

**The Effect of Emotion on False Memories**  
**in the Deese-Roediger-McDermott (DRM) Paradigm**

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## Abstract

Over the past two decades, researchers have shown that human memory is not as accurate as we would like to believe. Sometimes we recall the gist of a particular event, but the details of that event are incorrect and sometimes we report entirely false memories for an event that never occurred. On many occasions, our false memories are of little significance, but sometimes they can have dire consequences, particularly if those false memories are reported in court. Given these consequences, it is important to understand the conditions under which memory errors are most likely to occur. The most widely-used procedure to investigate false memories in the laboratory is the Deese-Roediger-McDermott (DRM) paradigm; in this paradigm, participants who study lists of words (e.g., bed, rest, pillow) in which each word on the list is related to a critical lure (e.g., sleep) often report having seen that critical lure even though it did not appear on the original list. In fact, the false recognition rate of critical lures is nearly as high as the correct recognition rate of studied words.

In many cases in which false memories really matter (e.g., eyewitness testimony or traumatic memories), the memories themselves are emotionally charged and are retrieved in a distinctive emotional context (mood). The overarching goal of my PhD research was to use the DRM procedure to investigate the effects of emotion on true and false memories in both children and adults, and to explore methods that might be used to reduce emotional false memories in laboratory settings. The first step in the research was to compile pure emotional DRM word lists in which all of the list words were semantically-related to the corresponding critical lure, and the list words and the critical lure share the same emotional valence (Chapter 4). The next step was to compare the magnitude of false memory produced by the new lists with the magnitude of false memory produced by hybrid emotional word lists used in previous research, and then to explore the effect of emotional content (i.e., new emotional word lists) on false recall (Chapter 5). To assess the effect of both emotional content and

emotional state (i.e., mood) on false memory, I then used mood induction procedures to elicit a particular mood and asked participants to learn the new emotional DRM word lists (Chapter 6). In Chapter 7, I tested different theoretical predictions regarding the effect of participants' mood on age-related increases in DRM false memories for emotional word lists. In the last two empirical chapters, I assessed whether warnings about the false memory phenomenon would reduce adults' emotional false memories (Chapter 8), and whether directed-forgetting cues would reduce children's emotional false memories (Chapter 9).

Generally, I found that 1) pure emotional lists generated more true recognition but less false recognition, compared to the hybrid emotional lists; 2) false memories were higher for negative word lists than for positive or neutral word lists, regardless of the type of memory test; 3) there was a negative mood-congruent false memory effect; 4) the age-related increase in false memories was eliminated in positive moods, whereas this increase was maintained in negative moods for negative information; 5) warnings had no impact on true recognition, but could reduce false recognition, no matter whether warnings were presented before study, or after study but before test; 6) directed forgetting reduced only children's true memory, but it did not influence either children's or adults' false memory. I also found that no single theory could account for all of these findings. In some cases, associative theories (i.e., *Implicit Associative Response Theory*, *Spreading Activation Theory*, *Associative Activation Theory*, and *Activation-Monitoring Theory*) provide the most suitable explanation for the findings, in some cases, Fuzzy-Trace Theory (FTT) is better and in other cases, both associative theories and FTT account for the findings. Taken together, the present findings not only have important theoretical implications for understanding the development of emotional false memories, but also have practical implications for understanding the formation of adults' and children's emotional false memories in forensic settings.

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## Publications Arising from This Thesis

### *Refereed Journal Articles*

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- ***I designed the experiment, collected and analysed data, took the lead role in writing and revising the manuscript. Coauthors provided guidance on all drafts and on revising the manuscript.***

Zhang, W., Gross, J., & Hayne, H. (2017b). If you're happy and you know it: Positive moods reduce age-related differences in false memory. *Child Development*.

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### *Conference Contribution – Published proceedings: Abstract*

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[http://c.ymcdn.com/sites/www.psychonomic.org/resource/resmgr/annual\\_meeting/2016\\_meeting/2016PS-Abstracts-11-27.pdf](http://c.ymcdn.com/sites/www.psychonomic.org/resource/resmgr/annual_meeting/2016_meeting/2016PS-Abstracts-11-27.pdf)

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## Chapter 1

### False Memory in the DRM Paradigm

“Yet, although cautious, we should not let the pendulum swing too far because in psychology (as in other science) much of what we learn about remembering (or any other topic) in the lab can provide important information about remembering in situations outside the lab.”

