairs, 96.1% of the responses were "same;" for the unrelated pairs, 98.3% of the responses were "different;" and for the decoy pairs, 97.4% of the responses were "different." There was no significant difference in accuracy between the decoy and related-picture pairs. Thus, viewers were almost always able to distinguish decoys from old pictures when they were presented for 173 ms, separated by a 173-ms visual mask. Clearly, the two pictures were not highly similar, visually. On the other hand, they were certainly more similar than two random pictures, so we cannot entirely rule out the possibility that there was sufficient visual similarity to produce some level of visual (rather than solely conceptual) matching once the memory for the first picture had been degraded by test interference.

Results and discussion

Participants made significantly more false yeses to decoys than to other distractors, although there were substantially more true yeses to old pictures than false yeses to decoys. Thus, viewers generally remembered more than just the gist of a picture, and so were able to reject a gist-sharing decoy much of the time. Importantly, the benefit of testing early was much greater for old pictures than for decoys (Figure 8).

Responses to old pictures, decoy pictures, and new pictures were scored separately. Overall, participants recognized old pictures 52% of the time and falsely recognized non-decoy distractors 15% of the time. They responded yes falsely to the decoy pictures 30% of the time.

In calculating \( P(Y_{corr}) \), the false-yes rate for non-decoy distractors was used both for yes responses to old pictures and for yes responses to decoys. For old pictures, the \( P(Y_{corr}) \) analysis of test position was significant, \( F(4, 76) = 61.26, p < .001 \), with a sharp drop-off in performance as shown in Figure 8 that was similar to that in the picture test conditions in Experiments 2 and 4. A trend analysis showed significant linear and quadratic components,
both p's < .001. For decoys, test position was also significant, $F(4, 76) = 12.21, p < .001$, with a drop-off that was less marked than that for old pictures. A trend analysis showed a significant linear component, $p < .001$; the quadratic component was not significant. In an analysis of $P(Y_{corr})$ comparing old pictures and decoys, there was a significantly greater probability of saying yes to an old picture than to a decoy, $F(1, 19) = 268.42, p < .001$; there was a main effect of test position, $F(4, 76) = 50.87, p < .001$, and there was an interaction, $F(4, 76) = 4.41, p < .01$. The interaction is seen in Figure 8: the advantage of seeing an old picture (relative to a decoy) was greater when tested early than when tested later.

In an analysis of correct yes responses to old pictures as a function of serial positions in presentation and in test, there was as usual a significant primacy effect for the first picture presented, with no other serial position effects, $F(4, 76) = 5.31, p < .001$, and a significant effect of test position, $F(4, 76) = 78.88, p < .001$, with high performance early in the test, dropping rapidly thereafter. There was no interaction between these effects, $F < 1.0$. In the corresponding analysis of yes responses to decoys, the only significant effect was for test position, $F(4, 76) = 20.58, p < .001$. Although the presentation position of the picture corresponding to the decoy had no significant effect, the probability of responding yes to a decoy was higher when the corresponding picture was the first one presented, suggesting a small primacy effect.

In sum, the decoys were clearly more effective than random, conceptually unrelated distractors in producing (false) yeses, but they were less effective than the genuine old pictures. This result suggests either that the decoy pictures are only moderately successful at accessing the stored representations underlying correct recognition, or else that they successfully lead to retrieval, but the retrieved representation includes enough additional information to allow the viewer to reject the decoy.

Experiment 5 shows clearly that gist information is not all that is retained from a series of briefly-presented, conceptually masked pictures: visual or conceptual detail is remembered as well. When participants are presented with a test picture that fails to capture
this visual detail (or includes different details), they are fairly likely to reject it, even if it is conceptually similar to an old picture. Because conceptual as well as visual memory for the presented picture falls off during the test, false recognition of the decoy also falls. As with titles in Experiments 2 and 4, the initial falloff is more rapid for true pictures than for decoys, showing that there is extra information about the presented picture early in testing--PSTM--that helps in recognizing an old picture but is not similar enough to the decoy to increase false yeses to it.

