

ILLUSORY RECOLLECTION: THE COMPELLING SUBJECTIVE REMEMBRANCE OF THINGS THAT NEVER HAPPENED. INSIGHTS FROM THE DRM PARADIGM

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Illusory recollection is the subjective detailed feeling of remembering that sometimes accompanies false remembering of events that never happened (e.g., high confidence, “Remember” judgements, or even remembrance of precise details supposedly associated with the false event). In this review, typical illusory recollection measures obtained from laboratory studies will be depicted, with a focus on the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995), one of the most largely used procedures to study memory distortion and its associated illusory recollection. The theoretical explanations of illusory recollection will be described and contrasted in light of factors affecting the phenomenon, in order to show their strengths and limits. Although the focus on the origins of illusory recollection is relatively recent, overall, this review suggests that DRM false memories can be an excellent tool to study this phenomenon under controlled conditions and to gain insights on false memories occurring in everyday life.

Introduction

Memories are malleable, often deviate from what actually happened and are not free from errors (e.g., Bartlett, 1932; Conway, 1997; Johnson, Hashtroudi, & Lindsay, 1993; Roediger, 1996; Schacter, 1999). Memory distortions (also called “commission errors”) comprise a wide variety of phenomena ranging from the distortion of particular elements or details of an actually experienced event, to the remembering of entire events that have never occurred (e.g., Roediger, 1996). For instance, it has been repeatedly shown that the information to which a witness is exposed after a witnessed event can be strongly detrimental to later memory accuracy and may contaminate his/her report (e.g., Ayers & Reder, 1998; Loftus, Miller, & Burns, 1978; Zaragoza & Lane, 1994). Moreover, a large body of research has also demonstrated that it is possible to implant false memories of entirely new events with the use of suggestive narratives (e.g., Loftus & Pickrell, 1995; see for a review, Garry & Ger-

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rie, 2005), associated or not with doctored photographs (e.g., Wade, Garry, Read, & Lindsay, 2002) or even true photographs (e.g., Lindsay, Hagen, Read, Wade, & Garry, 2004). Thus, research has shown that it is possible to make people falsely remember events that never occurred, but even more intriguingly, these memory distortions may be quite compelling as individuals often remember vivid details associated with the supposed occurrence of the events (e.g., Gallo, 2006; Loftus & Palmer, 1974; Wade et al., 2002), a phenomenon called “Illusory Recollection” (e.g., Gallo & Roediger, 2003) or “Phantom Recollection” (e.g., Brainerd, Wright, Reyna, & Mojardin, 2001). In this case, the memory distortion can be considered as a “false memory” (or a “memory illusion”) because it is falsely remembered as an event that actually occurred. That is, people are highly confident about the occurrence of the event and are able to provide details related to its occurrence.

The current review will focus on illusory recollection elicited by means of the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In this procedure, participants are presented with lists of associated words (e.g., thread, pin, eye, sewing...) that converge on non-presented critical lures (e.g., needle). Later, they typically falsely recall or recognise the non-presented critical lures at high rates^[1] and claim to recollect very specific details about their occurrence in the study list. Indeed, participants are often very confident that the critical lure has occurred and are able to provide descriptions and details regarding its presentation even though it has never been presented (e.g., Lampinen, Neuschatz, & Payne, 1998; Lampinen, Meier, Arnal, & Leiding, 2005; Mather, Henkel, & Johnson, 1997; Norman & Schacter, 1997). According to the “activation-monitoring” account (e.g., Gallo & Roediger, 2002; McDermott & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001), false recall or recognition of critical lures in this paradigm occur because, during the presentation of the list, the critical lure is activated as a result of a spreading of activation in an associative network that will subsequently result in its easier accessibility (McDermott & Watson, 2001; Roediger & McDermott, 1995). During retrieval, this activation must be correctly attributed to the participant’s own thoughts and not to the item’s occurrence in the list through a successful “reality monitoring” process (Johnson et al., 1993; Johnson & Raye, 1981).

An alternative account is provided by the “fuzzy-trace” theory (e.g., Brainerd & Reyna, 2002; Brainerd et al., 2001), which suggests that memory judgements are based on verbatim and/or gist traces that are encoded in parallel at study. Verbatim traces capture the surface details of physical stimuli,

1. For instance, Stadler, Roediger, & McDermott (1999) published norms for DRM list in English. Depending on the list, they showed that false recall of critical lures ranged from 10% to 65% while false recognition of critical lures ranged from 27% to 84%.

and gist traces represent the meaning of the stimuli but lack perceptual details. Recall of a studied list is based on a dual retrieval mechanism. One mechanism involves direct access to verbatim traces of list items and mainly supports veridical recall. A second mechanism reconstructs the items by processing the gist representation and is also responsible for false recall (e.g., Brainerd & Reyna, 2002; Brainerd et al., 2001). More specifically, critical lures are identified as part of the presented lists due to the attributes they share with the items on the corresponding study list. In contrast, verbatim representations can be used to edit out critical lures during retrieval. False-but-cue-consistent information may come to mind during retrieval and may cue verbatim details of the corresponding presented items, which may counter the familiarity associated with the false-but-cue-consistent information (e.g., Brainerd et al., 2001). Hence, both theories imply that it is likely that the critical lure will seem familiar due to either activation or reliance on gist traces (i.e., traces that support the general semantic theme). In addition, both explanations rely on the availability of item-specific information for the successful editing of memories. As such, the interest in understanding why some memory distortions are reported with phenomenological characteristics is of theoretical importance.

