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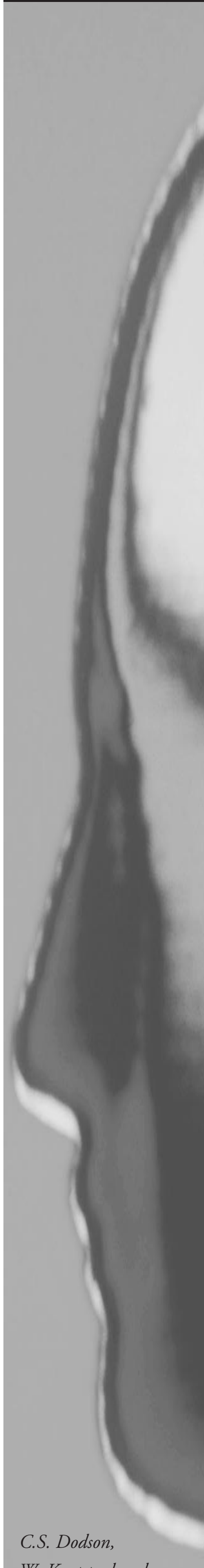

Escape from illusion: reducing false memories

Chad S. Dodson, Wilma Koutstaal and Daniel L. Schacter

Illusory memories are unsettling, but far from uncommon. Over the past several years, increasing experimental and theoretical attention has focused on misattribution errors that occur when some form of memory is present but attributed to an incorrect time, place or source. Demonstrations of errors and distortions in remembering raise a question with important theoretical and practical implications: how can memory misattributions be reduced or avoided? We consider evidence that documents the occurrence of illusory memories, particularly false recognition responses, and then review three ways in which memory distortion can be minimized.

Although memory is generally accurate, some illusions and distortions in remembering are almost unavoidable. People might accept illusory memories as true without questioning them unless (or until) they encounter contradictory evidence. Recalling his experience with the Vietnam War draft, Garry Trudeau provides an example of the durability of false memories[1]. Trudeau distinctly remembers calls of concern that he received from family and friends when they learned of his draft number. He accepted the validity of this memory for several years until he spoke with those whom he believed had commiserated with him and discovered that none of them remembered calling him. Trudeau now believes that he only imagined their concerns. In the course of examining this recollection more closely, he eventually concluded that he was, in fact, out having a few beers that night.

Memory distortions and illusions are troubling because they raise doubts about whether memory is a faithful mirror of the past. More practically, the prevalence and power of memory distortions raise an important question: how can false memories be reduced or even eliminated? We will first focus on two types of memory distortion, known as

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1364-6613/00/$ – see front matter PII: S1364-6613(00)01534-5

false recall and false recognition, and will then consider how these errors can be reduced by factors that operate primarily at encoding, retrieval or both of these stages of memory.

Creating false memories

False memories occur when people believe that they have experienced an item or event that is actually novel. A paradigm that was developed initially by Deese and recently revived and modified by Roediger and McDermott, has generated much experimental and theoretical interest because it produces very high levels of false recall and false recognition[2–4]. In the Deese/Roediger–McDermott (DRM) paradigm, individuals study lists of words (e.g. a list might consist of tired, bed, awake, rest, dream, night, blanket, doze, slumber, snore, pillow, peace, yawn and drowsy), where each word in a given list is related to a non-presented or 'lure' word (e.g. sleep). On a subsequent old–new recognition test that contains the studied words (e.g. tired, dream) and new words that are either unrelated (e.g. butter) or related (e.g. sleep) to the studied words, participants often mistakenly report that they previously studied the related new words, even claiming to 'remember' specific details about the items. In fact, the false recognition rate of the related new words is so high that it is often equivalent to, or closely approaches, the correct recognition rate for studied words[5–9].

Several recent investigations have begun to uncover the factors that contribute to this false memory effect. Several studies have shown that individuals are more likely to falsely recognize a related new word when they have studied many, rather than few, associates of the item beforehand[10–13]. For instance, Arndt and Hirshman presented participants with lists that contained either four or 16 related words (list lengths were equalized by including filler items)[10]. Recognition rates for studied words increased slightly, from 58% for lists of four related words to 61% for lists of 16 related words. By contrast, the rate of false recognition of related new words rose sharply from 41% to 67% (Ref. 12). These results suggest some potential explanations for the increase in the false recognition rate for related new words.

