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Semantic Integration of Verbal Information into a Visual Memory

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A total of 1,242 subjects, in five experiments plus a pilot study, saw a series of slides depicting a single auto–pedestrian accident. The purpose of these experiments was to investigate how information supplied after an event influences a witness's memory for that event. Subjects were exposed to either consistent, misleading, or irrelevant information after the accident event. Misleading information produced less accurate responding on both a yes–no and a two-alternative forced-choice recognition test. Further, misleading information had a larger impact if introduced just prior to a final test rather than immediately after the initial event. The effects of misleading information cannot be accounted for by a simple demand-characteristics explanation. Overall, the results suggest that information to which a witness is exposed after an event, whether that information is consistent or misleading, is integrated into the witness's memory of the event.

Almost two centuries ago, Immanuel Kant (1781/1887) spoke of the human tendency to merge different experiences to form new concepts and ideas. That tendency has crucial implications for one's ability to report his or her experiences accurately. When one has witnessed an important event, such as a crime or an accident, one is occasionally exposed to subsequent information that can influence the memory of that event. This occurs even when the initial event is largely visual and the additional information is verbal in nature (Loftus, 1975; Pezdek, 1977). For instance, in a previous study, subjects saw films of complex fast-moving events such as automobile accidents or classroom disruptions (Loftus, 1975). Immediately afterward, the subjects were asked a series of questions, some of which were designed to present accurate, consistent information (e.g., suggesting the existence of an object that did exist in the scene), while others presented misleading information (e.g., suggesting the existence of an object that did not exist in the original scene). Thus, a subject might have been asked, "How fast was the car going when it ran the stop sign?" when a stop sign actually did exist (Experiment 1). Or the subject might have been asked, "How fast was the white sports car going when it passed the barn while traveling along the country road?" when no barn existed (Experiment 3). These subjects were subsequently asked whether they had seen the presupposed objects. It was found that such questions increased the likelihood that subjects would later report having seen these objects. It was argued that the questions were effective because they contained information—sometimes consistent, sometimes misleading—which was integrated

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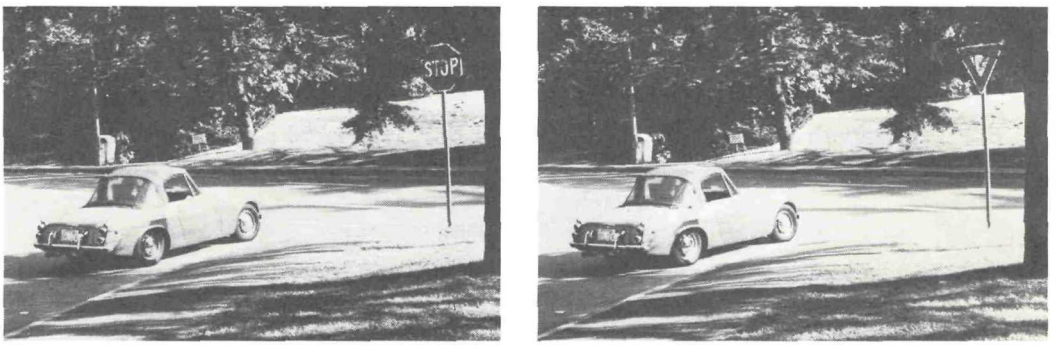

Figure 1. Critical slides used in the acquisition series.

into the memorial representation of the event, thereby causing a reconstruction or alteration of the actual information stored in memory.

In these earlier experiments, the original event was presented visually, the subsequent information was introduced verbally via questionnaires, and the final test was also verbal in nature. In the present experiments, a recognition procedure was used; it involved showing a series of slides depicting a complex event and afterward exposing subjects to verbal information about the event. This study phase was followed by a recognition test in which the subjects were presented with target pictures identical to ones seen before and distractor pictures altered in some way. The first reason for this change was that if one subscribes to the view that verbal and visual information are stored separately, one could argue that Loftus's (1975) final test, being verbal in nature, helped subjects access the subsequent verbal information, thereby resulting in an incorrect response.

The second reason for using a recognition test procedure was that if recognition is assumed to be a relatively passive and simple process of matching stimuli to specific locations in a content-addressable storage system, one would expect a representation of the actual (or true) scene to result in a match, whereas an alteration would fail to match. In other words, if the original visual scene is stored in memory, presenting the subject with the original stimulus might result in a match between the memory representation and the stimulus. If the original scene had been transformed so that an altered version was stored in memory, presenting the subject with the original stimulus would not result in a match between the memorial representation and the stimulus.

These considerations motivated the present series of studies. Before turning to them, we describe a pilot study in some detail, since the materials and procedures were similar to those used in the remaining experiments.

