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Creating false memories for visual scenes

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Abstract—Creating false memories has become an important tool to investigate the processes underlying true memories. In the course of investigating the constructive and/or reconstructive processes underlying the formation of false memories, it has become clear that paradigms are needed that can create false memories reliably in a variety of laboratory settings. In particular, neuroimaging techniques present certain constraints in terms of subject response and timing of stimuli that a false memory paradigm needs to comply with. We have developed a picture paradigm which results in the false recognition of items of a scene which did not occur almost as often as the true recognition of items that did occur. It uses a single presentation of pictures with thematic, stereotypical scenes (e.g. a beach scene). Some of the exemplars from the scene were removed (e.g. a beach ball) and used as lures during an auditory recognition test. Subjects' performance on this paradigm was compared with their performance on the word paradigm reintroduced by Roediger and McDermott [18]. The word paradigm has been useful in creating false memories in several neuroimaging studies [13, 21] because of the high frequency of false recognition for critical lures (words not presented but closely associated with lists of words that were presented) and the strong subjective sense of remembering accompanying these false recognitions. However, it has several limitations including small numbers of lures and a particular source confusion. The picture paradigm avoids these limitations and produces identical effects on normal subjects.

Key Words: false recognition; memory illusion; neuroimaging; schema.

Memory illusions and distortions have been studied since at least the time of Bartlett [2]. Recently, though, there has been renewed interest in the phenomenon of "false memory" and its implication in clinical, legal and laboratory settings. This interest has prompted several researchers to investigate the neural mechanisms underlying illusory memories [7, 13, 20, 21]. It is hoped that by elucidating the processes underlying the formation of false memories, a better understanding of the mechanisms involved in true memories can be achieved.

In two of the first studies to implicate neural mechanisms of false memory, lateralized recognition tests presented to a callosotomy patient demonstrated that the left hemisphere is more prone to false recognition of semantically related lures than the right hemisphere [12, 15]. More recent functional neuroimaging studies have revealed stronger activation in the dorsolateral prefrontal cortex for false memories than for "true" memories [13] and activation in the left medial temporal lobe for both true and false memories [21]. Furthermore, converging evidence for the involvement of the medial temporal lobes in the formation of false memories is provided from studies of amnesic patients [22].

With the advent of investigations into the neural mechanisms of false memory using various brain imaging techniques, there is a need to develop paradigms that can reliably create false memories in a laboratory setting. The paradigms need to be able to generate numerous false memories since many neuroimaging techniques rely on data that is averaged across many trials. To date, neuroimaging studies have relied on the use of a word-list paradigm first introduced by Deese [5] and then re-introduced by Roediger and McDermott [18]. In this paradigm subjects hear 16 word lists, each of which consists of close semantic associates of a *critical lure*, which is not presented in the list. For example, a list may include words such as "bed", "rest", "tired", and so forth, which are all associates of "sleep". Subjects typically report recognizing the critical lures almost as frequently as they recognize studied words. Furthermore, when they are probed for the recollection of the studied lists, subjects often report that they can consciously remember the critical lures being presented during the study session.

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Although, further studies on the qualitative characteristics of these "remembered" responses have shown that subjects report fewer auditory details about the critical lures than about the studied items. This suggest that the subjects tend to make false inferences about the occurrence of an item based on associations formed during the study session [11, 14].

There are several limitations to the word paradigm. One is that it takes many studied words to create a relatively small number of critical lures. Often, researchers will try to circumvent this problem by removing some of the words from the study lists and use more lists [7]. However, removing words from the study list also decreases the overall associative strength of the list and decreases the false recognition rate of the critical lures [17]. Another limitation in the word paradigm is that the false memory created by the word design could be attributed to a particular source confusion [7]. When subjects are encoding a list of words such as "bed", "rest", "awake", they may also be generating the associated word "sleep" as a mnemonic device, or even incidentally. When attempting to retrieve these items, they may be confused as to whether "sleep" was generated or perceived. A further limitation in the use of word lists is that they are less natural than pictures of everyday scenes and therefore may not be as generalizable to other situations. Other paradigms need to be created that effectively produce false memories and are practical to study in a variety of laboratory settings.

In this article we report a picture paradigm that overcomes these limitations. Our study uses pictures of scenes taken from illustrations of *The Saturday Evening Post*, which depict strong thematic, stereotypical scenes (e.g. a classroom, a beach scene). The pictures are manipulated so that some of the exemplars from the scene are removed (e.g. a teacher's chair and a chalkboard for the picture of a classroom, or a beach ball and beach umbrellas for the picture of the beach scene). Subjects are asked to study the pictures with the missing exemplars. These missing exemplars will later serve as critical lures. Our hypothesis is that subjects will report seeing the critical lures almost as often as the studied items.