Note, however, that the ecological validity of false memories produced by the DRM paradigm has been criticised (e.g., De Prince, Allard, Oh, & Freyd, 2004; Freyd & Gleaves, 1996; Pezdek, 2007; Pezdek & Lam, 2007; but see Wade, Sharman, Garry, Memon, Mazzoni, Merckelbach et al., 2007 for a nice reply). Indeed, some authors have suggested that memory distortions studied with the DRM paradigm cannot be generalised to more complex false memories occurring outside the laboratory (e.g., De Prince et al., 2004; Pezdek, 2007; Pezdek & Lam, 2007). Obviously, the DRM procedure allows one to study false memories (i.e., commission errors accompanied by compelling illusory recollection) that lack the complexity of false autobiographical memories, but there is evidence pointing to the fact that the same processes operating in the creation and resistance to false memories (e.g., plausibility assessment, imagery/creation of a mental representation, source monitoring failure) in laboratory studies are relevant to real life situations (e.g., Wade et al., 2007). Moreover, studies have shown that an individual's susceptibility to false recall or recognition of critical lures in the DRM paradigm correlates with his susceptibility to commit errors in other false memory tasks such as false autobiographical memories (Meyersburg, Bogdan, Gallo, & McNally, 2009; Platt, Lacey, Iobst, & Finkelman, 1998). Additionally, findings suggest that individuals who report the recovery of childhood sexual abuse during therapy are more likely to produce intrusions of semantically related critical lures (Geraerts, 2012; Geraerts, Lindsay, Merckelbach, Jelicic, Raymaekers, Arnold, & Schooler, 2009). Nevertheless, one might acknowledge, as sug-

gested by De Prince and collaborators (2004; see also Pezdek, 2007) that the term “false memory” has indeed been imprecisely used in the literature, but not because it has been applied to paradigms studying false memory for word intrusions in the laboratory instead of complex autobiographical memories, as suggested earlier. Rather, in the context of the DRM paradigm, the term has been used in a large body of published papers to refer to studies that were actually measuring false recall or recognition without any measure of illusory recollection (e.g., ourselves: Dehon, Bastin, & Larøi, 2008; Dehon, Larøi, & Van der Linden, 2011). Notwithstanding, the DRM paradigm allows one to elicit rates of illusory recollection among the greatest reported in the literature (e.g., Gallo, 2006). When these measures are reported in studies, one can truly consider studying a false memory, defined as a “memory commission error accompanied with illusory recollection (i.e., a compelling subjective feeling of remembering)”. In the following section, the various measures typically used to examine illusory recollection and the factors that influence it in the context of the DRM paradigm will be described.

Measures of illusory recollection in the DRM paradigm

Confidence ratings

Degree of confidence can be used as a first indication of the compelling nature of false memories. Indeed, numerous studies have demonstrated that false memories of related lures are accompanied by relatively high confidence, sometimes as high as that of studied items (e.g., Mather et al., 1997) and always higher than the confidence level for unrelated lures (e.g., Brédart, 2000; Dehon & Brédart, 2004; Payne, Elie, Blackwell, & Neuschatz, 1996; Roediger & McDermott, 1995). However, assessing confidence is not a sufficient measure of illusory recollection, as it is not always clear what high confidence ratings refer to exactly. They might be based on the recollection of details but, similarly, they might also simply reflect a strong feeling of familiarity or even guessing or inference strategies (e.g., “as it is highly related to the list items, the critical lure was very likely to be in the list”).

“Remember-Know” judgements

One way of obtaining a better idea of illusory recollection is to ask participants to distinguish memories that they actually recollect from those based on a strong feeling of familiarity, with the use of the “Remember-Know” procedure (e.g., Tulving, 1985). In this procedure, participants are asked to provide a “Remember” judgement for an item if their memory for the item is accompanied by the conscious recollection of any aspect of the original event, and

a “Know” judgement if they believe that the word has been presented (because it is familiar) but cannot remember specific details about its occurrence. In their seminal study, Roediger & McDermott (1995; Experiment 2) found that “Remember”^[2] and “Know”^[3] judgements for critical lures were higher than those for unrelated lures (a phenomenon known as the “relatedness effect”; e.g., Gallo, McDermott, Percer, & Roediger, 2001; Mather et al., 1997; Norman & Schacter, 1997; Payne et al., 1996; see Gallo, 2006 for an excellent review). When judgements for critical and studied items were compared, they found that familiarity (“Know” judgements) did not distinguish critical and studied items. However, if the rates of “Remember” judgements for studied items (.41) were higher than that for critical items (.38), they were quite high anyway (and much higher than that of unrelated lures, .02). Since then, many other studies have obtained evidence of illusory recollection as measured by the rates of “Remember” judgements (e.g., Gallo et al., 2001; Gallo & Roediger, 2003; Neuschatz, Payne, Lampinen, & Togliola, 2001). Collectively, they suggest that false memories are not just based on a strong feeling of familiarity, but that participants believe that they have recollected specific details associated with the presentation of non-presented critical lures.

However, although “Remember” judgements might be a first estimation of the degree of recollection associated with true and false memories, there are also some limits related to the use of the “Remember-Know” procedure to study illusory recollection. Firstly, it is very important to be sure that the participants actually recollect details of the presentation of the items when they are assigned a “Remember” response. Indeed, studies have observed that the instructions of the “Remember-Know procedure” may not always be well understood (e.g., Lampinen et al., 1998; McCabe, Geraci, Boman, Sensenig, & Rhodes, 2011). Hence, one should encourage the use of practice trials before the recognition/memory test to check that the participants have correctly understood the instructions (Lampinen et al., 1998). Secondly, there are various specific sets of instructions associated with the procedure (e.g., Rajaram, 1993; Tulving, 1985) and the use of one rather than another might affect the rates of “Remember” responses obtained, for items in general (e.g., Lampinen et al., 1998) or for critical lures in particular (e.g., Geraci & McCabe, 2006). Thirdly, even if practice trials and specific instructions are used, “Remember” judgements only indicate that the participant’s memory is associated with the conscious recollection of some details related to the occurrence of an item, but do not specify either the kind of details or the quan-

2. I.e., .38 vs. .02 for “Remember” judgements assigned to critical lures and false alarms, respectively.

3. I.e., .34 vs. .09 for “Know” judgements assigned to critical lures and false alarms, respectively.

tity of details. Hence, one might observe similar rates of “Remember” judgements for studied and critical items, which might be based on different quantities of recollected details or different recollection qualities (e.g., Mather et al., 1997; Norman & Schacter, 1997). Finally, recent evidence suggests that conditions that measure illusory recollection solely on the basis of “Remember-Know” judgements (i.e., without detailed justifications) might overestimate rates of true recollection (i.e., “Remember” judgements for studied items) in standard episodic memory tasks (e.g., McCabe et al., 2011) or in the DRM paradigm (Dehon & Lampinen, in preparation). The following section will thus present several methods that specifically assess the details that are associated with individuals’ memories.