(Roediger & McDermott, 1996, p. 815)

In July 1984, a man broke into 22-year-old university student, Jennifer Thomson-Cannino’s apartment and sexually assaulted her. At the time, Jennifer was a 22-year-old university student. During the brutal attack, she made every effort to remember the attacker’s face. As she subsequently reported, “I was just trying to pay attention to a detail, so that if I survived... I’d be able to help the police catch him” (“Ronald Cotton Time Served: 10 Years,” n.d.). A suspect was arrested. During both a photo graph line-up and a live line-up, Jennifer identified a man by the name of Ronald Cotton as her rapist. In court, she stated that she was 100% certain that he was the right man. In November 1987, Ronald Cotton was convicted of rape and was sentenced to life in prison. Eight years later, in the spring of 1995, he was exonerated on the basis of DNA test results. The governor of North Carolina officially pardoned Ronald Cotton in July 1995, but by that time, he had served more than 10 years in prison.

The story of Jennifer Thomson-Cannino and Ronald Cotton is compelling, but it is not rare. Often we adamantly believe that we remember something that, in the end, turns out to be entirely false. Developmental psychologists have known this for a long time. Jean Piaget, the famous developmental theorist often told the story of his own, strongly held, false memory. Piaget recounted that one of the clearest memories from his early childhood was

about being kidnapped when he was 2-years old. He had a vivid recollection of someone trying to abduct him from his pram while his nanny fought off the would-be kidnapper. At the age of 15 Piaget learned that the whole story of the failed kidnapping had been invented by his nanny in an attempt to get a financial reward. How did his false and highly-detailed memory develop? Piaget proposed that he must have heard the story being discussed as a child, imagined what it would have been like, and then retrieved the imagined version from his memory, claiming it as a real experience (Piaget, 1962). Taken together, the false memories of Jennifer Thomson-Cannino and Jean Piaget clearly illustrate that our memory does not work like a tape recorder faithfully storing an identical record of our actual experience, but rather, is prone to distortion; the subsequent distorted or entirely false memory is often detailed, vivid, and emotionally-laden.

The earliest empirical investigation of the phenomenon of false memory was conducted by Frederic Bartlett. In his research, participants were asked to read the narrative, *The War of the Ghosts*, twice at normal pace. Fifteen minutes later, they were required to write down what they had read, and then again after a few hours, a few days, or after an even longer delay. Bartlett found that, although the narrative that participants recalled became more and more logical and concise, the information that they recalled was not necessarily accurate. For example, some participants recalled that the events in the narrative happened during the day, but in fact, they occurred at night. Other participants recalled information such as “the Indian was wounded by an arrow” (Bartlett, 1932). This information was not actually part of the original narrative; instead, participants drew the inference based on what they had read and retained over a long delay. In other words, although accurate information from the original narrative was omitted, the false information that had initially been generated by the participants themselves was maintained (Bartlett, 1932). Although Bartlett did not use the term “false memory” in his original paper, his classic study clearly demonstrated that

human memory is highly fallible. We sometimes recall key parts of an event, but also, we sometimes remember things that never actually happened.

On many occasions, our false memories are of little significance. For example, we might remember drinking a bottle of orange juice when it was actually apple juice. On other occasions, however, our false memories can have dire consequences, for example, if memory errors like those of Jennifer Thompson-Cannino, are produced in court. In some cases, an individual's eyewitness testimony may be the only information available regarding the guilt or innocence of the accused, so errors in the witness's testimony may lead to irreparable consequences for an innocent person (Ceci & Bruck, 1995; Hood, Rothstein, & Baldwin, 2001). Given the real-life consequences of some false memories, researchers have investigated various aspects of false memory to understand how they emerge. There are two paradigms that are used most often in the laboratory settings to study false memory: the misinformation paradigm (Loftus & Hoffman, 1989; Loftus & Pickrell, 1995; Loftus & Zanni, 1975) and the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995).

### **Misinformation Paradigm**

Elizabeth Loftus was one of the first researchers to systematically study the conditions under which false memories occur. In Loftus' misinformation paradigm, participants watch a video depicting an event, such as a car accident. Some of the participants then receive misleading information about the target event (e.g., the car which caused the accident was white, when actually the car was blue). When asked about the color of the car that they saw in the original video, participants who received the misleading information tended to report that the car was white; their false recall rates were much higher than that of participants who had not been exposed to the misleading information (for a review, see Loftus, 2005).