This paradigm is unique with respect to other picture paradigms used to study memory illusions (e.g. [9, 15]) in that it only requires a single presentation of each picture to produce a number of critical lures. It also does not require suggestive or misleading information prior to testing [10], or repeated interrogations before an elaborate false recall occurs [4]. This picture paradigm also avoids the problems of the word paradigm mentioned earlier.

In this experiment, subjects were tested on both the picture paradigm we developed and the word paradigm used by Roediger and McDermott [18]. In testing both paradigms in one session, we can determine whether there will be any differences between the two tests across subjects. To facilitate this comparison, we switched the modalities originally used in the presentations of the word paradigm by Roediger and McDermott. Therefore, in both the picture and the word paradigms, the study session was presented visually and the test session was presented auditorily. However, we were concerned about the effects of switching the modalities on the word paradigm, so we pretested a separate group of subjects on the words using an auditory study and a visual test and found no effect of modality on false recognition rate.[1]

When subjects were shown either the pictures or the words, they were instructed to remember as much as they could about them. After an interval of distracter tasks, they were given a recognition test consisting of the studied items, critical lures and non-studied items unrelated to the pictures or word lists. We were also interested in their phenomenological awareness of their recollections. We used a procedure developed by Tulving [24] which assesses the subject's state of awareness about their recollection by using a "remember" vs "know" judgment. Subjects were instructed to respond "remember" when they were able to consciously recollect details or aspects of an event. They were instructed to respond "know" when they were confident that an event occurred but they were unable to consciously recollect details or aspects of the event. What distinguishes a false memory from a false feeling of knowing, is that a subject who experiences a false memory will consciously recollect details of an event that never happened. We predicted that subjects remember judgments for the critical lures in the picture paradigm would be similar to their remember judgments in the word paradigm.

Methods

Subjects

Forty-seven subjects were paid for their participation. Their ages ranged from 18–25 years old. Fifteen out of the 47 subjects were males. All of the participants signed consent forms and they were informed of their rights as experimental subjects.

Materials (pictures)

We used 18 color illustrations from The Saturday Evening Post which depict strong thematic, stereotypical scenes (e.g. a beach scene). Four exemplars from each scene which were

[1] A separate group of 23 subjects were tested on the word paradigm using the same procedures described in this report, except that the study session was an auditory presentation and the test session was a visual presentation, identical to the Roediger and McDermott design. During the study session, subjects were read the word lists at the rate of 1 word every 2 s. During the test session, subjects saw a word presented on a computer screen, and they were to write their response on an answer sheet. Results from this testing was compared with the results of the experiment reported here, using linear regression. There was no significant effect for the mode of presentation

closely associated to the schema of the scene were identified[2] (e.g. a beach ball). The Appendix contains a complete list of scenes and exemplars used for this test (Fig. 1). One group of pictures was created by removing two of these exemplars from each scene and a second group was created by removing the other two exemplars. All manipulations of the pictures were done using Adobe Photoshop. The 18 sets of pictures were divided into 3 experimental groupings of 6 pictures each. During a study session 12 pictures, or 2 groupings, were presented to the subject. Each picture contained 2 of the identified exemplars (studied items) and was missing the other two exemplars (critical lures). The 4 exemplars from the other 6 pictures not shown to the subject were used as non-studied items. Therefore, the recognition test contained 24 studied items, 24 critical lures and 24 non-studied items. All test items, and pictures were counterbalanced across testing groups (3–5 subjects each).

Materials (words)

The same 24 lists of 15 words from the Roediger and McDermott [18] study were used in this study. The word lists were compiled from associates of a target word based on Russell and Jenkins norms [19]. The order of the lists was held constant with the strongest associate appearing first and the weakest associate last. The 24 lists were divided into 3 experimental groupings of 8 lists each. During the study session, 16 lists of 15 words, or 2 groupings, were shown to the subject. Each list of words (e.g. bed, rest, awake, tired, etc.) was closely associated with a critical lure that was not presented (e.g. sleep). Eight other list of words were not presented to the subjects and two of the words from each of these lists were used as non-studied items. These include the target word of each list and the word in the eighth position in each list. Two words from each of the presented lists were used as studied items. These include the words from the first and eighth positions of each list. Therefore, the recognition test included 32 studied items, 16 critical lures and 16 non-studied items. The lists of words were counterbalanced across the subjects. However, unlike the pictures, individual items could not be counterbalanced since the lists of words were constructed from associates of the target words. For this reason, effects due to word frequency, imageability, etc., could not be accounted for (as they could not be in the original study by Roediger and McDermott [18].)

Procedure

Subjects were tested in groups of 3–5 per session. Each session lasted between 90 min and 2 h, and included both the picture paradigm and the word paradigm. The study and test portions of a particular paradigm were completed before moving on to the next paradigm, with a 5 min break in between. The full procedure for the picture paradigm lasted for 45–50 min, including study, test and the interval between study and test. Half the subjects participated in the picture paradigm first and the other half participated in the word paradigm first.