One potential explanation is that high false recognition rates are attributable to implicit associative responses[14]. That is, when individuals study the related words (e.g. bed, tired, etc.) they might 'think of' and spontaneously generate the new related word (i.e. sleep). The likelihood of producing this lure word might increase when many rather than few related words have been studied[15]. On the subsequent memory test, individuals might experience source confusions[16,17] regarding the origin of the lure word, mistakenly believing that they studied the lure word (i.e. that it was actually presented in the list) when in fact it was one that they generated themselves.

Another likely contributor to the high level of false recognition is the degree to which the related new word activates memory representations that are similar to it. When individuals are presented with a new related word, they might experience a strong sense of familiarity, and even feel that they can recollect studying it earlier, because the new word activates the representations (or overlapping features) of many words studied earlier. Based on this experience, individuals might report that the new word is 'old'. In addition, studying many related words might make it difficult to recollect the characteristics of specific items that have been studied, thereby forcing participants to respond on the basis of overall familiarity or the general similarity of a lure item to the memory of the studied items[8,9,18,19]. However, it is important to emphasize that false memories in the DRM paradigm are probably not driven completely by overall familiarity or similarity. This is because high levels of intrusion of the lure words are also observed during free recall[2–4] and, in recognition tests, participants frequently report that they 'remember' specific details about having studied the lure word[3,8].

Although the preceding two explanations of the increase in the false recognition rate for related new words are difficult to distinguish within the DRM paradigm, Koutstaal and Schacter[20] have provided data that are consistent with the latter explanation. After studying large numbers of pictures from various categories (e.g. cars, shoes, etc.), participants often falsely recognized new pictures from the same categories as the studied pictures. Koutstaal and Schacter[20] reasoned that it is highly improbable that participants had generated the new related pictures in the same way that they might generate the word 'sleep' when studying associated words in the DRM procedure. Instead, they attributed the false recognition of new pictures to the high degree of similarity among target items, which produces robust memory for what the related items have in common but poor memory for specific items (also see Ref. 21).

These findings suggest that source confusion errors, which involve a misattribution of internally generated events with actually presented events, do not necessarily contribute to false recognition. However, such confusions could still play a role in the DRM paradigm. Consistent with this possibility is the observation that although college students show very high levels of false recognition in the DRM paradigm, with the false recognition rate approaching that of veridical recognition, their false recognition rates in the categorized pictures paradigm are considerably lower. Implicit associative responses and resulting source confusion errors might thus exacerbate false recognition that is a result of poor item-specific memory in the DRM paradigm. Additionally, the associative 'connectedness' of the target and lure words contributes to false recall in the DRM paradigm. For example, the frequency with which each target item in the DRM lists elicits the lure word in free association can be used to predict the probability of false recall[2,22]. Such associative interconnectedness might increase the likelihood that participants will consciously generate the lure and thus increase the probability of source confusions. However, it is also possible that associative interconnectedness influences recognition performance in a less conscious manner by increasing the 'activation strength' of the lure without necessarily leading to conscious awareness of the item[23,24]. Evidence that is consistent with this possibility has been obtained from experiments where target items have been presented extremely rapidly, which presumably allows minimal extraction of item-specific information. For example, under conditions that involved the presentation of the list words at rates of 20 ms per word, participants still falsely recognized semantically related lures, even though they were unable to discriminate studied words from unrelated new words[21,25].

In the following sections, we consider the processes that have been implicated in working against the occurrence of false memories.

Encoding influences

One way in which false memories can be reduced is to enhance the encoding and subsequent recollection of source-specifying information. For instance, allowing individuals to repeatedly study and recall the related target words reduces false memory errors in the DRM paradigm. McDermott[26] presented participants with a series of related words and then asked them to recall the words, repeating this 'study and test' procedure five times. She found that false recall of the related lure word dropped from 57% for the first study–test trial to 32% for the fifth trial. By contrast, memory for studied words improved across the study–test trials. Specifically, participants recalled approximately 40% of the words on the first recall test and this increased to nearly 80% on the final recall test. Kensinger and Schacter[27] and colleagues[28,29] found a similar pattern with true and false recognition.