Verbal justifications and “Memory Characteristics Questionnaire”

Some studies have examined the details associated with recollected studied and critical items. Norman and Schacter (1997) asked their participants to make “Remember-Know” judgements and to provide a written justification for their judgements. They found that many participants reported details such as sensory details, position in the list, thoughts one had at the time of presentation, relationship of the word to the other list words and phonological information with their “Remember” judgements. Some details (related to the sensory/perceptual aspects of the words or the position of the words in the list) were more often associated with studied items than critical lures, whereas others (relatedness, associated thoughts) seemed equally likely to be reported with both studied and critical items.

Similarly, instead of asking participants to report verbal or written justifications for their “Remember” responses, it is also possible to use evaluation scales to assess the degree of recollection of specific details. One such instrument is the Memory Characteristics Questionnaire (MCQ; Johnson, Foley, Suengas, & Raye, 1988), which is composed of 38 questions about the qualitative characteristics of memories such as overall vividness, contextual details, visual details, event complexity, distinctiveness, etc. Participants are asked to rate each of their memories on the basis of these specific aspects. Although, originally, this scale was proposed to assess characteristics of autobiographical memories, shorter versions of the scale have also been used in the DRM paradigm (e.g., Gallo & Roediger, 2003; Mather et al., 1997; Neuschatz et al., 2001; Norman & Schacter, 1997; Read, 1996). Interestingly, although similar rates of “Remember” responses for studied and critical lures have been reported in the literature, studies using the MCQ have found differences between studied and critical items on some measures. For instance, Mather and collaborators (1997) asked participants to rate their memories for “perceptual details”, “emotional reactions”, “associations” and “trying to

remember". They found that studied items received higher ratings for auditory and emotional details compared to critical lures (see also Norman & Schacter, 1997), while critical lures had higher ratings for "associations", suggesting that true and false DRM memories might differ on average on some aspects of their content. Overall, similar findings have been observed in other studies assessing the phenomenological characteristics of memories in the DRM paradigm with the use of the MCQ (e.g., Gallo & Roediger, 2003; Neuschatz et al., 2001), although results are difficult to compare as the methods are somewhat different from one study to another (e.g., list length, modality of presentation, specific dimensions assessed within the MCQ,...). It is important to note, however, that differences between true and false DRM memories are often subtle and appear for averaged measures (e.g., mean ratings of contextual details associated with falsely recalled or recognised critical lures). Specific instances of false memories can be very similar to studied items on some occasions (e.g., when attention is divided during the learning phase, when participants focus on indistinctive/thematic information, etc.) or for some participants such as older adults (e.g., Dehon, 2006; Dehon & Brédart, 2004; Norman & Schacter, 1997). In any case, there is evidence that participants can report remembering details related to the presentation of the critical items and even if some differences between true and false memories can be found, these details are probably sufficient to drive or justify their "Remember" judgements. Accordingly, additional evidence using Receiver Operating Characteristics (ROC; e.g., Lampinen, Watkins, & Odegaard, 2006) and multinomial modelling techniques (e.g., Brainerd, Payne, Wright, & Reyna, 2003; Brainerd et al., 2001) further support the idea that some conscious recollection is occurring with critical lures that is similar to conscious recollection for studied items.

In addition to studies that have assessed the phenomenal characteristics of memories, some studies have also examined the ability of participants to assign more specifically a source to their memories (e.g., who has produced a word or how an item was presented at study; Johnson et al., 1993). Results reveal that although critical items have never been presented, a substantial part of the participants were willing to assign a specific source to critical items, such as attributing a voice or a visual versus auditory modality of presentation (Lampinen, Neuschatz, & Payne, 1999; Neuschatz et al., 2001; Payne et al., 1996). Critical items were often attributed to the source of their corresponding studied list (Gallo et al., 2001; Lampinen et al., 1999; Mather et al., 1997; Payne et al., 1996) or were distributed across the sources when 2 sources produced the list words, except if the sources differed with respect to their distinctiveness (i.e., when one was more distinctive than the other). In this case, source attributions associated with critical lures were not distributed evenly across the plausible sources but were more likely to be assigned to the

less distinctive source (e.g., Hicks & Marsh, 1999; Hicks & Marsh, 2001). Note that strongly warning participants that they could make source errors made them more likely to change the source attributed to critical items than that attributed to studied items. Yet, they still made substantial source attributions for non-presented critical lures suggesting that they were not merely guessing when they attributed a source to critical items (Lampinen et al., 1999; see also Neuschatz et al., 2001).

A final method used to gain information concerning the details that are reported with both true and false memories is the think-out-loud (or think aloud) procedure (e.g., Lampinen et al., 2005; Lampinen, Ryals, & Smith, 2008). This procedure is similar to that of the verbal reports presented earlier, except that participants are asked to verbalise at both study and test. Hence, by the direct comparison between what is reported at test and what was said during study, this procedure has proven to be very helpful to provide further insight into illusory recollection and its origins. Evidence of detailed justification accompanying “Remember” judgements for critical lures has been obtained with this procedure (Lampinen et al., 2005; Lampinen et al., 2008) and will be more largely discussed later, in the context of the empirical data supporting and challenging the theoretical accounts of illusory recollection presented in the next section.

Accounts of illusory recollection

Several explanations have been proposed to account for illusory recollection: *conscious activation* (e.g., Roediger & Mcdermott, 1995), the *familiarity plus corroboration model* (e.g., Lampinen et al., 2005; Lampinen et al., 2008) and *imagination* (e.g., Gallo et al., 2001; Gallo & Roediger, 2003).

Conscious activation (e.g., Roediger & McDermott, 1995)

One account of illusory recollection is that participants may consciously generate the critical lure during study in response to the presentation of the highly associated list words (see Implicit Associative Response, IAR, Underwood, 1965). The generated critical lure would then acquire an episodic status in the sense that it possesses its own characteristics (the moment of occurrence of the generation, a personal association, an emotional reaction...) and can even be subject to the encoding strategies used by the participant (e.g., rehearsed, added in a sentence or in an image in order to improve its memorisation). The participants may subsequently remember these generations and recollect their associated characteristics, which would result in illusory recollections.