Pictures Subjects were instructed that they would see 12 pictures presented on a computer screen. They were told that each picture was of a particular scene and that their task was to remember as much as they could about each picture. During the study session pictures were presented centrally on a computer screen for 10 s each. There was a 5 s interval between each picture during which time the subjects would see a countdown on the screen from 5 to 1. The subjects were instructed not to make any notes or comments during the presentation. There was a 30 min interval between the study and test sessions during which the subjects were engaged in fluency tasks (e.g. name as many state capitals as possible) and perceptual tasks in order to distract them from rehearsing the pictures.

After the 30 min interval†, an auditory recognition test was administered to the subjects. During the test, the experimenter read aloud the 72 items noted earlier. The subjects were instructed that some of the items would be items contained in the pictures that they saw and some of the items would not be items contained in the pictures. The subjects were to respond to each item read aloud by writing down either ''yes'' they recognized the item from the study session or ''no'' they do not recognized the item from the study session on an answer sheet. Furthermore, if they wrote down ''yes'' they were asked to make a further judgment as to whether they ''remember'' the item occurring or they ''know'' the item occurred. Subjects were given detailed instructions on making ''remember/know'' judgments using the instructions given in Rajaram [16].

Words Subjects were instructed that they would see 240 words presented on the computer screen one at a time. They were told that their task was to remember as many of the words as they could. During the study session words were presented centrally on a computer screen for 1 s each with a 1 s interval between each word. After 15 words from a particular list was presented, there was a 5 s interval before the next list of words during which time the subject saw a countdown from 5 to 1. The words were presented in the same order as the Roediger and McDermott [18] study with the highest associates first. The subjects were instructed not to make any notes or comments during the presentation. There was a 10 min interval between the study and test sessions during which the subjects were engaged in fluency tasks again.

After the 10 min interval, an auditory recognition test was administered using the same procedure as the pictures. In this case, there were 64 words read aloud as noted earlier. Again, the subjects were instructed that some of the words would be words from the study session and some would be words not from the study session. They were to write down either ''yes'' they recognized the word or ''no'' they do not recognize the word. Furthermore, if they wrote down ''yes'' they were to-make a further ''remember/know'' judgment. If this test was the second test given to the subjects they were only referred to

[2] Pretesting was done to select exemplars and to choose phrasing of the test items. Exemplars for each scene were chosen on the basis of how associated to the schema of the picture they seemed to be. During several pilot studies some exemplars were dropped in lieu of other exemplars due to their extremely low recognition rate as either a studied item or as a critical lure. In some cases items not in the original picture were graphically added to the scene if no other exemplars could be identified (e.g. slices of watermelon in a picnic scene). It was clear that in the final version some of the exemplars would make for better lures than other items, but we were not concerned with this effect since the items were counterbalanced. Similarly, the phrasing of the items in the auditory recognition test was important. The item ''ball'' did not have the same effect either as a studied item or as a critical lure as ''beach ball'' did because of the adjective ''beach''. The term ''ball'' could be an exemplar of many different schemas other than beach. Indeed, we also used a football, a baseball and a golf ball. As for other variations in phrasing, they seem to make little difference during the pilot studies. For example, there was-no difference between ''apples on the teacher's desk'' vs ''apples for the teacher'' or ''erasers on a chalkboard'' vs ''chalkboard erasers''.

† In order to save time for the entire session, the interval between study session and test session for the word paradigm was cut down from 30 to 10 min. Pretesting revealed that there was no difference between the two intervals as long as there were distracter tasks during the intervals.