**General Discussion**

The present experiments investigated the conceptual versus visual-pictorial nature of the fleeting memory for briefly glimpsed scenes reported by Potter et al. (2002). The question was whether this short term memory consists of just one type of information that is rapidly forgotten, or whether there are two distinct types of short term memory with different time courses, one visual-pictorial--PSTM--and the other conceptual--CSTM. To test this hypothesis, we used two methods--tests using titles versus pictures, and tests with decoy pictures versus old pictures--to distinguish between purely conceptual memory representations (titles or conceptually similar decoys) and representations that include visual as well as conceptual information (the pictures themselves). Our main interest in all of the experiments was the relation between test position and performance with conceptual versus perceptual memory probes.

In Experiments 1-4 participants viewed short sequences of pictures and were then tested either by viewing the same pictures mixed with new distractors, or by viewing titles of the old pictures intermixed with titles of distractors. The titles did not provide any explicit visual information, only the conceptual gist of the picture. Thus, to the extent that viewers remember mainly gist, titles should be similar to pictures in recognition testing. In Experiment 1 the pictures were presented at a rate of 1/s, slow enough so that performance was near ceiling with the picture test, showing that the pictures were in LTM. Performance
was lower with the title test, but still very good, indicating that titles can successfully tap memory for pictures. There was a significant decline in accuracy over the course of the recognition test, although it was a small effect.

In the subsequent experiments, pictures were presented for 173 ms each. In Experiment 2 overall performance was much lower than in Experiment 1, as expected from previous work, and the title test was again significantly worse than the picture test. Surprisingly, however, the difference between titles and pictures was if anything smaller than in Experiment 1. There was a significant decline in performance over the course of the yes-no test, much more marked than that in Experiment 1, showing that there was short term memory for the pictures that was lost over the first few seconds of testing. An interaction between test serial position and the type of test was significant in Experiment 2, with a much larger picture test advantage early in the test.

In Experiment 3 the pictures were presented for 173 ms as in Experiment 2, but were followed by an 827 ms blank ISI, for an SOA between pictures of 1 s as in Experiment 1. Performance was very similar to that in Experiment 1, showing that total processing time per picture determines whether or not the picture is consolidated in LTM, not actual presentation time (Intraub, 1980; Potter, 1976). Experiment 4 replicated the results of Experiment 2, using a within-subjects design. These results support Potter et al.'s (2002) claim that when presentation is rapid most pictures are remembered at least briefly, but many are forgotten over the course of the recognition test.

With respect to the questions addressed in the present study, the results of Experiments 2 and 4 support the hypothesis that the fugitive memory for a glimpsed picture consists in part of pictorial properties of the picture, information that is not tapped by a conceptual title. That is, for those pictures that are slated to be rapidly forgotten, a picture test given immediately can show that they were momentarily remembered, whereas an immediate title test does not produce the same high initial level of recognition. Performance continues to drop after the first test, but at about the same rate for pictures and titles,
suggesting that conceptual information is also being forgotten. The relatively small
difference between titles and pictures suggests that most of the information on which
recognition is based (after the first test items) is conceptual--at least for very briefly
presented pictures. (That a conceptual title is sufficient for recognition does not show that
there is no memory for visual information about that picture, but suggests that the initial
visual information has fallen to a level at which there is little or no redundancy gain in
testing with a picture rather than a title.) Toward the end of the 10-item test performance
approached an asymptote, suggesting that pictures still remembered after 6-8 s of testing are
in LTM, where they can be tapped either by a test picture or by a gist title.