Content borrowing and the “familiarity plus corroboration model” (e.g., Lampinen et al., 2005; Lampinen et al., 2008)

Another account of illusory recollection is the “familiarity plus corroboration model” proposed by Lampinen and collaborators (e.g., Lampinen et al., 2005; Lampinen et al., 2008). Following this account, when presented with a DRM list, a critical lure would seem familiar to the participants because of a spreading of activation in the semantic network due to the presentation of the list words (i.e., activation-monitoring account; e.g., Roediger & McDermott, 1995) or because it shares strong similarities with the list words (i.e., fuzzy-trace theory; e.g., Brainerd et al., 2001). The participants would then initiate a search for corroborating details (that the subject presumed were associated with the critical lure) in memory in order to explain this feeling of familiarity. During this search, characteristics associated with the list words (such as position in the list, emotional reaction or associated thoughts) could be used as corroboration and could be associated with the critical lure through a process of “content borrowing” (e.g., Lampinen et al., 2005). Such content borrowing implies a breakdown of feature binding such that features that are loosely bound to list words are retrieved and are erroneously bound to the memory for the critical lures.

Imagination (e.g., Gallo et al., 2001; Gallo & Roediger, 2003)

This account is very similar to the content borrowing account except that details are not extracted or taken from presented words that were studied, but rather participants may infer or imagine the characteristics (e.g., how the words might sound like or whether it would have been presented in the beginning or at the end of the list) in an effort to try to remember and when participants are specifically asked about their recollective experience. Illusory recollection might then occur if the participants mistake this imagination for a memory through a reality monitoring error (Johnson & Raye, 1981).

In conclusion, similarly to the “familiarity plus corroboration” account, the “imagination” account supposes that illusory recollection is created at test. The difference between both accounts lies in the origin of the illusory content (i.e., features from actually studied items vs. imagination). Moreover, both of these accounts rely on attribution processes (e.g., Whittlesea, 1993; Whittlesea, 2002; Whittlesea & Williams, 2000). More specifically, since the critical lures were never actually presented, their detailed recollections should come from another source. That is, because of the presentation of the semantic associates in the DRM lists, the critical lures are processed more fluently (because of associative activation or similarity-based mechanisms) than unrelated lures. This increased fluency then causes one to misattribute perceptual details (whatever borrowed from actually presented items or imagined).

However, both of these accounts contrast with the “conscious generation” account that postulates that illusory recollection is created at encoding (and is retrieved later on).

Note that the fuzzy-trace theory (e.g., Brainerd & Reyna, 2002; Brainerd et al., 2001) provides a way to conceptualise the “content borrowing” phenomenon proposed by the familiarity plus corroboration account. Indeed, verbatim traces are supposed to disintegrate over time so that item-specific information that was once associated with studied items can become available for binding with gist traces (e.g., Brainerd et al., 2001). Binding might also be more difficult in the context of the DRM paradigm due to the high similarity between the list items (e.g., Johnson et al., 1993). Hence, when presented with critical lures at test, the retrieval of these detailed gist traces would result in an illusory recollective phenomenology (i.e., phantom recollection, e.g., Brainerd et al., 2003; Brainerd et al., 2001). Moreover, phantom recollection can also be created online at test when the search in memory for supporting details from studied items leads to the attribution of these details to the critical lure through attribution processes. Similarly, illusory recollection could also be understood in the more general context of the activation-monitoring theory (McDermott & Watson, 2001; Roediger & McDermott, 1995). For instance, evidence from overt rehearsal studies or think-out-loud procedures have shown that the critical lure can indeed be generated at study, leading it to be confused with actually presented items though a monitoring failure (that might happen either at study or at test). However, implicit associative activation might also increase fluency for critical lures at test and, due to this increased fluency, details might be attributed to the critical lures and cause illusory recollection. This, in turn, might flaw source monitoring processes.

What influences illusory recollection?

Several factors have been shown to affect illusory recollection. Overall, they are related to the specific instructions or testing conditions used at retrieval, the specific materials used in the DRM experiments, or individual differences. The aim of this section is to present these factors. In addition, insights from neuroimaging studies will also be provided before discussing supports and limitations of the three accounts of illusory recollection.

Retrieval effects

“Remember” instructions

Some evidence suggests that the kind of “Remember” instructions used in the “Remember-Know” procedure (Tulving, 1985) affects the rates of illusory recollection. Indeed, Geraci and McCabe (2006) contrasted the traditional

instructions based on Rajaram (1993), asking participants to indicate a “Remember” judgement if they could recollect any aspects of the presentation of the word including information about other list words (i.e., “you may remember the words that came before or after”), and a modified version that did not include any reference to other items in the list. Their rationale was that because traditional “Remember” instructions focus on the remembering of details associated to other list items, illusory recollection could be driven by the recollection of these details and not by a vivid recollection of details regarding the critical lure. Hence, if memory for surrounding context was indeed influencing illusory recollection, then modified instructions that do not focus on this information should reduce the rates of “Remember” responses to critical lures. In agreement with their hypothesis, they found that the modified instructions reduced the rates of “Remember” judgements for critical lures but did not affect “Remember” judgements assigned to studied items.

Warnings

Warning participants after study but before test was shown to reduce the rates of “Remember” judgements (e.g., Anastasi, Rhodes, & Burns, 2000; Gallo et al., 2001; McDermott & Roediger, 1998) or source attributions to critical lures (e.g., Lampinen et al., 1999; Neuschatz et al., 2001). However, warnings before study do not seem to have great effects on illusory recollection (e.g., Dehon 2006; Dehon & Brédart, 2004). The persistence of illusory recollection after a warnings condition is interesting because it suggests that illusory recollection is not related to some kind of inference or guessing strategy as the participants were actually trying to avoid memory errors.