Pilot Experiment

In a pilot experiment (Loftus, Salzberg, Burns, & Sanders, Note 1), a series of 30 color slides, depicting successive stages in an auto–pedestrian accident, was shown to 129 subjects. The auto was a red Datsun seen traveling along a side street toward an intersection having a stop sign for half of the subjects and a yield sign for the remaining subjects. These two critical slides are shown in Figure 1. The remaining slides show the Datsun turning right and knocking down a pedestrian who is crossing at the crosswalk. Immediately after viewing the slides, the subjects answered a series of 20 questions. For half of the subjects, Question 17 was, "Did another car pass the red Datsun while it was stopped at the stop sign?" The remaining subjects were asked the same question with the words "stop sign" replaced by "yield sign." The assignment of subjects to conditions produced a factorial design in which half of the subjects received con-

sistent or correct information, whereas the other half received misleading or incorrect information. All subjects then participated in a 20-min filler activity, which required them to read an unrelated short story and answer some questions about it. Finally, a yes–no recognition test was administered either immediately or 1 week later. The two critical slides (i.e., those containing the stop and yield signs) were randomly placed in the recognition series in different positions for different groups of subjects.

The results indicated that relative to the case in which consistent information is received, misleading information resulted in significantly fewer hits (correct recognitions of the slide actually seen) and slightly more false alarms (false recognitions of the slide not actually seen). With misleading information, the percentage of hits was 71 and the percentage of false alarms was 70, indicating that subjects had zero ability to discriminate the sign they actually saw from the sign they did not see.

Some aspects of the data from this study preclude a clear interpretation of the results and beg for a variation in design. Most of the subjects responded "yes" to the slide shown first in the recognition series, even though the opposite sign had been seen and mentioned in the questionnaire. This indicates that the two critical slides are so similar that subjects failed to make any distinction between them. Perhaps when the second slide appeared, some subjects responded "yes" again, thinking it was the same slide, while others felt obliged to respond "no," having already responded "yes" to the earlier slide. For these reasons, a forced-choice recognition test seemed necessary, since it eliminates the problem of successive recognition tests and forces the subjects to discriminate between the two critical slides.

Overview of the Experiments

In Experiment 1, subjects were presented with the acquisition series of slides, an intervening questionnaire, and a final forced-choice recognition test. It is shown that misleading information results in substantially less accurate responding than does consistent information. Next, we consider the possibility that subjects are simply agreeing with the information in their questionnaires, fully remembering what they actually saw. Experiment 2 was actually a demonstration designed to show that the results thus far cannot be explained simply by the demand characteristics of the procedure. In Experiment 3, we asked whether information presented verbally has a different effect depending on whether it is introduced immediately after the initial event (i.e., at the beginning of the retention interval) or just prior to the final test (i.e., at the end of the retention interval). It was found that misleading information has a greater impact when presented just prior to a recognition test rather than just after the initial event. Finally, we addressed the question of whether the verbally presented information actually results in a transformation of an existing representation or whether it is simply a supplementation phenomenon. To answer this issue, one needs to know whether the original sign entered memory in the first place. If not, then the subsequent verbal information may simply introduce a sign where none existed, supplementing the existing memorial representation. If the sign originally did get into memory, the subsequent information has caused either an alteration in the original representation (i.e., one sign replaced the other in memory) or the creation of a new, stronger representation that successfully competes with the original one, rendering the latter so dramatically suppressed as to be, for all intents and purposes, gone. Experiment 4, in conjunction with Experiment 3, indicates that the traffic sign is encoded by most subjects when they view the series of slides. Experiment 5 demonstrates the generality of the findings with other materials.

Experiment 1

Method

Subjects were 195 students from the University of Washington who participated in groups of various

sizes. With a few exceptions, the procedure was similar to that used in the pilot experiment. The subjects saw the same series of 30 color slides, seeing each slide for approximately 3 sec. Approximately half of the subjects saw a slide depicting a small red Datsun stopped at a stop sign, whereas the remaining subjects saw the car stopped at a yield sign. Immediately after viewing the acquisition slides, the subjects filled out a questionnaire of 20 questions. For half of the subjects, Question 17 was, "Did another car pass the red Datsun while it was stopped at the stop sign?" For the other half, the same question was asked with the words "stop sign" replaced with "yield sign." Thus, for 95 subjects, the sign mentioned in the question was the sign that had actually been seen; in other words, the question contained consistent information. For the remaining 100 subjects, the question contained misleading information.

After completing the questionnaire, the subjects participated in a 20-min filler activity that required them to read an unrelated short story and answer some questions about it. Finally, a forced-choice recognition test was administered. Using two slide projectors, 15 pairs of slides were presented, each pair of slides being projected for approximately 8 sec. One member of each pair was old and the other was new. For each pair, the subjects were asked to select the slide that they had seen earlier. The critical pair was a slide depicting the red Datsun stopped at a stop sign and a nearly identical slide depicting the Datsun at a yield sign. The slides that the subjects actually saw varied in the left and right positions.