In Experiment 5 we used a second method to address the same questions. A decoy
picture with the same gist as one of the five old pictures was substituted for the old picture
in the recognition test, so that the test consisted of 4 old pictures, 1 decoy, and 5 distractors.
The question was whether a picture with the same gist as one that had been presented would
be falsely recognized--even though it was visually different from the presented picture.
False yes responses to the decoy picture would be expected only if a viewer retained
conceptual information about the original picture but not specific visual information. If a
viewer remembered no more than conceptual gist equivalent to a title such as "dogsled", then
a different picture of a dogsled should be falsely recognized as frequently as the original
picture is correctly recognized. However, if specific pictorial information or conceptual
detail is remembered, then little or no false recognition should be observed, because there
was little or no specific pictorial overlap between decoys and the original pictures: In a
control study, the decoy and original picture were easily discriminated when one was
presented 173 ms after the other.

The results indicated that false recognition of decoys did occur, although less
frequently than true recognition. As had been the case with title tests in the earlier
experiments, the superiority of true old pictures was greatest at the beginning of the
recognition test: only true old pictures showed a marked peak at the beginning of the test.
However, just as memory for old pictures continued to decline during the test, false recognition of decoys also declined. This suggests that, as with recognition tests using titles, gist is being forgotten during the test, as well as pictorial properties.

**Do titles tap conceptual memories or visual memories?** An alternative account of how titles are used to cue picture memory is the following. Suppose that what is remembered is a visual-pictorial representation of the picture. When a title is presented, it is understood conceptually and is used to retrieve or construct an appropriate image (e.g., of a camel). That image is then compared with pictorial representations in recent memory, and if a match is found, the response is "yes." The main problem with this alternative hypothesis is that a title has many (an infinite number of) potential matching pictures, only one of which would be imaged by the viewer of the title—so the chances of a good visual match with the actual picture shown are small. In contrast, the probability is high that the title captures the conceptual gist of the picture. So, matching the meaning of the title to the remembered conceptual gist of the picture is likely to be easy; matching the visual image that the title might produce in the mind of a viewer to the visual appearance of the particular picture we presented would be highly error-prone.

**PSTM, CSTM, and visual short term memory (VSTM).** We have assumed that the initial peak in recognition of pictures is due to brief persistence of visual-pictorial information (PSTM), not conceptual information (CSTM). We cannot, however, rule out the possibility that conceptual details are the basis for the peak, details that are rapidly forgotten. Whereas the titles and decoys provide conceptual gist that matches presented pictures, they do not match the presented picture in conceptual detail. For example, the fact that the camel was lying down may be part of the conceptual information conveyed by picture A1 in Figure 7, and the presence of two dogsleds may be part of the conceptual information in picture B1. If we assume that this additional conceptual information is quickly lost during the test, that could account for the initial peak for test pictures, relative to titles or decoys.

Although there is no gold standard for distinguishing between conceptual and
perceptual knowledge, there is some agreement that novel and meaningless combinations of visual features such as color and shape or novel patterns such as partly filled checkerboard-like arrays are remembered visually rather than conceptually: the visual properties of the array seem to exhaust the conceptual content. That is why studies of VSTM have typically used colored geometric objects and the like. However, memory for such materials is usually poor except for the most recent stimulus (e.g., Phillips & Christie, 1977), so that studies of VSTM capacity have normally looked only at memory for the most recent array (e.g., Luck & Vogel, 1997). Thus, the evidence that viewers can remember fleetingly four or five presented pictures in the present experiments (and up to 20 pictures in Potter et al., 2002) indicates that PSTM has different properties than VSTM as studied by Phillips and Luck, among others.