An improvement in true recall across trials is readily explained. True recall and recognition of the studied words probably improved with repeated study and testing because greater exposure to the studied words provided more opportunities to encode specific features of the individual words on the lists. By contrast, there are several plausible interpretations of the decrease in false recognition with repeated study and testing. One possibility is that repeated cycling through the study and test phase might have allowed participants to notice that the lure words had not been presented during the study episode. For instance, if the lure word 'sleep' had been falsely recalled or recognized on the first test, participants might have noticed during the subsequent study presentation that 'sleep' was not actually one of the studied items. Thus, participants might have 'tagged' the lure word as a non-studied item and then based their subsequent test performance on this judgment, thereby successfully rejecting the lure.

Alternatively (or in addition), the decrease in false recognition rates across the study–test trials might be a consequence of improved memory for the studied words. As repetition enriches the representations of studied items, it might simultaneously makes the new words less similar to studied items and thus more easy to reject. Interestingly, Kensinger and Schacter[27] found that although older adults show increased recognition for more studied items across study–test trials, they show no decrease in false recognition responses to the lure words (also see related work by Jacoby[30]). Although there are alternative explanations of this pattern of performance by older adults, Kensinger and Schacter[27] noted that one likely explanation involves older adults' difficulty in encoding and recollecting specific details about studied items. That is, there is an increase in general similarity or gist information across trials, which contributes to improved veridical recognition, but there is a failure to encode and/or recollect increasing amounts of item-specific information across trials, which would normally counteract the occurrence of false memories. However, the pattern of performance of older adults corresponds with studies with young adults, which show that simply improving overall memory for studied items does not reduce false memories in the DRM paradigm. Manipulations that improve true recall and recognition, such as studying words in a meaningful manner, rather than superficially, either increase or do not affect levels of false recall and recognition (Refs 4,31; see also Ref. 32). Therefore, the reduction in false memories in the DRM paradigm appears to depend on how participants encode information. Specifically, false memories seem to be reduced when participants encode and later recollect detailed, item-specific information.

We will revisit the importance of encoding item-specific information in the final section when we discuss how it enables participants to invoke a retrieval strategy to reduce false memories.

Retrieval influences

Remembering is not merely a matter of passively activating stored information. The kind and amount of information that is remembered can be influenced by several factors, including how people are prompted or oriented to examine their memory[11,33–39]. Surprisingly, several studies have demonstrated that simply changing the format of the memory query can affect the likelihood that participants will make false recognition errors.

Consider, for example, an experiment by Koutstaal *et al.*[11] in which subjects studied pictures of categorized items, such as different types of cars and cats. Participants completed a recognition test three days later that contained: (1) some of the pictures seen earlier; (2) new, related pictures (e.g. a new picture of a cat); and (3) new, unrelated pictures (single exemplars from other categories, such as a sofa). Participants who had been instructed to respond either 'old' (i.e. the picture was seen during the study phase) or 'new' (i.e. the picture was not seen earlier) often falsely recognized the new pictures, particularly when many similar (categorically related) pictures had been studied. However, false recognition rates of the categorically related new pictures were lower when participants had been oriented to respond in one of three ways to each test item, namely 'old and identical', 'new but related' or 'new and unrelated'. This reduction in false recognition errors was observed in both younger and older adults. Apparently, when people receive typical old–new instructions, they are biased to respond on the basis of overall familiarity[33,34]. By contrast, the three-part instructions might orient participants to demand more specific information about an item that would satisfy a response such as 'old and identical' to a test item. Although the new pictures on the test might appear to be familiar, especially if they are related to studied pictures, they should not evoke detailed memories (e.g. what one thought and felt upon seeing the picture at study). Therefore, a retrieval orientation that promotes a response on the basis of specific item information could serve as a mechanism for rejecting false memories.