Results

The percentage of times a subject correctly selected the slide he or she had seen before was 75 and 41, respectively, when the intervening question contained consistent versus misleading information, $Z = 4.72$, $p < .001$. If 50% correct selection is taken to represent chance guessing behavior, subjects given consistent information performed significantly better than chance, $Z = 5.10$, $p < .001$, whereas those given misleading information performed significantly worse than chance, $Z = 1.80$, $p < .05$ (one-tailed test).

Experiment 2

Some time ago, Orne (1962) proposed that certain aspects of any psychological experiment may provide clues, or *demand characteristics*, that permit observant subjects to discern the experimental hypothesis. Obliging subjects may then try to confirm that hypothesis. In the context of the present paradigm, it is possible that some or all of the subjects not only remembered what traffic sign they observed but also remembered what sign was presupposed on their questionnaire and then "went along" with what they believed to be the experimental hypothesis and chose the sign from their questionnaire. A slightly different version of this position would argue that at the time of the final test, subjects said to themselves, "I think I saw a stop sign, but my questionnaire said 'yield sign,' so I guess it must have been a yield sign." Experiment 2 was designed to investigate this possibility.

Method

The method was similar to that of Experiment 1 with a few exceptions. Ninety subjects saw the slide series. Half of them saw a stop sign, and half a yield sign. Immediately after slides, the subjects filled out the questionnaire. For 30 subjects, the critical question was, "Did another car pass the red Datsun while it was stopped at the intersection?" In other words, it did not mention a sign. For 30 other subjects, the critical question mentioned a stop sign, and for the remaining 30 it mentioned a yield sign. Thus, for one third of the subjects, the key question contained a true presupposition; for one third, the presupposition was false; and for the remaining one third, the question made no reference to a sign at all. A 20-min filler activity occurred, followed by a forced-choice recognition test.

Finally, the subject was given a "debriefing questionnaire." It stated,

> The study in which you have just been involved was designed to determine the effects of subsequent information on eye-witness testimony. In the beginning, you saw a series of slides which depicted an accident. One of the slides contained either a stop sign or a yield sign. Later you were given a questionnaire. One of the questions on this questionnaire was worded to assume that you had seen either a stop sign or a yield sign or else it contained no information about what kind of sign you saw.
>
> Please indicate which sign you think you saw and what was assumed on your questionnaire.

I Saw	My Questionnaire Mentioned
A stop sign	A stop sign
A yield sign	A yield sign
	No sign.

Table 1
Data from Experiment 2

Information given	Incorrect subjects on forced-choice test		Correct subjects on forced-choice test	
	n	% correct on debriefing questionnaire	*n*	% correct on debriefing questionnaire
Consistent	9	22	21	52
Misleading	17	12	13	31
None	11	9	19	42
Weighted *M*		14		43

This final debriefing questionnaire permitted a subject to claim, for example, that he or she had seen a stop sign but that the questionnaire had mentioned a yield sign. In other words, it gave the subjects the opportunity to be completely "insightful" about their condition in the experiment.

Results

Of the 90 subjects who took the forced-choice recognition test, 53 chose the correct sign; 37 chose the incorrect sign. As in the previous experiment, accuracy depended on whether the subject had been given consistent, misleading, or no information on the intervening questionnaire. This relationship can be seen in Table 1.

The subjects who chose the correct sign during the forced-choice test were more than three times as likely as incorrect subjects to be completely correct on the debriefing questionnaire. Overall, 43% of the subjects choosing the correct sign accurately responded to the debriefing questionnaire, whereas only 14% of the incorrect subjects were completely accurate, $Z = 2.96$, $p < .01$. Again, whether the subjects responded accurately to the debriefing questionnaire depended on whether they had been given consistent, misleading, or no information on their intervening questionnaires.

Of central concern was the performance of subjects who had been given misleading information and who had subsequently chosen incorrectly on their forced-choice test. For example, they saw a stop sign, read that it was a yield sign, and subsequently chose the yield sign on the forced-choice test. These subjects were the ones who may have been acting the way the experimenter wanted them to act. They may have been deliberately choosing the sign mentioned on their questionnaire although fully remembering what they saw. Yet, when given the debriefing questionnaire that afforded them the opportunity to say, "I think I saw the stop sign, but my questionnaire said yield," only 12% did so.

Experiment 3

The issue that motivated Experiment 3 was whether the information introduced subsequent to an event has a different impact when it is introduced immediately after the event than when it is introduced just prior to the final test. To determine this, we varied the time interval between the initial slides and the final forced-choice test. The intervening questionnaire was presented either immediately after the acquisition slides or it was delayed until just prior to the final test.

Method

Subjects were 648 students from the University of Washington who either participated for course credit or were paid for their participation. They participated in groups of various sizes.