In the present study visual information is bound to the conceptual identity of meaningful objects or scenes. This bound information is more distinctive and therefore easier to retain than an arbitrary combination of a limited number of shapes and colors. That may be why Hollingworth and Henderson (2002) find that visual properties such as the orientation in depth of an object in a realistic scene can be retained accurately over multiple intervening fixations on other objects in the scene. However, the evidence in their study that the information about orientation typically persists in LTM (see also Hollingworth, 2003a) leaves open the question of whether there is also disruptible short term memory for object orientation that is like PSTM, and if so, whether it survives one or more subsequent fixations on other objects. In Hollingworth & Henderson's (2002) studies there is evidence that the probability of detecting an object change is lower when the object was viewed for a shorter time, but there was little evidence that increased time between initial viewing and the test affected memory. Using a new technique in which the viewer follows a dot that moves to a new object in a scene about once a second, Hollingworth (2003b) found that most objects are remembered stably in LTM, although there is significantly better memory for the two most recent objects viewed, suggesting a VSTM capacity of two objects. This result
seems consistent with the time course of PSTM in the present study.

Although it is not clear from previous work whether visual information is distinct from conceptual information either in kind or in time course of forgetting, we adopt a widely accepted assumption that rich visual detail is lost more rapidly than more holistic and categorical semantic information. This assumption is consistent with the present evidence that picture recognition tests, if administered immediately, tap information about presented pictures that is not tapped by a title test or a decoy picture.

Do titles cue retrieval of visual information? Just how are titles recognized? We can be certain that viewers are not encoding pictures verbally when they are presented at the rate of 6/s (Intraub, 1979), so there is little likelihood that a verbal title was generated during viewing and matched to the test title. Instead, the test title must be understood and then matched to the encoded conceptual gist of a picture in memory. However, it is clear from the decoy experiment that participants remember more than bare gist equivalent to the titles we used. We propose that a title's gist is the basis for initial retrieval of the matching picture, but that more information about the picture is then recalled, including visual information: the picture is redintegrated (Horowitz & Prytulak, 1969). This process accounts for the strong intuition that we can picture a recalled scene. When the test picture is a decoy, its gist also results in retrieval of the relevant picture, but subsequent redintegration of the retrieved picture is sufficient in most cases to show that it does not match the decoy—the participant recalls-to-reject (e.g., Clark & Gronlund, 1996).

Conclusion. Pictures glimpsed briefly in a rapid sequence mimic the input from successive eye fixations, in an idealized situation in which there is no overlap in content from one "fixation" to the next. Earlier work (Potter, 1976) showed that such pictures can be momentarily understood, but they are then likely to be forgotten within minutes. In more recent work (Potter et al, 2002) we showed that forgetting was not instantaneous: as many as 20 pictures in a sequence could be remembered with a high probability as long as they were tested immediately, but as the test continued there was rapid forgetting. In the present
study we showed that this short term memory for pictures has two components, one visual-pictorial (PSTM) and the other conceptual (CSTM). These two components coexist initially, but PSTM is lost very early in testing, within 2-3 s, whereas CSTM lasts somewhat longer, for 5-6 s. Further forgetting is very gradual, showing that the surviving pictures were those whose visual and conceptual properties were consolidated into LTM during presentation. As we make a new fixation under normal viewing conditions, information about the visual as well as conceptual contents of the last few fixations may be available, although fated to be forgotten shortly. Such transient information--initially both perceptual and conceptual, then primarily conceptual--may be important in maintaining and updating a coherent representation of the scene.
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Notes

1 The drop in performance over the test was not accounted for by the higher false alarm rate (false yeses to distractors) early in the test, because the effect persisted after correction for guessing ($Y_{corr}$: see text), as shown in Figure 2.

2 Although there is only a suggestion of an asymptote in Figure 2, most of our studies confirm a leveling off after 3 or 4 old test items and a corresponding number of distractors.

3 The main reason for reporting the $Y_{corr}$ results rather than $A'$ is that the former measure is transparently related to the raw $P(TY)$ and $P(FY)$ results. The second reason is that previous studies of picture memory (Potter, 1974) indicate that the variances of the distributions of the familiarity of old and new pictures differ, such that the variance is much greater for old pictures, suggesting that measures such as $A'$ and the two-high-threshold correction that assume symmetry between these distributions are inappropriate.