The primary goal of research like that conducted by Loftus and her colleagues is to examine whether memory can be modified by exposure to misinformation about an event that has occurred. On the basis of more than three decades of research, we now know that it is fairly easy to alter the details of a previously established memory (Belli, 1989; Lindsay & Johnson, 1989; Loftus, 2005; Loftus & Hoffman, 1989; Loftus & Zanni, 1975; Zhu et al., 2010). In one study, Lindsay and Johnson (1989) asked participants to initially study a slide that depicted an office scene, and then asked them to read a narrative description of the scene. For half of the participants (controls), the narrative contained only accurate information, whereas for the other half of the participants, the narrative included eight objects that were related to the theme of the scene but had not been presented in the slide. Half of the participants in each group completed a recognition test and half completed a source-monitoring test. Both tests consisted of 32 items: 8 items that had been presented in the slide, 8 items that had been presented in both the slide and the text, 8 items that had been presented only in the misleading text, and 8 new items. The recognition test required participants to judge whether each item was present *in the slide*, whereas the source-monitoring test required participants to indicate whether each item was present *in the slide*, *present in the text*, *present in both the slide and the text*, or *present in neither the slide nor the text*.

Lindsay and Johnson found that misled participants given the recognition test were more likely to falsely attribute unpresented objects to the slide, while misled participants given the source-monitoring test were more likely to attribute those objects to the text which was their actual source. Thus, although memory can easily be distorted, making source-monitoring judgments may help misled people to reduce or eliminate their false memories. Furthermore, empirical evidence has also shown that individual differences in susceptibility to misinformation are reliably related to cognitive abilities; people with low intelligence and

poor perceptual abilities are more likely to be influenced by misinformation (Zhu et al., 2010).

In another line of research, Loftus and her colleagues (1995) have also examined whether it is possible to implant a memory for an entire event that never occurred. To explore this possibility, the researchers interviewed the relatives of their participants to garner information about three real experiences that had happened to the participant when he or she was 4- to 6-years old. The relatives also provided information about a typical shopping trip, and the researchers used this information to fabricate a false event (e.g., getting lost in a mall). In the experiment, participants were asked to recall the four events (three true, one false). One to 2 weeks later, they were interviewed again and were asked to recall each event in as much detail as possible. They were also asked to rate the clarity and their confidence in their memory for each event. Although the clarity and confidence ratings for the false events were lower than for the true events, at least 25% of the participants claimed to remember the false event. As Loftus and Pickrell (1995) noted, this was the first experimental demonstration that our memory not only could be distorted by exposure to misleading information about an event that actually happened, it could also be distorted by implanting a memory for an entire event that the participant never experienced.

In reviewing the results of research using her misinformation paradigm, Loftus (2005) has identified three factors that influence the probability that a false memory will occur. First, the time interval between the original event and exposure to misinformation is associated with susceptibility to misinformation; the longer the time interval, the greater the susceptibility (Loftus & Hoffman, 1989). This finding makes sense considering that, with the passage of time, the memory for the original event becomes weaker and participants find it increasingly difficult to detect the difference between the original memory and the misinformation. Second, warning people that they may be exposed to misinformation in the

future may enhance their ability to resist the misinformation. However, warning people that they may have been exposed to misinformation in the past (post-misinformation warnings) may not have same effect in terms of resisting the misinformation. Third, the age of the participant also influences his or her susceptibility to misinformation. Generally, older children and young adults are less susceptible to misinformation than are younger children (Ceci & Bruck, 1993). Additionally, older adults are more susceptible to misinformation than are young adults (Davis & Loftus, 2005; Karpel, Hoyer, & Toggia, 2001; Wylie et al., 2014).

In addition to providing misinformation to directly induce participants' false memories, sometimes false memories can be generated by our own cognitive system, such as through imagination. Some researchers have predicted that imagining a childhood event might increase the confidence that the event actually happened (Garry, Manning, Loftus, & Sherman, 1996). To test this hypothesis, researchers designed a three-step procedure. First, participants were asked to complete a 40-item Life Events Inventory (LEI), in which they assessed their confidence in whether each of 40 events had happened or not before age ten (1 = definitely did not happen; 8 = definitely did happen). Based on participants' assessment, three judges selected eight events that probably did not happen. Next, participants were asked to imagine half of the selected events and the other half were regarded as control items. Finally, participants were told that their original assessments had been lost and they had to do the LEI again. The key finding was that participants who first believed that an event had not happened were more likely to increase their confidence that the event had happened after they imagined the event (Garry et al., 1996; Garry & Polaschek, 2000). This finding raises concerns for evidential interviewers and clinical psychologists who use guided imagery as a way to collect relevant information from victims, witnesses, and clients. What these people report following this imagery might not necessarily be accurate.