The procedure was nearly identical to that used in Experiments 1 and 2, with the major variations being the retention interval and the time of the intervening questionnaire. Subjects saw each acquisition slide for approximately 3 sec. Half saw the key slide that contained a stop sign, and half saw a yield sign. A questionnaire was administered,

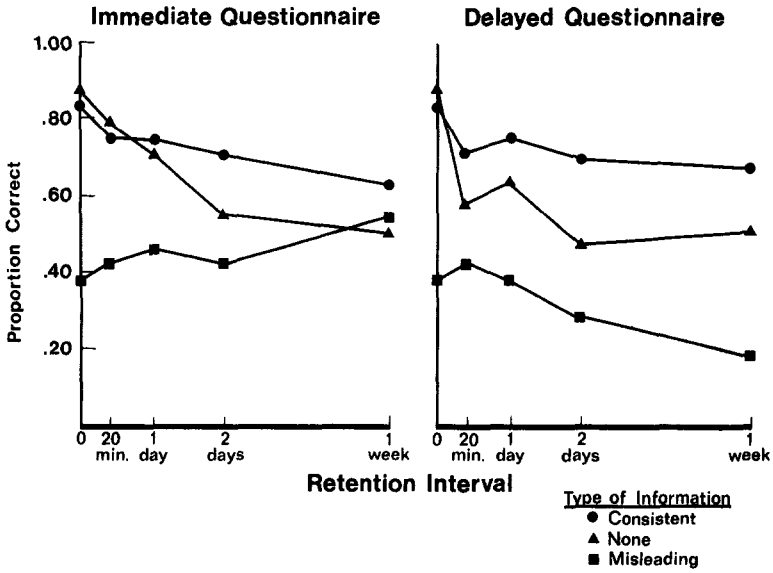

Figure 2. Proportion of correct responses as a function of retention interval displayed separately for subjects given an immediate questionnaire and subjects given a delayed questionnaire in Experiment 3. (The curve parameter is type of information the subject received during the retention interval.)

followed by a forced-choice recognition test. The forced-choice test occurred after a retention interval of either 20 min, 1 day, 2 days, or 1 week, with 144 subjects tested at each interval. Half of the subjects at each retention interval answered the questionnaire immediately after viewing the acquisition slides (immediate questionnaire), and the other half answered it just before the final forced-choice test (delayed questionnaire). In addition, 72 subjects saw the slides, received the questionnaire immediately afterward, and immediately after that were given the forced-choice test. For purposes of analysis, we consider this group to have been tested at a retention interval of zero.[1]

Except at the zero retention interval, all subjects read a short, unrelated "filler" story for 20 min and then answered some questions about it. Subjects who were given the immediate questionnaire completed the filler activity after answering the questionnaire. Subjects who were given the delayed questionnaire completed the filler activity after viewing the acquisition slides.

Question 17 on the questionnaire was the critical question. It mentioned either a stop sign, a yield sign, or no sign at all. Equal numbers of subjects received each version. Thus, one third of the subjects were given consistent information, one third were given misleading information, and one third were given no information at all relevant to a traffic sign.

In the final forced-choice recognition test, subjects were asked to choose the slide they had seen before and give a confidence rating from 1 to 3, where 1 indicated the subject was sure of the answer and 3 indicated a guess.

Results and Discussion

Proportions of correct responses as a function of retention interval are displayed separately for subjects in different conditions in Figure 2. The data for subjects tested at a retention interval of zero appear twice in Figure 2, once under immediate questionnaire and once under delayed questionnaire, because the questionnaire occurred, by definition, both immediately after the slides and just prior to the final test. In a sense, it was both an immediate and a delayed questionnaire.

Before presenting statistical analyses, we shall point out some major observations. First, for both the immediate and delayed

[1] A better design would have orthogonally varied the two critical intervals, namely, the interval between the slides and the questionnaire and the interval between the questionnaire and the recognition test. However, such a design would have required nearly three times as many subjects to obtain reasonably stable proportions in each cell, and the authors' colleagues were already becoming distressed at the rapidity with which these experiments were depleting the psychology department's subject pool. We doubt that any conclusions would be changed as a result of the fuller design.

questionnaire, longer retention intervals led to worse performance. Type of information given also had an effect: Relative to a control in which subjects were given no information, consistent information improved their performance and misleading information hindered it. The functions obtained when no relevant information was given show the usual forgetting over time. By 2 days, subjects were performing at chance level. Immediately after viewing the slides, however, there was relatively good memory for them (up to 87% correct).

The first analysis considered only the immediate-questionnaire data. A 5 (retention intervals) × 3 (types of information) analysis of variance of the arc sine transformed proportions was conducted (Mosteller & Tukey, 1949, p. 189). All F tests reported here are with $MS_e = .01$ and $p < .01$, unless otherwise indicated. The analysis showed that longer retention intervals led to less accurate performance, $F(4, \infty) = 5.67$. Further, the type of information to which a subject was exposed affected accuracy, $F(2, \infty) = 50.19$, and there was an interaction between these factors, $F(8, \infty) = 5.19$. A test for monotonic trend for the subjects who were given consistent information yielded a significant trend, $F(1, \infty) = 10.38$. Similarly, the trend was significant for subjects given inconsistent and no information, $F(1, \infty) = 4.43$ and $F(1, \infty) = 43.13$, respectively.