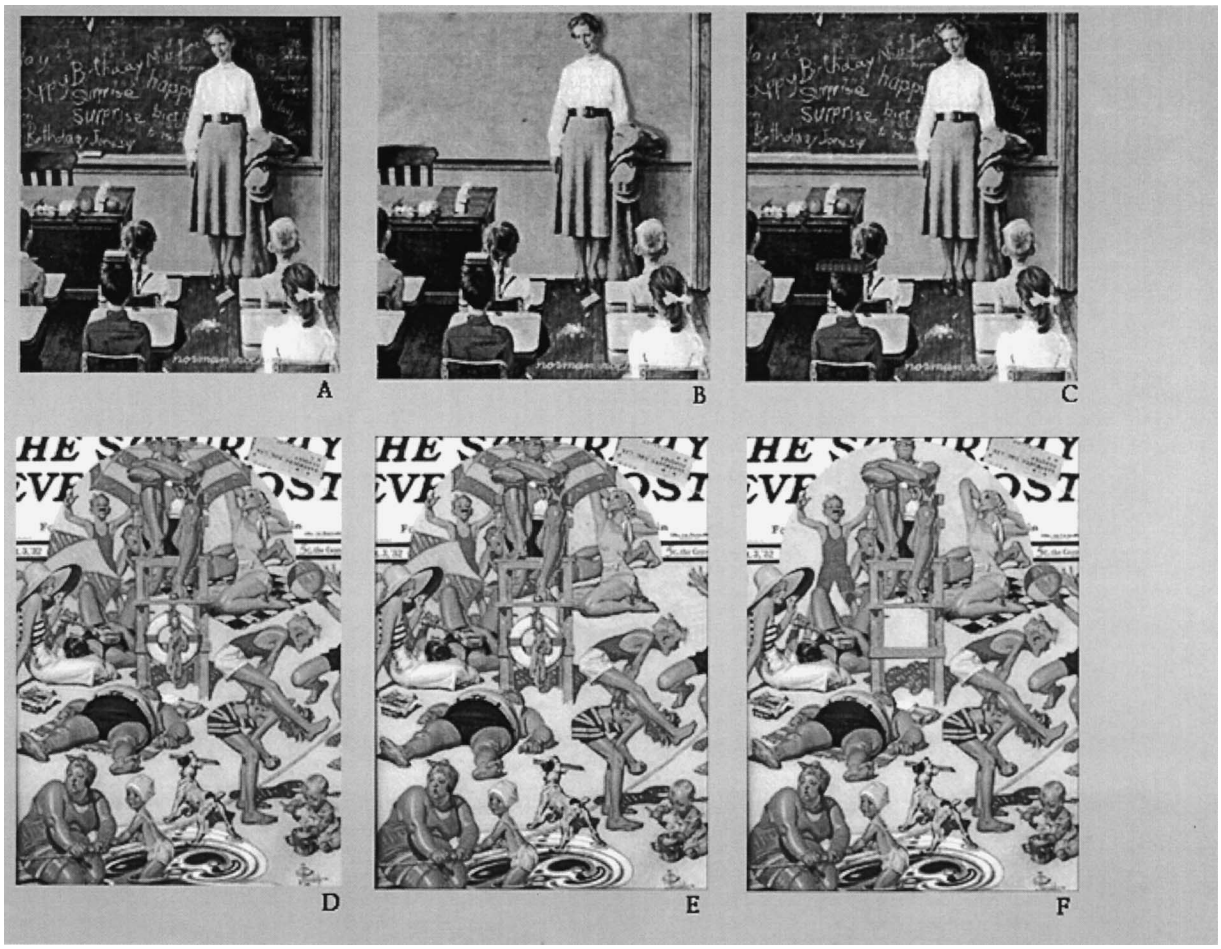

Fig. 1. Pictures A and D are achromatic versions of the thematic illustrations which contain all 4 exemplars (see the Appendix for a full listing of the pictures). Pictures B, C, E, and F are achromatic examples of the color pictures that the subjects studied in the experiment. Each picture had 2 of the exemplars removed which served as the critical lures. The 2 remaining exemplars were used as studied items. Exemplars from pictures not shown to the subject were used as non-studied items. The missing exemplars for the pictures shown above include: B, chalkboard, apples on the teacher's desk; C, teacher's chair, chalkboard erasers; E, beach ball, beach blankets; F, beach umbrellas, lifeguard's life preserver.

the previous detailed instructions on making the "remember/know" judgments.

Results

The results from the recognition test on the picture paradigm, were analysed using a repeated measures ANOVA with item category as the within subjects factor. Item category included critical lures, studied items, and non-studied items. The results are presented in Fig. 2 showing that subjects' "yes" response to the critical lures (50%) was much closer to the studied items (64%) than the subjects' "yes" response to the non-studied items (9%). An ANOVA indicated a significant main effect for item category ($F(2,92) = 274.29$, $MS_e = 0.014$, $P < 0.001$). A planned comparison between studied items and critical lures was significant ($F(1,46) = 30.3$, $MS_e = 0.015$, $P < 0.001$), as was a planned comparison between critical lures and non-studied items ($F(1,46) = 283.07$, $MS_e = 0.014$, $P < 0.001$).

Results from the recognition test on the word paradigm were analysed in the same manner as the picture paradigm and showed a very similar pattern (Fig. 2). Subjects' "yes" response to the critical lures was 51% and to the studied items was 69%, while their response to the non-studied items was only 12%. An ANOVA indicated a significant main effect for item category ($F(2,92) = 156.24$, $MS_e = 0.025$, $P < 0.001$). Again, a planned comparison between studied items and critical lures was significant ($F(1,46) = 26.1$, $MS_e = 0.030$, $P < 0.001$), as was a planned comparison between critical lures and non-studied items ($F(1,46) = 104.09$, $MS_e = 0.033$, $P < 0.001$).