Similar results have been found in both younger and older adults in an eyewitness testimony paradigm[34,37,38]. In this paradigm, participants typically view a sequence of slides that depict an event and then read an ostensibly accurate description of the previously viewed material. However, the description contains misleading information, such as an inaccurate characterization of an object that was presented earlier (e.g. a stop sign is referred to as a yield sign). On a final old–new recognition test, participants often respond on the basis of the misleading information, claiming to have seen items that were only read about[40]. Apparently, participants confuse the origins of their memories, mistakenly reporting that the misinformation was seen in the slides. However, individuals are better able to distinguish between objects that were seen in the slides and those that were only read about when they are given a memory test that requires them to identify the source of each test item (e.g. was it seen, read, both seen and read or is it new?)[34,37,38]. As in the Koutstaal *et al.* study[11], performance improves when the test format or response requirements encourage participants to examine memory for source information. Taken together, these studies suggest that people do not seem to recognize, of their own accord, the need to consider the source of their memory and instead appear to be biased to rely on familiarity as a default strategy.

The findings that illustrate the effects of retrieval orientation on false recognition and source attribution errors are consistent with both the source monitoring framework (SMF) of Johnson and colleagues[16,17] and the constructive memory framework (CMF) of Schacter and colleagues[41]. According to the SMF, the characteristics of memories from different sources typically differ on various dimensions. For example, on average, people rate memories for imagined events as containing less sensory and contextual information than memories for perceived events[42]. When oriented to examine this kind of memorial information, these qualitative differences between memories can serve as a basis for identifying the origin of a memory. In terms of the CMF, the source test is more effective than the old–new recognition test because it generally forces participants to use sufficiently focused and detailed retrieval cues so that they are likely to match some aspect of the sought-after trace, rather than matching aspects of competing traces.

However, sometimes memories from different sources are so similar that even when people are oriented to examine specific information about an item, there is no reduction in false recognition responses. For example, in the DRM paradigm, participants characterize their false memories of the lure words as being very similar on a number of dimensions to their true memories for studied words[6,7]. However, some subtle differences in the nature of true and false memories have been observed in this paradigm. Compared to memories for presented words, false memories typically are rated as containing less auditory information (when the studied items were presented aurally) and as possessing fewer details about feelings and reactions. Because of the high level of similarity between true and false memories in the DRM paradigm, orienting individuals to scrutinize their memories for specific information does not significantly reduce false recognition responses to the lure words (although see Ref. 6 for data pointing to some improvement when the study words are randomly intermixed). Similarly, providing a general warning to participants at the time of retrieval to look out for the related lure words did not decrease false recognition rates (see the 'cautious condition' in Ref. 43 and see Ref. 44 for evidence that providing warnings prior to study, even under conditions that involve the presentation of a single list and an immediate one-item recognition test, does not eliminate illusory recognition).

The foregoing studies indicate that the effectiveness of the type of retrieval orientation for reducing false recognition responses depends on two variables, namely how individuals evaluate their memories and the similarity of the memories to one another (see Ref. 45 for further discussion of false memories and the SMF). In general, querying memory for specific source or item information produces fewer false recognition responses than responding on the basis of overall familiarity. However, there might be a limit to the effectiveness of this item-specific retrieval orientation if the memories to be discriminated are extremely similar to each other.

Combined encoding and retrieval influences: the distinctiveness heuristic

False recognition rates are influenced not only by how people are oriented to examine their memory, but also by the strategies that people use to assess or evaluate the remembered information. According to the SMF, individuals can make a judgment after quickly assessing the kind and amount of remembered information about an event (e.g. the familiarity of the event or how much pictorial information is remembered). Alternatively, judgments can be based on a more strategic and deliberative examination of the remembered information in light of other knowledge[16]. Consistent with the latter judgment process, we focus on a retrieval strategy, known as the distinctiveness heuristic, that depends on the joint influences of the encoding and retrieval stages of memory[5,46]. Drawing on individuals' metamemorial beliefs about what they feel they ought to remember about past events[16,47], the distinctiveness heuristic refers to a decision rule whereby the absence of memory for expected distinctive information is taken as evidence that an event is new (i.e. not previously experienced)[5,46]. For related strategies, see Refs 21,48–54. Several recent studies have demonstrated that the distinctiveness heuristic has been particularly effective at reducing false memories in both younger and older adults.