The second analysis considered the data from subjects who received a delayed questionnaire. A 5 × 3 analysis of variance of the arc sine transformed proportions indicated that longer retention intervals led to less accurate performance, $F(4, \infty) = 13.37$. Type of information and the interaction were also significant, $F(2, \infty) = 90.91$, and $F(8, \infty) = 2.98$, respectively. Again, the monotonic trends for each of the three types of information also reached significance: $F(1, \infty) = 5.92$ for subjects given consistent information, 14.05 for inconsistent information, and 35.85 for no information (all ps $< .05$).

Consistent information. Not surprisingly, when a subject is exposed to information that essentially repeats information previously encoded, recognition performance is enhanced. With an immediate questionnaire, the visual and verbal repetitions are massed, whereas with a delayed questionnaire, they are spaced. Whereas in most memory tasks, successive repetitions affect memory less than do repetitions that are spaced apart in time (Hintzman, 1976), this outcome was not obtained in the present experiment. A popular explanation for the spacing effect is in terms of voluntary attention. The subject chooses to pay less attention to the second occurrence of an item when it closely follows the first occurrence than he does when the interval between the two is longer. In the present case, it appears as if the subject may have paid more attention to the second occurrence when it closely followed the first, resulting in memory enhancement that was able to survive longer retention intervals.

Misleading information. When misleading information occurs immediately after an event, it has a different effect than when it is delayed until just prior to the test. The immediate procedure results in a nearly monotonically increasing function, whereas the delayed procedure leads to a monotonically decreasing function. This result makes intuitive sense. When false information is introduced immediately after an event, it has its greatest impact soon. Therefore, when the test was immediate, such subjects performed well below chance. But after an interval of, say, 1 week, both the event and the misleading information apparently had faded such that the subject performed near chance levels. On the other hand, when the misleading information was delayed, it was able to influence the subjects' choice more effectively as the delay increased. Presumably, the weaker the original trace, the easier it is to alter.

To see more clearly the effects of an immediate versus a delayed questionnaire, we excluded the data for subjects tested at a retention interval of zero and collapsed the data over the four remaining retention intervals. The results of these computations are shown in Figure 3. The proportion correct is presented as a function of the type of information given, with the im-

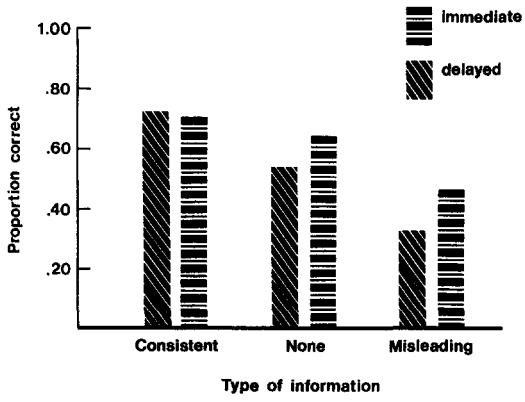

Figure 3. Proportion of correct responses for subjects given different types of information in Experiment 3. (Data for subjects given an immediate questionnaire are shown separately from data for those given a delayed questionnaire.)

mediate versus delayed questionnaire data shown separately. It is again evident that the delayed questionnaire had a larger impact than the immediate one when the subjects were given misleading information: When misleading information was introduced immediately after the incident, 46% of the subjects were correct; however, when it was delayed until just prior to the final test, that percentage dropped to 31.5%, $Z = 2.06$, $p < .05$.

We should mention here that Dooling and Christiaansen (1977) have found a different effect of misleading information. They found that such information had a greater effect on memory distortion when it occurred before the retention interval rather than afterward. As these investigators rightfully point out, there are so many differences between their experimental paradigm and ours that it is difficult to essay a resolution of the difference in results. Our subsequent manipulation focuses on one particular detail of the material to be remembered, and a peripheral detail at that. In Dooling and Christiaansen's task, the subsequent information consists of the name of a famous person about whom subjects already have a great deal of knowledge stored in memory. Unfortunately, neither they nor we have been able to come up with an appealing hypothesis for why these paradigmatic differences should lead to different results.

Surprisingly, it appears that even when the questionnaire contained no information relevant to the traffic sign, performance on this key item was somewhat better when subjects were interrogated immediately after the event rather than later. Although this difference failed to reach significance by a Z test involving all four retention intervals, $Z = 1.41$, $.10 < p < .20$, it held up for those retention intervals that, showed some memory performance above chance. For the 20-min and 1-day intervals, the immediate questionnaire had about a 15% advantage over the delayed. Perhaps the early questionnaire permitted the subjects to review the incident in order to answer questions about it, and in the course of this review, some of them refreshed their memory for the traffic sign even though they were not specifically queried on this detail.