Even though there was a significant difference between the studied items and critical lures for both tests, the subject's response to the critical lures in both cases was much closer to the studied items than to the non-studied items. The similarity between the two tests was striking. An ANOVA revealed no significant difference between the picture paradigm and the word paradigm ($F(1,46) = 1.91$, $MS_e = .023$, Ns). To discount any order

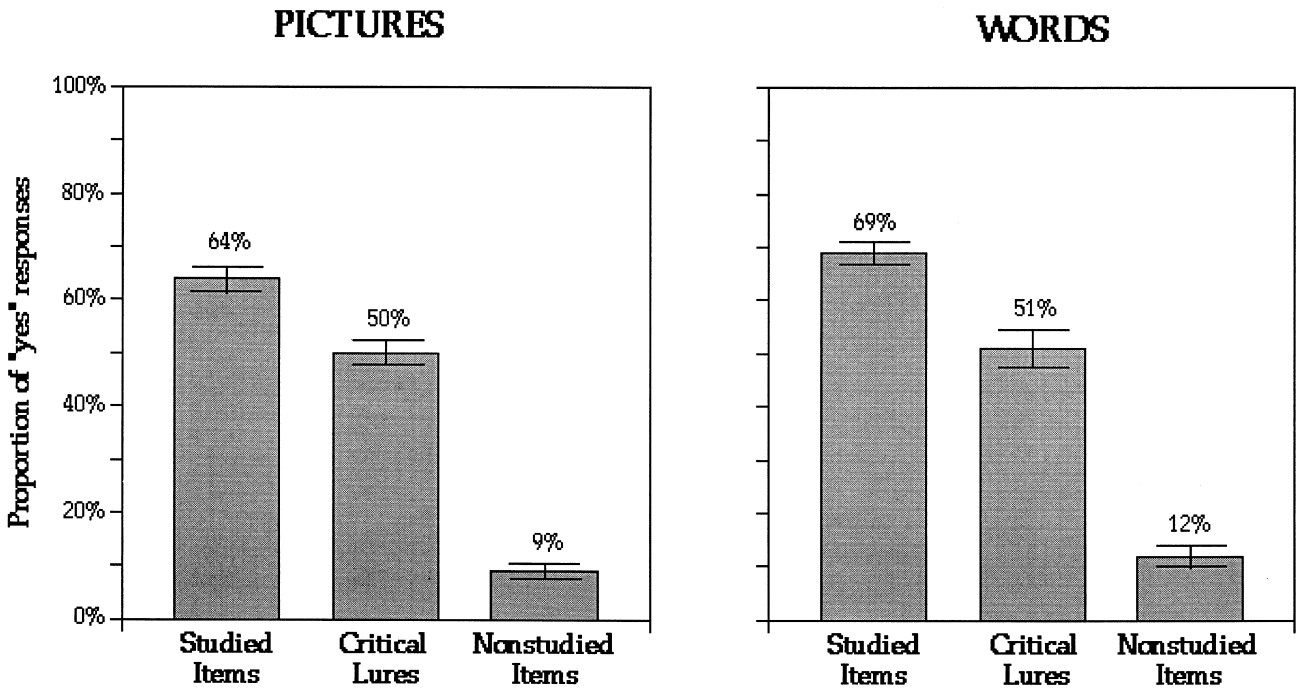

Fig. 2. Comparison of the recognition rates between the picture paradigm and the word paradigm. Each bar represents the proportion of "yes" responses to whether they recognized the item from the study session. There was no significant difference between the two paradigms. Error bars represent the standard error of the mean.