Some researchers have criticised the use of imagination to investigate false memories. Their key concern has been that it is impossible to rule out the possibility that the target life event did or did not happen during the life of the participant. That is, it is possible that imagination might not induce false memories, but rather may make a memory of an actual event more accessible. To avoid this possibility, researchers have used a video clip of an event rather than the LEI so that they can be certain that a scene that participants later report was indeed true or false. For example, Wright, Loftus, and Hall (2001) showed adult participants a video clip of a car accident caused by drink driving, which included several scenes. The critical scene was that a policeman drove the drunk man away from the scene. This scene was critical because it actually did not happen in the video clip. Some participants were instructed to imagine this critical scene and then completed a recall test, whereas other participants imagined the critical scene followed by a recognition test. The results again supported the argument that imagination can distort our memory; 15% and 40% of participants who were asked to imagine the critical scene either falsely recalled or falsely recognised this unrepresented scene during the test, respectively.

### **DRM Paradigm**

The misinformation paradigm has yielded valuable insights into the establishment of false memories, but the most widely-used paradigm to study false memory in laboratory settings is the Deese-Roediger-McDermott (DRM) paradigm. Compared to false memories generated by suggestive information, DRM false memories occur spontaneously. That is, participants generate false memories themselves, rather than through exposure to additional information.

The DRM paradigm is based on an early study by Deese (1959), the primary goal of which was to investigate the effect of associations on false recall of unrepresented, but semantically-related, words. These unrepresented but semantically-related words were later

referred to as critical lures. In Deese's study, participants were given 36 lists of words from Russell and Jenkins (1954). Each list contained 12 words that were shown to participants, but a critical lure for each list was not. For instance, for the critical lure *sleep*, participants heard the list words: *bed, rest, awake, tired, dream, wake, night, comfort, eat, sound, slumber, snore*. After hearing each list, participants were asked to recall as many words as they could remember from the list. Deese found that the ability of the list words to elicit critical lures varied considerably across lists; 44% of the participants falsely recalled the critical lure *sleep* while no one falsely recalled the critical lure *butterfly* after hearing its list words. He also found that the associative strength between the list words and the critical lure could explain 76% of the variance in the false recall rates; the correlation between associative strength and false recall was very high ( $r = .87$ ). That is, the more likely it was that the list words could generate the critical lure on a free-association test, the more likely it was that the critical lure would be falsely recalled. Deese was the first researcher to document the relation between free association and false recall, but the significance of his findings went unnoticed until Roediger and McDermott replicated and extended his study using a similar procedure in 1995. Since then, this experimental procedure has been referred to as the Deese-Roediger-McDermott (DRM) paradigm.

There were two experiments in Roediger and McDermott's (1995) seminal study. The goal of the first experiment was to replicate Deese's (1959) original findings for recall, and to extend Deese's recall test to include a recognition test. Thirty-six participants heard 6, 12-word lists, which were selected from Deese's study. After hearing each list, participants were asked to write down as many words as they could remember without guessing. Once the sixth list was finished, participants completed a 42-word recognition task by rating each word based on their confidence that it had been presented on the list using a 4-point rating scale (1 = *sure that the item was new*; 4 = *sure that the item was old*). On the recall test, the true

recall rate for the studied words was .65, which was higher than the false recall rate for the critical lures (.40). On the recognition test, the results indicated that even for unrepresented critical lures, participants were very confident that the word had appeared; 86% of the studied words and 84% of the critical lures were given a rating of 3 (*probably old*) or 4 (*sure old*). Taken together, the first experiment of Roediger and McDermott's (1995) study indicated that false recall and false recognition were robust using Deese's method.