Confidence ratings. Recall that subjects indicated how confident they were in their responses, circling "1" if they felt certain and "3" if they were guessing. The rating "2" was used for intermediate levels of confidence. Figure 4 illustrates how these ratings varied as a function of the type of information a subject was exposed to, the timing of that information, and whether the response was correct or incorrect.

A 3 × 2 × 2 unweighted-means analysis of variance (Winer, 1962, p. 241) was performed on all but the zero retention-interval data. This analysis included the 576 subjects who were unambiguously given either an immediate or a delayed questionnaire. The error for all F tests is .493, and $p < .01$ unless otherwise indicated.

Type of information affected confidence, $F(2, 564) = 9.15$, as did whether the subject responded correctly or incorrectly, $F(1, 564) = 23.64$; in other words, subjects were more confident if correct than if incorrect (1.92 vs. 2.18). The main effect of timing (whether the questionnaire was answered immediately or whether it was delayed) was not significant ($F < 1$). The Response Accuracy × Type of Information

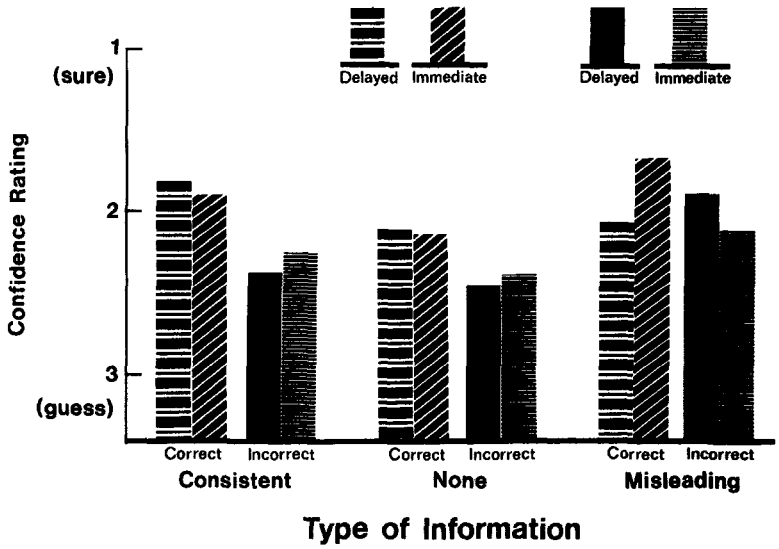

Figure 4. Mean confidence ratings as a function of type of information given, immediate versus delayed questionnaire, and correct versus incorrect responses in Experiment 3.

interaction was marginally significant, $F(2, 564) = 2.71$, $.05 < p < .10$, while the other two-way interactions were not (Fs < 1). Finally, the triple interaction reached significance, $F(2, 564) = 5.01$. It is evident from Figure 4 that a subject's confidence is boosted by being told anything, whether it is true or not. Further, delaying misleading information raises confidence in incorrect responses above the corresponding value associated with correct responses.

To summarize the major results, there appear to be two discernible consequences of exposing a subject to misleading information. First, the likelihood is lowered that a subject will correctly recognize the object previously seen. This is particularly true if the information is introduced just prior to the final test. Second, the misleading information affects a subject's confidence rating. Generally subjects are more confident of their correct responses than their incorrect ones. However, when exposed to delayed misleading information, they are less confident of their correct responses.

Experiment 4

Loftus (1975) argued that the information contained in a questionnaire influences subsequent choices because that information is integrated into an existing memorial representation and thereby causes an alteration of that representation. This view assumes that when a person sees the initial event, the items of interest are actually encoded at the time of viewing. In the context of the present stimuli, this position would hold that when a person sees a stop sign, for example, the sign gets into memory (i.e., is encoded). If a subsequent questionnaire reports that the sign was a yield sign, that information might, according to this view, enter the memory system and cause an alteration of the original representation. The subject can now be assumed to have a yield sign incorporated into his memorial representation of the event.