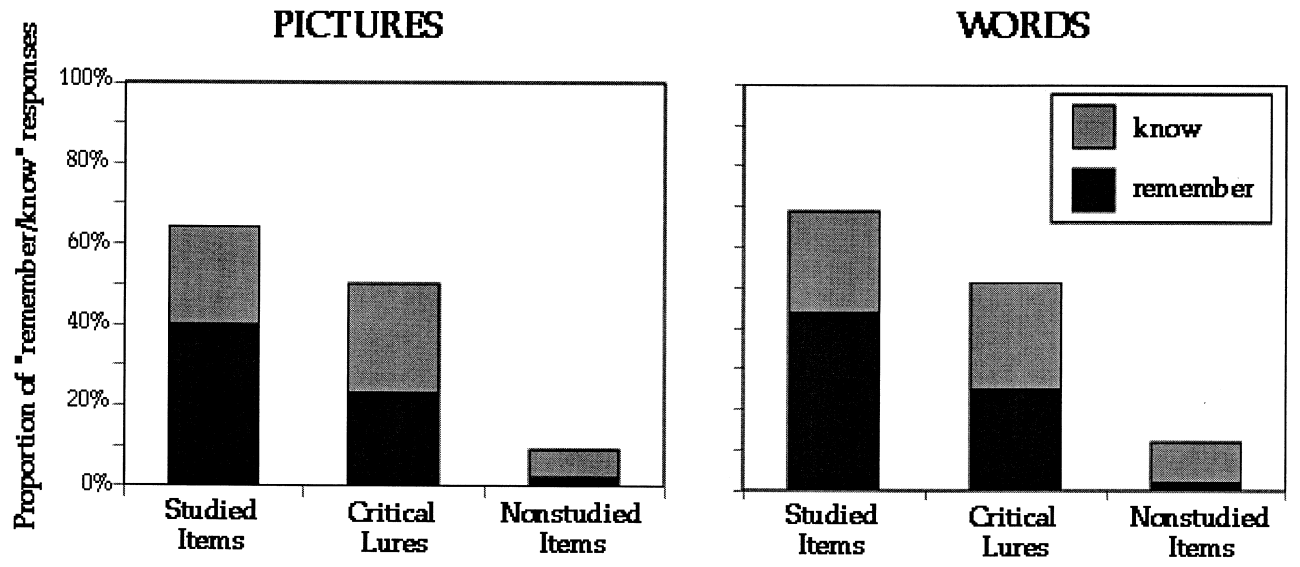

Fig. 3. Comparison of the "remember/know" judgments between the picture paradigm and the word paradigm. Each bar represents the proportion of "remember" and "know" judgments for the "yes" responses in the recognition test. As with the recognition rates, there was no significant difference between the two paradigms.

effects we also separated the data by the order in which the paradigms were presented. A between-subjects ANOVA revealed no significant difference for order ($F(1,46) = .429$, $MS_e = .024$, Ns).

As for "remember/know" judgments, subjects reported in the picture paradigm for the critical lures a "remember" response to 46% of the "yes" responses, or 23% of all responses, while they reported for the non-studied items a "remember" response to 11% of the "yes" responses, or 1% of all responses. Their report of a "remember" judgment to the studied items was 63% of the "yes" responses, or 40% of all responses. An ANOVA indicated a significant main effect for item category ($F(2,92) = 173.6$, $MS_e = 0.01$, $P < 0.001$). As for the word paradigm, subject's reported for the critical lures a "remember" response to 49% of the "yes" responses, or 25% of all responses, while they reported for the non-studied items a "remember" response to 17% of the "yes"

responses, or 2% of all responses. Their report of a "remember" judgment to the studied items was 64% of the "yes" responses, or 44% of all responses. Again, an ANOVA indicated a significant main effect for item category ($F(2,92) = 118.61$, $MS_e = 0.018$, $P < 0.001$). As with the recognition rates, the similarity between the picture paradigm and the word paradigm for the absolute "remember" judgment was striking. An ANOVA revealed no significant difference between the two paradigms ($F(1,46) = 2.36$, $MS_e = 0.014$, ns).[3]

Discussion

These results confirm our hypothesis that subjects would report seeing the critical lures almost as often as the studied items in the picture paradigm. This false memory effect is further confirmed by the high proportion of "remember" responses to the critical lures—subjects reported a conscious recollection that an item occurred when it had not been presented. Furthermore, we have demonstrated that the picture paradigm has proven to be as effective as the word paradigm in creating false memories. When subjects are given both the word test and the picture test, the results reveal no difference between the two tests in both recognition rate and "remember" judgments. However, the fact that both tests showed similar performance in this study does not imply that the two tests necessarily involve identical memory processes. For example, it may be possible that the false memory generated in the word paradigm could result from a constructive process during encoding whereas the false memory generated in the picture paradigm could result from a reconstructive process during retrieval. Further studies will need to be conducted to investigate possible differences in the false memories generated by these two paradigms.

The picture paradigm could be an important tool in neuroimaging studies and studies on brain damaged patients investigating neural mechanisms underlying false memories versus true memories. Previous studies have relied on the use of the word paradigm to show neural activations during the retrieval of critical lures versus the retrieval of studied items [7, 13, 20, 21]. This picture paradigm can now be used in similar studies to corroborate sites of neural activation being attributed to false memories.

This picture paradigm has several advantages over the word paradigm. One, the picture paradigm requires only a single presentation to create a number of critical lures whereas the word paradigm requires a list of words to create a single critical lure. Therefore, many more lures can be created for use in these neuroimaging studies. This would be a benefit in averaging data across many trials and in making more direct comparisons between types of items and baseline conditions. Two, the words used as lures have a different word frequency and imageability ranking than the words used as studied items. Since the studied words are constructed from associates of the lure word, there is no way to counterbalance these items. The items in the picture paradigm, however, can be counterbalanced, so their effects cannot be attributed to some characteristics of the items. Third, the effects of the word paradigm could be attributed to a particular source confusion [7, 8]. For example, when subjects see lists of words such as bed, rest, awake, they may also be generating the word sleep, either incidentally or as a mnemonic strategy. When asked if they recognize the word in a test. they could confuse the source of their recollection. Often subjects would report after the testing was complete that they consciously tried to remember the categories of the word lists as a strategy. During the test, the subject would recall that the word they were being asked about was actually one of the categories, but they would become confused as to which. words were categories and which words were actually studied items. However, this was not a strategy or confusion they reported for the picture paradigm. The picture paradigm avoids this particular source confusion since the lure itself is only a feature of the event and the subjects are not generating a picture based on a series of events.