Other manipulations at retrieval

Illusory recollection seems to increase when the conditions of item presentation at test do not match the conditions that prevailed at study (e.g., Gallo, 2006). That is, changing the modality of testing (e.g., auditory study but visual testing or a male voice producing the words at study but a female voice producing the items at test) is related to increased rates of “Remember” judgements for critical lures (e.g., Dodson, 2007, but see Roediger, McDermott, Pisoni, & Gallo, 2004).

Delay

Reduced rates of “Remember” responses to both studied and critical items have been reported after a 48-hour delay compared to immediate testing conditions (e.g., Lampinen & Schwartz, 2000). However, using the think-out-

loud procedure, Lampinen and collaborators observed increased rates of “Remember” judgements with detailed justification after a 2-week delay (Lampinen et al., 2008). Interestingly, in contrast with the findings obtained with longer delays of retention in the classical DRM procedure, DRM false memory effects have been recently reported in a short-term memory task (e.g., Atkins, & Reuter-Lorenz, 2008; Coane, McBride, Raulerson, & Jordan, 2007). Indeed, in this short-term variant of the DRM task, participants were asked to retain 4 semantic associates over a 4-s filled retention interval. Evidence of false recall was obtained in this condition. Moreover, confidence ratings and “Remember-Know” judgement analyses revealed similar false memory effects in this short-term variant (ST, 4-s interval) and in a long-term (LT, 20 min interval) condition (i.e., Flegal, Atkins, & Reuter-Lorenz, 2010). That is, critical lures were falsely recognised at higher rates than that of unrelated lures, assigned “Remember” judgements (.36 vs. .27 for ST and LT conditions, respectively) and endorsed with considerable confidence (rated as “somewhat high” in both conditions).

DRM materials

DRM lists may vary in many aspects, one being the strength of associative connection between the list words and the related lures (i.e., Backward Associative Strength, BAS). Strong DRM lists that have high connections are associated with increased rates of “Remember” responses as compared to weak DRM lists (Gallo & Roediger, 2002; see also Brainerd et al., 2003). In addition, there is evidence that, within a specific DRM list, in a condition in which 2 different voices presented the list items, participants were more likely to attribute the critical items to the voice that produced the strongest associates and less likely to attribute the critical lures to the voice that produced the weakest associates (Hicks & Hancock, 2002; Hicks & Starns, 2006). Similarly, increasing the number of associates presented within the DRM lists increased the rates of “Remember” responses to critical lures (Dehon & Lampinen, in preparation; Gallo & Roediger, 2003) and increased ratings of the memory features assessed by the MCQ (Gallo & Roediger, 2003).

Nature of the DRM lists

False memory effects can also be observed when participants are presented with phonological lists (e.g., Kit, Fat, Hat... associated with the critical related item “CAT”) rather than semantic lists (e.g., Ballou & Sommers, 2008; Sommers & Lewis, 1999; Watson, Balota, & Sergent-Marshall, 2001). Although illusory recollection can occur with these errors, they are typically more frequently associated with “Know” judgements. Similar results have

been reported for categorised lists (e.g., “felines” for which the prototype is “Lion”) as compared to the typical associative lists (i.e., semantically associated words converging to the word “Lion”; e.g., Dewhurst, 2001).

Emotional content of the lists

Despite the fact that the interest in false memories was associated with legal cases typically involving negative events, it is only recently that emotion has been taken into account in studies of memory distortion. In this respect, data seem to concur showing that negative emotion might influence the production of false memories in many false memory procedures (e.g., Hyman, Husband, & Billings, 1995; Nourkova, Bernstein, & Loftus, 2004; Otgaar, Candel, & Merckelbach, 2008; Porter, Spencer, & Birt, 2003; Porter, Yuille, & Lehman, 1999). With an emotional variant of the DRM paradigm, we found evidence of substantial false memories for emotional and neutral DRM lists, but negative DRM false memories elicited more “Remember” responses (Dehon, Laroi, & Van der Linden, 2010; see also Pesta, Murphy, & Sanders, 2001) compared to neutral and positive false memories (but see Brainerd, Stein, Silveira, Rohenkol, & Reyna, 2008). Whether similar effects can be found on source attribution is currently under investigation in our lab as, to our knowledge, no study has examined this specific issue within the DRM paradigm. In addition, the use of think-out-loud protocols (e.g., Lampinen et al., 2005) to examine the details reported with positive, neutral and negative critical items should be interesting to specifying the kind of information associated with “Remember” judgements. It may be possible that, compared to neutral critical lures, “Remember” responses for emotional critical lures refer to indistinctive emotional reactions (e.g., “this is something unpleasant”, an emotional reaction that could virtually apply to any associate in the study list) or thematic associations (e.g., “this is another unpleasant word related to the others/belonging to the same theme”) following the presentation of associates, rather than to vivid illusory recollections (i.e., “I remember that particular sound”, “it was the second word presented in the list”). These issues are currently under investigation.

Age

The susceptibility to DRM false memories has been shown to increase with age (e.g., Dehon, 2006; Dehon & Brédart, 2004; Dehon & Lampinen, in preparation; Gallo & Roediger, 2003; Norman & Schacter, 1997; but see also Butler, McDaniel, Dornburg, Price, & Roediger, 2004). However, whether older adults are more likely to report illusory recollection is still under debate. Indeed, compared to younger adults, similar rates of illusory recollection and similar length effects on source judgements and MCQ ratings have been

observed in older adults (Gallo & Roediger, 2003; see also Meade & Roediger, 2006). In contrast, some studies have shown increased false recollection in older adults, particularly if they were tested under forced recall conditions (Meade & Roediger, 2006), with repeated testing conditions (Skinner & Fernandes, 2009), or at their non-optimal time of the day (Intons-Peterson, Rocchi, West, McClellan, & Hackney, 1999). Similarly, recent data using the think-out-loud procedure suggest that older adults might be more likely to report illusory recollection and misrecollect details associated with studied items to justify their “Remember” judgements compared to younger adults (Dehon & Lampinen, in preparation). Interestingly, reducing younger adults’ attentional resources at study (i.e., studying DRM lists under divided attention) seems to increase illusory recollection in a way similar to that observed in older adults under full attention (Skinner & Fernandes, 2009; but see Dewhurst, Barry, Swannell, Holmes, & Bathurst, 2007).