As noted previously, in the DRM paradigm, participants initially study lists of words that are associatively related to a non-presented lure word. On a subsequent old–new recognition test, participants frequently erroneously judge related lure words as having been studied before. However, studying the same items with accompanying pictures, instead of as words alone, dramatically reduces false recognition rates for the related lures among both younger and older adults[46,55]. Schacter *et al.*[46] argued that this increased success in rejecting related lure words after picture-plus-word encoding, as compared to word-only encoding, stems from participants' metamemorial belief that they ought to remember the distinctive pictorial information. By this view, participants invoke a distinctiveness heuristic whereby they demand access to pictorial information as a basis for judging items as previously studied. The absence of memory for this distinctive information would indicate that the test item is new (for an alternative view, see Refs 56,57). By contrast, participants who studied only words would not expect detailed recollections about studied items and, therefore, would not base recognition decisions on the presence or absence of memory for distinctive information. Dodson and Schacter[5] reported a similar reduction in false recognition responses to related lures in young adults when participants actually spoke aloud the target words on the study lists, compared to when they simply heard the target words (participants also saw the studied words in both conditions). Paralleling the reasoning regarding distinctive pictorial information, Dodson and Schacter[5] suggested that participants who spoke words while studying them employed a distinctiveness heuristic during the recognition test, demanding access to the distinctive 'say' information in order to judge an item as 'old'. Although the related lure words might have felt familiar, these words should not have evoked the distinctive information that was associated with actually having said a word out loud and, consequently, could be identified as 'new'.

In all of the situations thus far considered, we have examined methods or factors that help to reduce false recognition in circumstances where the items to be remembered share considerable conceptual or perceptual similarity with each other (e.g. the various pictorial exemplars within a category such as shoes or cars share many conceptual and perceptual features, while words in the DRM lists share strong semantic and associative similarities). However, an important question is whether techniques that effectively reduce false recognition for items where the lures are related to many previously experienced items are also effective in situations where the items are unrelated. Recently, Dodson and Schacter (unpublished) examined this question with regard to the distinctiveness heuristic, developing a modified form of the 'repetition lag' paradigm that was initially reported by Jennings and Jacoby[58]. In the modified version of this paradigm, participants either study a list of unrelated words or pictures and then make old–new recognition judgments about previously studied items and new words. Each new word occurs twice on the test, with a variable lag (i.e. a variable number of intervening words) between the first and second occurrence. The new words repeat at lags of either four, 12, 24 or 48 words. Participants are instructed to say 'old' to studied words and to say 'new' to non-studied words, even when they are repeated.

Although participants are explicitly told that if a word occurs twice on the test, they can safely conclude that it is a new word, participants in a word-only encoding condition nevertheless incorrectly respond 'old' to many of the repeated new words, especially when they repeat at the longer lags. Jennings and Jacoby[58], in a similar condition involving only words, found that older adults were highly likely to recognize falsely the repeated new words. Presumably, individuals mistake the familiarity of the repeated new words (derived from their earlier exposure on the test) for prior presentation in the study phase. By contrast, both older and younger adults exhibit a reduced false recognition rate for the repeated new words when they studied pictures of the items. Dodson and Schacter (unpublished) argue that participants in the picture-encoding condition, as in the DRM paradigm, used a distinctiveness heuristic during the test, inferring that test items were new when they failed to recollect memory for pictorial information about an item.

In summary, people are aware that different kinds of encoding activities yield memories that vary in strength, detail and vividness. This metamemorial knowledge underlies a retrieval strategy in which people can infer that the absence of memory for expected information indicates that an item is novel.

Conclusions

In answering the question with which we began this article, we have considered a variety of mechanisms operating at encoding, retrieval, or both stages of memory processing, which have proven effective in reducing false memories. The reviewed studies indicate that a prominent contributor to the likelihood that individuals will experience false memories is the failure to recollect detailed information about an item. Therefore, memory for specific item information plays a central role in each of the techniques for reducing false memories. In the DRM paradigm, for instance, encoding specific item information through multiple study–test trials reduces false recognition responses to lure items. Alternatively, false memories can be reduced when individuals are oriented at retrieval to scrutinize their memory for specific source information or other item-specific details. Finally, the distinctiveness heuristic hinges on the expectation of remembering distinctive item information; thus, failing to remember this kind of information is a signal that the test item is new, irrespective of how familiar it might seem.