To further illustrate this point, consider the difference between associations and categories. If you ask a person to say the first word that comes to mind when you say "table", it is likely they will say "chair". It is even more likely if you also say the words "sit", "stool" and "seat". However, if you say a word which represents a category like "furniture", it is relatively unlikely they will say "chair". The person may think of all sorts of items including sofa, bed, furniture in a dollhouse, etc. The paradigm using schematic visual scenes induces this kind of categorical processing, making it improbable that the subject would freely generate the missing exemplar. It could still be argued that subjects will generate the missing exemplar to some extent, but it is unlikely given the short time period of the study session. Whereas the word paradigm is highly associative and it is very likely that the subject generated the item during encoding.

The results of this experiment demonstrate the powerful influence of inferences and perspectives on the retrieval of an event. In studies of split-brain patients, Gazzaniga [6] has demonstrated the influence of interpretations and inferences on cognitive actions by showing how the left hemisphere will often make up a rational, plausible explanation for the covert behavior of

[3] One notable difference between the picture paradigm and the word paradigm was the subject's prior knowledge of the word test. Due to recent media exposure of the false memory word test and its use as a classroom demonstration, 12 out of the 47 subjects were familiar with the test and particular lures that were being used. This had a significant impact on the word performance, the "yes" recognition rate for the critical lures climbed from 51 to 61% when these subjects were removed, whereas on the picture performance it only climbed from 50 to 52% when the same subjects were removed.

the right hemisphere. In the picture paradigm presented in this study, the influence on memory could be coming from the subject's schema of the picture. A schema is a common concept or representation defined by a configuration of features [1]. When subjects are trying to retrieve details of an event (items in the picture) they rely on the schema of the event and integrate expectancies from those schemas with stored perceptual details that actually occurred. Often, the conscious recollection of those details that did not occur are just as vivid as the recollection of details that did occur. A classic experiment on the role of schemata in memory was conducted by Brewer and Treyens [3] in which subjects who had waited in a "graduate student's office" were later tested on their memory for objects in that office. Often the subjects would report they saw books in the office even though there were none, since that is what one would expect to see in a graduate student's office. Even on a more perceptual level, subjects' immediate memory for details of a scene are fallible compared to the schema or gist of a scene. Simons [23] has demonstrated that when an object's identity is changed during an eye movement, the subject is often unaware of any change to the scene. As the experiment in the study presented here has shown, memory is not immune to this process of the integration of interpretations, schema expectancies, and elements of episodic memory. This picture paradigm provides a valuable technique for investigating the neural basis of these processes.