In their second experiment of the same study, Roediger and McDermott (1995) had four aims. First, they wanted to examine the DRM procedure with a larger set of word lists; to do this, they developed 24, 15-word lists. Second, they wanted to investigate whether prior recall would boost recognition rates. To this end, after learning half of the lists, participants were randomly assigned to do either a recall task or a math task. By comparing the recognition rates between these two groups, Roediger and McDermott could test whether prior recall had an effect on subsequent recognition. Third, they wanted to determine whether the false memories for the critical lures still occurred when the corresponding list words had not been presented. To test this idea, the critical lures of unstudied word lists were included in the recognition task. Finally, they wanted to obtain some measure of the subjective experience of false memories. To achieve this goal, Roediger and McDermott drew on a procedure developed by Tulving (1985). First, participants made an old/new judgment for each word. For words that participants deemed to be "old", they made a further "remember/know" judgment. "Remember" indicated that participants had a subjective feeling of having seen the word on the list and had a vivid recollection of its details; "Know" indicated that participants had an impression of the word, but could not recollect its actual presentation (Rajaram, 1993).

The experimental procedure in Experiment 2 was similar to that of Experiment 1, except that participants heard 16, 15-word lists, and half of the participants were required to

do a recall task after learning half of the word lists. The recognition test consisted of 96 words, including 48 studied words, 24 critical lures, and a total of 24 words from unstudied word lists. These words were randomly presented on the test sheet and participants circled old or new for each one. If they indicated that the word was old, they wrote *R* or *K* in the space next to that word. The false recall rate for critical lures was .55 in Experiment 2, which was significantly higher than that in Experiment 1 (.40). Roediger and McDermott concluded that this finding was probably due to the increased length of the lists (15 words vs 12 words). The recognition data showed that it was very difficult for participants to distinguish the studied words that were actually presented, from the critical lures that were not presented. That is, there was no significant difference between the true recognition rate for the studied words and the false recognition rate for the critical lures. This was especially true when participants completed the recall task prior to the recognition task; the false recognition rate in the recall condition was .81 while the false recognition rate in the maths condition was .72. In terms of fulfilling the last two aims of their study, Roediger and McDermott found that the false recognition rate for the critical lures of the unstudied word lists was marginally higher than that for the list words of the unstudied word lists. However, these false memories tended to be associated with *know*, rather than *remember* judgments. In contrast, the false memories for the critical lures that were from the studied word lists were associated more with *remember* relative to *know* judgments.

In short, Roediger and McDermott found a false memory effect, using both recall and recognition tests. More importantly, the false memory effect created by the DRM paradigm was so robust that participants even vividly recalled the details of the critical lures' presentation (i.e., *Remember* judgments for critical lures).

## Replications and Extensions of Roediger and McDermott (1995)

Based on Deese's (1959) and Roediger and McDermott's (1995) studies, Stadler, Roediger, and McDermott (1999) went on to collect normative information about the 24 lists developed by Roediger and McDermott (1995) as well as another 12 lists developed by McDermott (1995) (cited in Stadler et al., 1999). Although these word lists were all based on Russell and Jenkins (1954) word-association norms, there was a considerable difference between the word lists in terms of producing false memories. More specifically, the false recall rate was highest for the *window* list (.65) while it was lowest for the *king* list (.10). A similar pattern was also found for false recognition rates; the false recognition rate for the *window* list (.84) was significantly higher than that for the *king* list (.27). The apparent variability of word lists in generating false memories was consistent with the findings of Deese's (1959) and Roediger and McDermott's (1995) original studies, which inspired researchers to further investigate the factors that determined this variance.

In one study, Roediger, Watson, McDermott, and Gallo (2001) proposed seven factors that might account for the variance in false recall rates. These factors were categorised into two groups. Three factors pertained to the critical lure itself, and four factors pertained to the word lists. The first group of factors consisted of *word length* — the number of letters in each critical lure; *word frequency* — the number of times that the critical lure was found in print per million words; and *concreteness* which was based on the ratings obtained from a 7-point scale (1 = *the least concrete*; 7 = *the most concrete*). The second group of factors consisted of *forward associative strength* (FAS), *backward associative strength* (BAS), *connectivity*, and *true recall*. FAS refers to the frequency with which a critical lure (e.g., sleep) generates the studied words (e.g., bed, rest) as a response on a word association test. BAS, in contrast, refers to the frequency with which the studied words elicit the critical lure as a response on a word association test. *Connectivity* refers to the inter-item associative strength of the studied