A question arises as to whether the stop sign actually got into memory in the first place. If it did not, then the subsequent verbal information may simply be introducing a sign where none existed. In other words, the existing memorial representation of the accident is simply supplemented. On the other hand, if the sign was encoded into memory, then the subsequent information may have caused what is functionally a transformation of the original representation. Thus, it is theoretically important

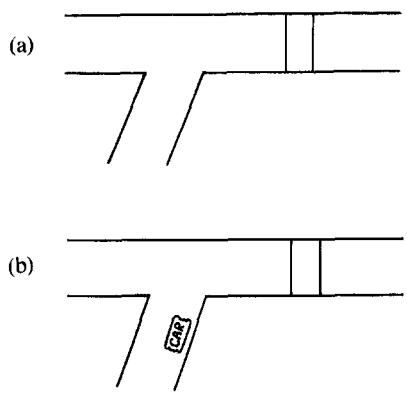

Figure 5. Diagrams used in Experiment 4.

to determine whether subjects attend to and/or encode the sign. A portion of the data from Experiment 3 suggests that people do. Notice in Figure 2 that when no information is contained in the questionnaire, subjects show some ability to discriminate the sign they saw from the one they did not, up to and including a retention interval of 1 day. For these subjects, the sign must have been encoded, otherwise performance would have been at chance level. Experiment 4 was designed to provide a further test of whether subjects encoded the sign they saw in the acquisition series.

Method

Ninety subjects were shown the same series of slides described above, each slide for approximately 3 sec. Following the series, they were given a sheet of paper with a diagram on it similar to that shown in either Figure 5a or 5b. Forty-five subjects received Diagram 5a, and 45 received 5b. The instructions were to fill in as many details as could be remembered.

The reason for using two versions of the diagram stems from an observation made during a pilot study. Recall that the slides depict a red Datsun traveling along a side street toward an intersection. From there the car turns right and knocks over a pedestrian in the crosswalk. If the diagram contains no sketch of the car (5a), the subjects tend to concentrate their attention on details at the crosswalk, which is where the accident took place. They may have seen the sign at the corner, but do not draw it, since it does not seem important to the accident. What is needed is a way to focus their attention on the intersection, and the placing of a car near the intersection as in Figure 5b appeared to be a way of accomplishing this. The experiment lasted less than 10 min.

Results

For purposes of analysis, we counted as correct the drawing made by any subject who either drew the sign he had seen or wrote its name. Over all, 45% of the subjects indicated the correct sign. Of those subjects given the outline without a car (Figure 5a), 36% correctly drew the stop sign, while 32% correctly drew the yield sign. Of those subjects given the outline with a car (Figure 5b), 60% correctly drew the stop sign, while 52% correctly drew the yield sign. An analysis of variance of the arc sine transformed proportions indicated that more subjects depicted a sign when a car was used to direct their attention to the intersection (Figure 5b) than when the diagram contained no car (5a), $F(1, \infty) = 19.94$, $MS_e = .01$. Whether the subject had actually seen a stop sign or a yield sign did not significantly affect the likelihood of drawing the correct sign, $F(1, \infty) = 1.51$, $MS_e = .01$, $p < .20$. The interaction also failed to reach significance ($F < 1$). Three of the 50 subjects who saw a yield sign incorrectly drew a stop sign in their diagram; none of the "stop sign" subjects drew a yield sign.

The results indicate that when subjects view the particular series of slides used throughout these experiments, at least half of them (and perhaps more) do encode the correct sign. The data from subjects given Diagram 5b (with a car to focus their attention on the intersection) indicate that over half have encoded the sign to the point of including it in their diagrams. Others may also have encoded it, but this was not revealed by the present procedure.

Experiment 5

The purpose of Experiment 5 was to demonstrate the generality of our studies beyond the single-stimulus pair used in the previous studies.

Method

A new series of 20 color slides depicting an auto–pedestrian accident was shown to 80 subjects. A

male pedestrian is seen carrying some items in one hand and munching on an apple held with the other. He leaves a building and strolls toward a parking lot. In the lot, a maroon Triumph backs out of a parking space and hits the pedestrian.

Four of the 20 slides were critical. One version of each critical slide contained a particular object (such as a pair of skis leaning against a tree), while the other version contained the identical slide with a changed detail (a shovel leaning against a tree). Each subject saw only one version of the critical slides, and each critical slide was seen equally often across subjects.

Following the slides, which had been seen at a 3-sec rate, subjects completed a 10-min unrelated filler activity. Then they read a three-paragraph description of the slide series supposedly written by another individual who had been given much more time to view the slides. The description contained four critical sentences that either did or did not mention the incorrect critical object. For example, if the subject had seen skis leaning against a tree, his statement might include a sentence that mentioned "the shovel leaning against the tree." The statements were designed so that the mention or nonmention of a critical incorrect detail was counterbalanced over subjects for the four critical items.

After an interval of 10 min, subjects were given a forced-choice recognition test. Using two slide projectors, 10 pairs of slides were presented. The 4 critical pairs were randomly intermixed with the remaining filler pairs. One member of each pair had been seen before, whereas the other had not. The slides that the subject had actually seen varied in the left and right positions.

Results

The percentage of times a correct selection occurred was 55.3 when the intervening statement contained misleading information and 70.8 when it contained no information. For purposes of analysis, two proportions were calculated for each of the 4 critical slide pairs. One was the proportion of correct selections when misleading information had intervened, and the other, when no information had intervened. A t test for related measures indicated that the mean percentages (given above) were statistically different from each other, $t(3) = 9.34$, $SE_{\text{diff}} = 1.66$.