Additional insights from neuroimaging data

Event-related potential (ERP) and functional magnetic resonance imaging (fMRI) have investigated the neural activity associated with performance in the DRM task (e.g., Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Curran, Schacter, Johnson, & Spinks, 2001; Darsaud, Dehon, Lahl, Sterpenich, Boly, Dang-vu et al., 2011; Dennis, Kim, & Cabeza, 2007; Fabiani, Stadler, & Wessels, 2000; Kahn, Davachi, & Wagner, 2004; Kim & Cabeza, 2007; Schacter, Buckner, Koutstaal, Dale, & Rosen, 1997; Schacter, Reiman, Curran, Yun, Bandy, McDermott et al., 1996; Slotnick & Schacter, 2004). Overall, these studies have shown that true recognition of studied items and false recognition of critical lures elicit similar patterns of neural activity. More specifically, comparable patterns of activity in the medial temporal regions (including the hippocampus; e.g., Cabeza et al., 2001; Schacter et al., 1997; Schacter et al., 1996; Slotnick & Schacter, 2004) were found and were thought to reflect the recollection of information from the study episode, such as the gist of the list. Furthermore, prefrontal activations (especially in the right dorso-lateral prefrontal cortex) were also similarly activated for true and false recognition, presumably reflecting monitoring or decision processes (Cabeza et al., 2001; Schacter et al., 1996). Moreover, some studies have found analogous activity in lateral parietal regions for true and false recognition (Cabeza et al., 2001; Schacter et al., 1997; Slotnick & Schacter, 2004), supposedly reflecting the recuperation of information supporting an “old” decision.

In addition, some differences between true and false recognition were also observed. For instance, Schacter and colleagues (1996) found higher activation in the auditory cortex for true recognition than for false recognition (see

also Abe, Okuda, Suzuki, Sasaki, Matsuda, Mori et al., 2008), while Cabeza and collaborators (2001) found higher activation in the parahippocampal region for true compared to false recognition. However, the divergent results might be due to some differences in the methodologies across these studies (such as the modality of presentation of the items, whether the items were presented in a mixed or blocked fashion, etc.). In addition, with a few exceptions, most of the studies done in this area compared activation associated with global correct or incorrect recognition performance (mixing “recollected” and “known” items) so that critical lures falsely recognised on the basis of a general feeling of familiarity, or accompanied with illusory recollection, were confounded. One study has even averaged performances and examined neural activity across different materials (i.e., DRM and categorised lists; Cabeza et al., 2001) although there are good reasons to believe that these materials elicit different amounts of illusory recollection (see above: Nature of the DRM lists).

One first exception in this literature is provided by Düzel, Yonelinas, Mangun, Heinze, and Tulving (1997). They conducted an ERP study in which they asked participants to study DRM lists presented visually and to complete a recognition task with “Remember-Know” judgements. They found that “Remember” and “Know” judgements elicited different patterns of activity but that these patterns were similar for studied items and critical lures. Similarly, Darsaud and collaborators (2011) conducted an fMRI study in which they asked their participants to study DRM lists presented in an auditory modality before completing a recognition test with “Remember-Know” judgements. Again, they found no important differences in neural activation between true and false recognition or between measures of true and illusory recollection (“Remember” judgements). Note, however, that the aim of this last study was to observe the effect of sleep deprivation and that the participants were tested 3 days after they had learned the lists.

In conclusion, only a few studies have examined neural activity associated with illusory recollection in the DRM paradigm. Research examining false recognition of critical lures or more specifically illusory recollection, has had some difficulty in observing differences in terms of neural activation between true and false recognition or between true and illusory recollection. Future studies are needed to examine more precisely the neural activity associated with illusory recollection. For instance, one might try to disentangle the specific effects of factors such as the study modality, the measure of illusory recollection used (“Remember-Know” judgements vs. MCQ ratings), among others, to get a comprehensive view of the similarities and differences in the pattern of neural activity for true compared to illusory recollection. It is also worthy to note that in all the reported studies, false memory performance (or illusory recollection) was measured in the context of a recognition memory

test because this enables procedures to be standardised and also confounding variables (e.g., frequency of items, number of responses, etc.) can be controlled.

Theories of illusory recollection in light of the empirical data

The “conscious activation” account

Following this account, illusory recollection occurs because participants may overtly generate the critical lures at study and later remember the characteristics of these generations as supporting evidence that the critical lures were presented. In agreement, there is a considerable number of studies reporting that individuals sometimes consciously think of critical lures (e.g., Brédart, 2000; Dehon, 2006; Dehon & Brédart, 2004; Dehon et al., 2010; Dewhurst, 2001; Goodwin, Meissner, & Ericsson, 2001; Lampinen et al., 2005; Seamon, Lee, Toner, Wheeler, Goodkind, & Birch, 2002) and use the memory of this rehearsal as a justification for their recognition of critical lures (Brédart, 2000; Dehon & Lampinen, in preparation; Dehon et al., 2010; Lampinen et al., 2005; Lampinen et al., 2008). The difficulty in observing differences in neural activity between true and illusory recollection is also consistent with this account (Darsaud et al., 2011; Düzel et al., 1997). In addition, divided attention at study (as well as normal aging or testing at a non-optimal time of the day) might affect the ability to distinguish presented words from passing thoughts during the learning of the lists (e.g., Johnson & Raye, 1981), making illusory recollection of such a kind more likely (see for supporting evidence, Skinner & Fernandes, 2009). In contrast, however, other data suggest no relationship between the probability of conscious thought of critical lures and the rates of “Remember” judgements (e.g., Lampinen et al., 2005; Lampinen et al., 2008; Seamon et al., 2002) or verbal reports in think aloud procedures (e.g., Dehon & Lampinen, in preparation; Lampinen et al., 2005; Lampinen et al., 2008). Overall, some support for this account is found in the literature but the findings also suggest that this mechanism is not the unique contributor to illusory recollection. Future research should establish whether illusory recollection that originates from conscious generation of critical lures is associated with specific study/test conditions or to individual differences in information processing (e.g., Dehon et al., 2008; Dehon et al., 2011).