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References

1. Anderson, J. R., *The architecture of cognition*. Harvard University Press, Cambridge, MA, 1983.
2. Bartlett, F., *Remembering*: *A study in experimental and social psychology*. Cambridge University Press, Cambridge, England, 1932.
3. Brewer, W. F. and Treyens, J. C., Role of schemata in memory for places. *Cognitive Psychology*, 1981, **13,** 207–230.
4. Ceci, S. J., Loftus, E. F., Leichtman, M. D. and Bruck, M., The possible role of source misattributions in the creation of false beliefs among preschoolers. *International Journal of Clinical & Experimental Hypnosis*, 1994, **42,** 304–320.
5. Deese, J., On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, 1959, **58,** 17–22.
6. Gazzaniga, M. S., Organization of the human brain. *Science*, 1989, **245,** 947–952.
7. Johnson, M. K., Nolde, S. F., Mather, M., Kounios, J., Schacter, D. L. and Curran, T., The similarity of brain activity associated with true and false recognition memory depends on test format. *Psychological Science*, in press.
8. Koustaal, W. and Schacter, D. L., Gist-based false recognition of pictures in older and younger adults. *Journal of Memory and Language*, in press.
9. Loftus, E. F., Miller, D. G. and Burns, H. J., Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology*: *Human Learning and Memory*, 1978, **4,** 19–31.
10. Loftus, E. F. and Pickrell, J. E., The formation of false memories. *Psychiatric Annals*, 1995, **25,** 720–725.
11. Mather, M., Henkel, L. A. and Johnson, M. K., Evaluating characteristics of false memories: remember/know judgments and memory characteristics questionnaire compared. *Memory and Cognition*, in press.
12. Metcalfe, J., Funnell, M. and Gazzaniga, M. S. Right-hemisphere memory superiority: Studies of a split-brain patient. *Psychological Science*, 1995, **6,** 157–164.
13. Miller, M. B., Buonocore, M., Wessinger, C. M., Tulving, E., Robertson, L. C. and Gazzaniga, M. S. Remembering false events rather than true events produces dynamic changes in underlying neural circuitry: a fMRI study. *Abstract for the Society for Neuroscience* 26*th Annual Meeting*, Washington, D.C., 1996.
14. Norman, K. A. and Schacter, D. L., False recognition in younger and older adults: exploring the characteristics of illusory memories. *Memory and Cognition*, in press.
15. Phelps, E. A. and Gazzaniga, M. S., Hemispheric differences in mnemonic processing: the effects of left hemisphere interpretation. *Neuropsychologia*, 1992, **30,** 293–297.
16. Rajaram, S., Remembering and knowing: two means of access to the personal past. *Memory & Cognition*, 1993, **21,** 89–102.
17. Robinson, K. J. and Roediger, H. L., III. Associative processes in false recall and false recognition. *Psychological Science*, 1997, **8,** 231–237.
18. Roediger, H. L. III and McDermott, K. B., Creating false memories: remembering words not presented in lists. *Journal of Experimental Psychology*: *Learning, Memory and Cognition*, 1995, **21,** 803–814.
19. Russell, W. A. and Jenkins, J. J., The complete Minnesota norms for responses to 100 words from the Kent-Rosanoff Word Association Test. (Tech. Rep. No. 11, Contract N8 ONR 66216, Office of Naval Research). University of Minnesota, 1954.
20. Schacter, D. L., Curran, T., Galluccio, L., Milberg, W. and Bates, J., False recognition and the right frontal lobe: a case study. *Neuropsychologia*, 1996, **34,** 793–808.
21. Schacter, D. L., Reiman, E., Curran, T., Yun, L. S., Bandy, D., McDermott, K. B. and Roediger, H. L. III., Neuroanatomical correlates of veridical and illusory recognition memory: evidence from positron emission tomography. *Neuron*, 1996, **17,** 267–274.
22. Schacter, D. L., Verfaellie, M. and Pradere, D., The

neuropsychology of memory illusions: false recall and recognition in amnesic patients. *Journal of Memory and Language*, 1900, **35,** 319–334.
23. Simons, D. J., In sight, out of mind: when object representations fail. *Psychological Science*, 1996, **7,** 301–305.
24. Tulving, E., Memory and consciousness. *Canadian Psychologist*, 1985, **26,** 1–12.

Appendix

The 18 pictures, each with 4 items, used in the experiment (see Footnote #1 for the factors involved in including an item). The dates of the issues in which the illustrations appeared in The Saturday Evening Post are in parentheses.

Artist (10/8/38)
artist palette
artist paintbrushes
artist paint
easel

Barbershop (4/29/50)
barber's chair
barbers in a back room
barber's push broom
barber's electric clippers hanging on a wall

Barnyard (7/24/48)
barn door
water well with a hand pump in a barnyard
barn window
chickens in a barnyard

Beach Scene (9/3/32)
beach ball
beach blankets on the sand
beach umbrellas
lifeguard's life preserver

Baseball game (4/20/57)
baseball
catcher's mask
baseball bats
line-up card posted in a baseball dugout

Blacksmith shop (11/2/40)
blacksmith's hammer
horseshoes in a blacksmith's shop
blacksmith's anvil
blacksmith's fireplace in the wall

Classroom (3/17/56)
chalkboard
apples on the teacher's desk
teacher's chair
chalkboard erasers

Doctor (3/9/29)
stethoscope
medical books on a doctor's desk
doctor's diploma
doctor's bag

Fisherman (4/29/39)
fishing rod
fishing hooks in a fisherman's hat
pail for fishing bait
fish in the water

Football game (10/21/50)
football
fans in the distance at a football game
football helmet
yard line on a football field

Golf course (8/6/55)
sand trap on a golf course
golf ball
golf scorecard
golf bags

Grocery store (3/28/59)
grocer's cash register
grocer's produce scale
window signs in a grocery store
produce bin in a grocery store

Moon landing (Look, 1/ 10/67)
moon craters
booster rocket on a lunar module
astronaut's footstep on the moon
crescent-shaped view of earth from the moon

Newspaper office (5/25/46)
typewriter on a news reporter's desk
newspapers in an office
telephone on a news reporter's desk
errand boy in a news office

Picnic scene (8/26/33)
picnic thermos
picnic blanket on the grass
picnic basket
watermelon slices at a picnic

Pirate (9/11/09)
pirate's eye patch
bags of pirate's treasure
pirate's sword
pirate's pistol

Plumbers (6/12/51)
plumber's plunger
plumber's toolbox
plumber's notebook
plumber's pipe wrench

Wedding (6/13/53)
bridal veil
flower girl
bridal bouquet
maid of honor