Age appears to be an important boundary condition on the use of the reviewed mechanisms for reducing false memories. Like younger adults, older adults can use the distinctiveness heuristic to reduce false memories. Older adults also make fewer misattribution errors when they receive a retrieval orientation, such as a test format that requires responses that are based on source memory. However, in contrast to younger adults, older adults show no reduction in false memories in the DRM paradigm when they are given multiple study–test trials. Therefore, whereas older adults might have difficulty in building up specific item information across trials, possibly as a result of problems with binding together the features of an event[59] and/or keeping memory representations separate from each other[60] (see Ref. 27 for alternative accounts), they do not appear to have trouble with adjusting their retrieval criteria to reduce false memories.

Although we have emphasized the importance of remembering (or expecting to remember) source information, it is worth noting that remembering vivid details about a past event does not guarantee its accuracy. Occasionally, as in Gary Trudeau's experience, exceptionally vivid and detailed memories that are accepted as true parts of one's personal past might, in fact, be false.

Outstanding questions

- Can children use the distinctiveness heuristic? If this heuristic depends on metacognitive knowledge about the kinds of encoding activities that yield distinctive memories (e.g. studying pictures) then young children might not have developed this knowledge and therefore might fail to exhibit evidence of using a distinctiveness heuristic.
- What are the neuroanatomical substrates underlying the use of the distinctiveness heuristic? More specifically, are the brain regions that contribute to the retrieval of source information different from the areas that are involved in the strategic evaluation of this information?
- The evidence reviewed here appears to point to an inconsistency in metamemorial strategies. Individuals readily (and without instruction) appear to adopt the distinctiveness heuristic to reduce false recognition. However, the default strategy adopted at the time of retrieval in other situations, such as the eyewitness testimony paradigm which involves misleading post-event information, appears to rely on familiarity, thereby increasing vulnerability to errors. What accounts for this difference? Are metamemorial beliefs about the effects of post-encoding processing (e.g. subsequent questioning) themselves mistaken?
- To what extent are strategies or techniques for reducing false recognition errors that are learned in one context generalized or spontaneously adopted in other contexts? Does general knowledge about the nature of memory errors and the conditions under which they arise reduce false recognition and false recall in situations that would allow the effective application of such knowledge?

Acknowledgements

Supported by National Institute on Aging Grant AG08441 and a grant from the Human Frontiers Science Program. We appreciate the helpful comments of Kathleen McDermott, Roddy Roediger, Bill Rohwer and the anonymous reviewers.

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Individual differences in music performance

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Music cognition depends on the existence and deployment of processes for detecting, storing and organizing musical materials according to underlying structural features. Common cultural experiences develop these processes to a certain degree, but specifically designed and supported learning environments are required to achieve the levels of expertise required to perform western art music. Certain motivational and social factors are therefore implicated in the maintenance of activities that promote skill-acquisition, such as practice. Expert musical performance is not just a matter of technical motor skill, it also requires the ability to generate expressively different performances of the same piece of music according to the nature of intended structural and emotional communication. This review examines these abilities and describes how some of them have been shown to have lawful relationships to objective musical and extra-musical parameters. Psychological research is thus engaged in a process of demystifying musical expertise, a process that helps to improve upon culturally prevalent, but ultimately non-explanatory, notions of inborn 'talent'.

The vast majority of contemporary research on music cognition has focussed on perceptual processes in the listener[1–4]. This is unsurprising and defensible: the musical experience of the listener is at the heart of all musical activity. Without heard experience composition and performance would have no purpose. In addition, the vast majority of the population in contemporary industrialized nations are listeners rather than performers. It makes sense to focus scientific effort on processes that are shared by the majority of a population. Taking into account performers as well as listeners, the core questions for the study of music cognition are: what representational and control processes underlie people's ability to recognize, store, recall, transform and generate musical materials?

Research on music perception has established that, as for language, the cognition of music is underpinned by the human ability to extract, store and manipulate a range of abstract structural representations from a complex

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