4 The design, procedure, materials, and analyses used in the picture test condition of Experiment 1 were like those in Experiment 1 in Potter et al. (2002), although the presentation duration was 1 s rather than 173 ms in the previous study.

5 The overall pattern of results for the picture group--rapid forgetting of some of the pictures during the test, in particular in the early part of the test--replicated the results of a similar experiment in Potter et al. (2002; see Figure 2 in the present article).

6 An ANOVA of $P(Y_{corr})$ combining Experiments 1 and 2 showed a highly significant difference between the experiments and significant main effects of type of test and test serial position, as well as significant interactions. Importantly, the triple interaction among experiment, test type, and serial position in test was also significant, $p < .05$, consistent with
the conclusion that title and picture test were more nearly equivalent at the high rate, except at the beginning of the test.

7 A different possibility, contradicted by the results of Experiments 1 and 2, is that because a title provides a relatively impoverished representation of a picture, only a robust memory representation could successfully match it. On this hypothesis, a scantly picture memory provided by a short, 173 ms glimpse would provide a poor match with a title test. One would then expect performance with titles relative to pictures to be much worse in the 173 ms condition than in the 1 s condition--contrary to what we observed.

8 We thank a reviewer for suggesting this experiment.

9 Test position was not significant in the A' analysis.

10 Test position was not significant in the A' analysis.

11 We thank a reviewer for this suggestion.

12 There are also other problems with the imaging hypothesis, such as that images take seconds to generate and lack the vividness of a color photograph.

13 We distinguish between conceptual information and verbal information; while most concepts (as well as most visual properties) can be expressed in words, the words themselves are not concepts: they are pointers to concepts.
Figure Captions

Figure 1. Proportion of correct detections of specified pictures compared with recognition memory for pictures (adapted from Figure 1, Potter (1976)). In the detection task targets were specified by showing the picture in advance or by giving a short verbal title. Recognition memory was corrected for guessing ($Y_{corr}$). Presentation time is on a log scale.

Figure 2. Probability of recognizing an old picture ($TY$), falsely recognizing a new picture ($FY$), and recognizing an old picture corrected for guessing ($Y_{corr}$) as a function of relative serial position in the recognition test in Potter et al. (2002), Experiment 1. (Adapted from Figure 2B, Potter et al., 2002.)

Figure 3. Probability of recognizing an old picture corrected for guessing ($Y_{corr}$), as a function of relative serial position in the recognition test, separately for the group given a picture recognition test and the group given a title test, in Experiment 1. Presentation rate was 1/s.

Figure 4. Probability of recognizing an old picture corrected for guessing ($Y_{corr}$), as a function of relative serial position in the recognition test, separately for the group given a picture recognition test and the group given a title test, in Experiment 2. Presentation rate was 5.8/s (173 ms per picture).

Figure 5. Probability of recognizing an old picture corrected for guessing ($Y_{corr}$), as a function of relative serial position in the recognition test, separately for the group given a picture recognition test and the group given a title test, in Experiment 3. Presentation duration was 173 ms, followed by a blank ISI of 827 ms, for an overall rate of 1/s.

Figure 6. Probability of recognizing an old picture corrected for guessing ($Y_{corr}$), as a function of relative serial position in the recognition test, separately for picture recognition tests and title tests, in Experiment 4. Trials with picture tests and with title tests were intermixed within subjects. Presentation rate was 5.8/s (173 ms per picture).
Figure 7. Examples of original pictures and decoys, used in Experiment 5: A, "Camel," B, "Dogsled." The original picture in each case is on the left.

Figure 8. Probability of recognizing an old picture, and falsely recognizing a decoy picture, corrected for guessing ($Y_{corr}$), as a function of relative serial position in the recognition test in Experiment 5; non-decoy distractors were used to assess the guessing rate in both cases. Presentation rate was 5.8/s (173 ms per picture).