The “familiarity plus corroboration” account

Following this account, illusory recollection occurs because participants search for details to corroborate the familiarity of the critical lure at test. During this search, characteristics associated with the list words (such as position in the list, emotional reaction or associated thoughts) could be used as corrob-

oration and could be associated with the critical lure through a process of content borrowing (e.g., Lampinen et al., 2005). In agreement with this idea, it has been found that when the classical “Remember-Know” instructions were modified so that participants were less likely to focus on the characteristics of studied items to make their “Remember” judgements, the rates of illusory recollection decreased, suggesting that the participants indeed relied on studied items characteristics for some of their “Remember” judgements (Geraci & McCabe, 2006). A similar pattern of activity between true and illusory recollection observed in neuroimaging studies is also consistent with this account (Darsaud et al., 2011; Düzel et al., 1997). In addition, the increased rates of illusory recollection observed under divided attention at study (as well as normal aging, especially if participants were tested at their non-optimal time of the day) also support this account (Skinner & Fernandes, 2009). Indeed, efficient binding of details (e.g., Chalfonte & Johnson, 1996) should be reduced in this condition, compared to a full attention condition. Hence, memory details might be more available for content borrowing, and illusory recollection should be increased in this context. Moreover, the effects should be even more important if repeated study sessions increased the familiarity of the critical lures (see for supporting evidence, Skinner & Fernandes, 2009).

Nevertheless, the most direct evidence of content borrowing has been reported in the literature with the use of the think-out-loud procedure (Lampinen et al., 2005; Lampinen et al., 2008). For instance, Lampinen and collaborators (2005) asked participants to study and remember DRM lists while thinking out loud. By comparing reported details provided by the participants at study with those reported at retrieval, they found that many falsely recognised critical lures were associated with “Remember” responses and that the details provided to justify these “Remember” responses were, in many instances, details related to presented items at study. For example, Lampinen and collaborators reported that when presented with the item “sugar” at study, one of their participants said that “It’s fattening but it is good”. When presented with the word “sweet” during the recognition test, the participant said: “I remember liking sweets but thinking that they are gonna make me fat” (see Lampinen et al., 2005, p. 150).

Moreover, because the search for corroboration should be driven by familiarity (or anything that makes the critical lure more fluently processed; e.g., Kurilla & Westerman, 2008; Whittlesea, 1993; Whittlesea, 2002; Whittlesea & Williams, 1998; Whittlesea & Williams, 2000), content borrowing should be more likely for related critical items than for weakly related distractors items, which is indeed the case (Lampinen et al., 2005; Lampinen et al., 2008). Similarly, as the number of associates presented in the list increases, so does the familiarity (and fluent processing) of the critical lures. In agreement with this hypothesis, higher rates of content borrowing were reported

for longer DRM lists of associates (15 items) compared to shorter lists (10 and 5 items; Dehon & Lampinen, in preparation). In addition, it is predicted that with time, features of studied items will be more loosely bound with studied items and more available for content borrowing. In agreement, illusory recollection – and more specifically content borrowing – occurred more often for critical lures after a 48h- and 2 week-delay compared to immediate testing (Lampinen et al., 2005; Lampinen et al., 2008). Finally, content borrowing was frequent in older adults (Dehon & Lampinen, 2011; Dehon & Lampinen, in preparation) known to have misrecollection problems, and more specifically binding deficits, in spite of spared semantic processing, compared to younger adults (e.g., Dodson & Krueger, 2006).

There are, however, some puzzling data that at first glance do not seem to support the account. For instance, if familiarity is driven by either perceptual or conceptual similarity (or activation), materials inducing high perceptual (e.g., phonological DRM lists) or conceptual similarities (categorised lists vs. associative lists; positive vs. negative lists) should induce rather equivalent rates of illusory recollection and content borrowing. Surprisingly, however, this does not seem to be the case (e.g., Dehon & Lampinen, in preparation; Dehon et al., 2010; Dewhurst, 2001; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000). In addition, some of the explanations reported by the participants for both studied and critical items have nothing to do with what has been produced and recorded during the study phase but, rather, seem to have been newly created (e.g., Dehon & Lampinen, in preparation). Although it is possible that these ideas were actually thought of by the participant but not overtly reported, it is also possible that these explanations were created online during the effort to remember and misattributed to the study episode due to a reality monitoring failure at test (Johnson & Raye, 1981). Future studies should examine these issues more precisely. In conclusion, although there is large support for content borrowing in the literature, some mechanisms proposed by this account must be refined to fully account for the available data such as, for instance, clarifying why high levels of similarity/familiarity do not always induce content borrowing.

The “imagination” account

Dodson (2007) has provided evidence that illusory recollection can be created at test when a misleading retrieval cue (i.e., a voice that did not correspond to the voice that originally produced the list words) is incorporated into the recollective experience through automatic attribution processes (e.g., Whittlesea, 1993; Whittlesea, 2002; Whittlesea & Williams, 1998; Whittlesea & Williams, 2000). In agreement, some of our recent data show that manipulating the fluent processing of critical lures which is responsible for these attribu-

tions (for instance, by manipulating the contrast of words presented visually or by manipulating the participant's expectations) during the recognition test influenced the rates of "Remember" responses to critical lures from both studied and unstudied DRM lists (Dehon & Willems, in preparation; see also Kurilla & Westerman, 2008; Willems & Dehon, 2009; but see Karpicke, McCabe, & Roediger, 2008). Finally, results from the think-out-loud procedure in which participants reported "new" justifications to critical lures (Dehon & Lampinen, in preparation) seem to support this explanation as well. However, it is important to note that even if there is evidence for "online-created" illusory recollections from think-out-loud protocols, they are typically not as frequently reported as is evidence of content borrowing or conscious generation (Dehon & Lampinen, in preparation; Lampinen et al., 2005; Lampinen et al., 2008).