Discussion

The analysis of Experiment 5 permits us to generalize our findings beyond the single stop-sign–yield-sign stimulus pair. In the present experiment, subjects who saw a slide containing a particular detail, A, but who were given the information that the slide contained Detail B, were subsequently more likely than control subjects to select on a forced-choice recognition test a slide containing B rather than a slide with A.

Note that even with misleading information, subjects were correct about 55% of the time, a figure that is much higher than the approximately 42% figure obtained with the stop–yield stimuli in Experiment 3 after a comparable retention interval. There is probably good reason for this. Any particular object, such as a shovel, can assume many forms. The particular shovel that any subject imagines while reading the story may not agree with the version shown during the recognition test. A subject can then successfully reject the slide containing the shovel, not because he or she recognizes the other slide (containing the skis) but because of not having seen the particular shovel presented during the recognition test.

With common traffic signs, this would not tend to happen. If a subject imagines a stop sign while answering a question that mentions a stop sign, the imagined sign will certainly match the stop sign that would be presented during the recognition test.

General Discussion

When a person witnesses an important event, he or she is often exposed to related information some time afterward. The purpose of the present experiments was to investigate how the subsequent information influences memory for the original event.

In the pilot experiment, subjects saw a series of slides depicting an accident, and afterwards they were exposed to a questionnaire that contained either consistent or misleading information about a particular aspect of the accident. The misleading information caused less accurate responding on a subsequent yes–no recognition test. Similarly, in Experiment 1, misleading information resulted in poorer performance

on a forced-choice recognition test. For example, in one condition, subjects saw a stop sign but a subsequent question suggested it was actually a yield sign. Some time later they were given a forced-choice test and asked to choose the sign they thought they had seen. Over half of these subjects incorrectly chose the yield sign.

It has been suggested that the reason this happens is that when the misleading information is presented, it is introduced into the memorial representation for the accident and causes an alteration of that representation. Another interpretation is that subjects are simply agreeing with the information contained in their questionnaires, even though they actually remember what they saw. This is a demand-characteristics explanation. Experiment 2 showed that when subjects were told that they might have been exposed to misleading information and were asked to state whether they thought they had, most of them persisted in claiming that they had seen the incorrect item.

A second interpretation of the forced-choice results is that the original sign information may not have been encoded in the first place. If it had not been encoded, then the subsequent question may have introduced a sign where none existed. In other words, the phenomenon may be one of supplementation. On the other hand, if the sign got into the original memory (i.e., was encoded), then the subsequent information caused either an alteration in the original representation or the creation of a new, stronger representation that competed with the original representation. Experiment 4 showed that at least half of the subjects encoded the initial sign to the point where it was included in a drawing they made of the incident.

The paradigm used throughout this research involves two critical time intervals: the time between the initial event and the presentation of subsequent information and the final test for recollection of the event. In Experiment 3, these intervals were examined. Subjects received their final test after a retention interval of 0 min, 20 min, 1 day, 2 days, or 1 week. The subsequent information was introduced either immediately after the initial event or just prior to the final test. The usual retention-interval results were observed: poorer performance after long intervals than after short ones. Of major interest was the finding that misleading information had a larger impact if presented just prior to a recognition test rather than just after the initial event.

We have noted two interpretations for our results, namely that either the subsequent information alters the original memory or both the original and the new information reside in memory, and the new competes with the old. Unfortunately, this extremely important issue cannot be resolved with the present data. Those who wish to maintain that the new information produces an alteration cannot prove that the earlier information will not one day spontaneously reappear. Those who wish to hold that new and old information both exist in memory will argue that a person who responds on the basis of new information alone does so because the proper retrieval cue or the right technique has not been used. The value of the present data lies in the fact that they clear up a number of alternative explanations for previously published phenomena. Furthermore, they indicate something about the conditions under which new information is more or less likely to affect accuracy.

The present work bears some resemblance to earlier work on the influence of verbal labels on memory for visually presented form stimuli. Much of the earlier work was designed to test the Gestalt hypothesis that progressive memory changes in the direction of a "better" figure occur autonomously. Riley (1962), in an excellent review of that earlier literature, concluded that the hypothesis of autonomous change is probably not testable. Despite this drawback, the work on verbal labels was useful in revealing that reproductions and recognition memory (Carmichael, Hogan, & Walter, 1932; Daniel, 1972) of simple forms were affected by the labels applied to those forms. The present work represents a much needed extension in that it reveals

that these effects occur not only with artificial forms but also with highly naturalistic scenes under conditions that have a high degree of ecological validity. Further, the present work convincingly demonstrates both the integration of information from more than one source into memory and the use of that information to reconstruct a "memory" that was never actually experienced.

Reference Note

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