Conclusions and perspectives

Laboratory studies have provided considerable evidence that memory distortions can be created and studied under controlled conditions. These memory errors occur in many different contexts and populations and can be quite compelling (see for instance, Gallo, 2006; Schacter, 1999). There are currently three explanations for this compelling illusory recollection that have gained support over the years, although none of them is able to fully account for the empirical results. Compared to the study of the conditions that lead to false recall or recognition of critical lures, the focus on illusory recollection is relatively recent and additional work is needed in order to better understand its origins. More specifically, it would be interesting to contrast the various accounts, to determine under which encoding and/or retrieval condition one is more likely to elicit illusory recollection and whether it is possible to develop retrieval instructions (e.g., Geraci & McCabe, 2006) that may help to reduce the rates of illusory recollection. In addition, future studies should examine more carefully the exact nature of the processes that lead to increased familiarity of the critical lures (i.e., similarity-based vs. activation-based processes) and/or whether the nature of the information to be processed (e.g., semantic vs. phonological materials) might be a significant predictor of illusory recollection. Based on the few available data, it seems that illusory recollection is more likely to occur for semantically-related lists than for phonologically-related lists and more for associative lists than for categorised lists (e.g., Dewhurst, 2001). Another factor to consider is that the way these variables affect illusory recollection might depend on the type of memory test (i.e., recall vs. recognition). For instance, McEvoy, Nelson, and Komatsu (1999) have shown that the associative connections between the list items (i.e., inter-item associative strength) led to reduced false recall of the critical lure. They

suggested that the shared associative connections between studied items cause them to activate each other at the expense of the activation of the critical lure. However, the reverse effect was found in recognition in which the greater connectivity between the list words led to greater false recognition of the critical lure. Hence, processes such as associative activation and similarity-based mechanisms might differentially contribute to illusory recollection depending on the memory task. The suggestion is interesting as most of the studies examining illusory recollection in the DRM paradigm used recognition memory (see for some exceptions Brainerd et al., 2003; Goodwin et al., 2001; Seamon et al., 2002). In addition, others (e.g., Gallo & Roediger 2002) have suggested that the differential contribution of activation- and similarity-based mechanisms might depend on the delay between the study phase and the memory test. Hence, future studies should be warranted to examine these issues.

Another interesting question that needs an answer is “Who is more likely to demonstrate illusory recollection?”. For instance, some studies have examined illusory recollection in older adults (e.g., Gallo & Roediger, 2003; Meade & Roediger, 2006), but little is known with respect to the factors that affect illusory recollection in children (e.g., Howe, 2007; Rybash & Hrubis-Bopp, 2000). Moreover, whether individual differences in personality (e.g., extraversion, encoding style, compliance...) and/or cognitive abilities (e.g., imagery and/or working memory abilities), in addition to affecting susceptibility to DRM false recall and recognition, also affect the susceptibility to illusory recollection is still unknown. Indeed, most of the studies examining the influence of such individual differences in the context of the DRM procedure, including our own work (e.g., Dehon et al., 2008; Dehon et al., 2011), have typically compared overall rates of false recall or recognition but not their associated illusory recollection.

Understanding the origins of compelling illusory recollections is also theoretically important because main false memory explanations rely on the availability of item-specific information for the successful editing of memories (e.g., Johnson et al., 1993; Lampinen et al., 1998; Payne, Neuschatz, Lampinen, & Lynn, 1997). For instance, in the case of implanted autobiographical memories or post-event suggestions, it is important to examine why a mental representation is mistaken for a memory. The source-monitoring-framework (e.g., Johnson et al., 1993) postulates that the evaluation of the characteristics composing these mental representations leads to an attribution that might or might not be correct depending, for instance, on the specific weight assigned to the available characteristics in order to make the source decision. However, the fluency-based attribution model (e.g., Whittlesea, 2000) discussed earlier in the context of illusory recollection that originates from imagination, suggests that individuals can actually create those characteristics. Interestingly, this phenomenon does not seem to be restricted to the

DRM paradigm. Indeed, work by Loftus and colleagues (1978) has shown that people could remember details that were not present in studied scenes depicting an accident, such as the presence of broken glass.

Finally, in addition to the theoretical motivations to study this phenomenon, there are also a number of applied interests directly related to a better understanding of illusory recollection. Indeed, in legal practice, the credibility and validity of statements are in part assessed through the witness's or the victim's ability to report his/her memories in a vivid manner (see Lampinen et al., 1999; for a discussion). DRM illusory recollection studies can add insights to these issues in determining, for instance, in which condition one is more likely to produce illusory recollection and/or whether some individuals or populations are more likely to produce illusory recollection than others. Moreover, to date, it is somewhat difficult to distinguish true and false memories (even if averaged differences might be observed) both behaviourally and from neuroimaging studies. The issue of proposing tests and/or instructions that might clearly differentiate particular true and false memories in this context and/or to refine credibility and validity assessments is of importance and should be further investigated.

In any case, more generally, illusory recollection accompanying memory illusions is thought to be the consequence of normal memory processes and a phenomenon similar to that of perceptual illusions (e.g., Payne et al., 1996; Roediger, 1996; Schacter, 1999), an idea that has gained further support this last decade (e.g., Howe, 2011; Schacter, Guerin, & St. Jacques, 2011). More specifically, Schacter and collaborators (2011) have suggested that memory distortions and false memories can be fully understood in the context of an episodic memory system whose function is not to maintain literal episodes but that rather serves as a tool for one's mental time travel/time projection (regardless of whether this projection concerns the individual's past or future). If such a hypothesis is correct, one might expect significant correlations between the susceptibility of a person to commit high levels of illusory recollection (in the DRM paradigm or in other false memory tasks) and his/her ability to report detailed projections in the past or in the future.

In conclusion, false memories in the DRM paradigm are obviously less complex phenomena than false autobiographical implanted memories, but the paradigm nevertheless allows one to study the illusory subjective compelling feeling of remembering (which is the trademark of a false memory) under controlled conditions. As such, it can be a fantastic tool to help gain insights into false memory creation and resistance, provided that researchers focus on appropriate false memory measures defined as "false recall or recognition of critical lures accompanied with illusory recollection". Otherwise, researchers should acknowledge that they are only studying "memory distortions", in general, or "false recall" or "false recognition" of critical lures, in particular.

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