words. Finally, *true recall* denotes the probability of recalling the studied words for each word list. Roediger, Watson, et al. (2001) initially collected BAS and FAS data for 55 word lists from Nelson, McEvoy, and Schreiber's (1998) norms. For some words, their BAS scores were missing from the existing norms. Roediger and colleagues collected their own norms using the same procedure as Nelson et al. (1998). To obtain connectivity data, they initially constructed 225 pairs of studied words for each word list, including 15 self-connections. For example, in an *anger* list, the studied words may be *rage*, *enrage*, *mad*, *fury*. In this case, there are 4×4 (16) pairs of studied words, in which *rage-rage*, *enrage-enrage*, *mad-mad*, or *fury-fury* are named as self-connections. They then estimated the associative strength of each pair of studied words and calculated the mean connectivity score for each list.

On the basis of a simultaneous multiple regression analysis, Roediger, Watson, et al. (2001) concluded that the seven factors accounted for approximately 68% of the variance in false recall. Of the seven factors, three were correlated with false recall. BAS was positively correlated with false recall and was the strongest predictor compared to the other factors. That is, the closer the associations between the studied words and the critical lure, the more likely that false recall would occur. This finding supported Deese's (1959) and Roediger and McDermott's (1995) inference that it was the backward associative strength (BAS) obtained on a word-association task that predicted the magnitude of false memories. Word length and true recall were negatively correlated with false recall. This finding indicated that the more letters in a critical lure, the less likely that it was falsely recalled, similarly, the more studied words that were recalled from a list, the less likely it was that the corresponding critical lure was falsely recalled.

### **Methodological Variables that Influence DRM False Memories**

Since 1995, the DRM paradigm that was used to produce the spontaneous false memory phenomenon has attracted extensive attention by memory researchers. Researchers

have manipulated a variety of factors in the DRM procedure to investigate the conditions under which false memory rates increase or decrease. Broadly defined, these factors can be divided into two categories. One concerns study factors, including BAS variations, list length, presentation rate, presentation modality, level of processing, divided attention, and stress. The other category concerns test factors, which consist of retention interval, test instructions (except warnings), part-list cuing, and language shift (Gallo, 2013). Appendix A provides a summary of some representative studies in which researchers have examined these factors. In the Appendix A1, studies in which researchers have manipulated study factors are described first, followed by studies in which researchers have manipulated test factors (Appendix A2). Below I have summarised the main findings of these studies.

Generally speaking, both study and test factors can influence the magnitude of DRM false memories; the influence of some factors is consistent, whereas the influence of some others is not. For example, factors including BAS variations, list length, presentation rate, presentation modality, level of processing and part-list cuing consistently affect the magnitude of false memories. As noted earlier, BAS, as one of the most important factors, is positively correlated with DRM false memories; higher BAS scores are associated with a higher rate of false memories (Brainerd & Wright, 2005; Gallo & Roediger, 2002; Howe, Wimmer, & Blease, 2009; McEvoy, Nelson, & Komatsu, 1999). The length of a list usually refers to the number of associations in the list. A consistent finding is that with increasing list length, DRM false memories increase (Robinson & Roediger, 1997; Sugrue & Hayne, 2006; Sugrue, Strange, & Hayne, 2009). There is also an inverted U-shaped effect of presentation rate on false memories. That is, as the presentation rate increases, false memories initially increase (e.g., 20 ms or 250 ms per word), and then decrease when the presentation rate becomes longer (e.g., 5000 ms per word) (Gallo & Roediger, 2002; McDermott & Watson, 2001; Seamon, Luo, Kopecky, et al., 2002). In the DRM paradigm, words are presented

either visually or aurally; visual presentation tends to reduce false memories compared to aural presentation (Cleary & Greene, 2002; Gallo, McDermott, Percer, & Roediger, 2001; Kellogg, 2001; Smith & Hunt, 1998). As for level of processing, false memories in the deep-processing condition (e.g., make a concrete/abstract rating of each studied word; semantic processing) are greater than those in the shallow-processing condition (e.g., count the number of vowels in each studied word; superficial processing) (Rhodes & Anastasi, 2000; Thapar & McDermott, 2001; Toggia, 1999). The factors discussed so far are all study factors, which play a role at encoding. In contrast, part-list cuing is a test factor, which plays a role at retrieval. Experimenters usually provide a subset of studied words or semantically related words (i.e., non-critical lures) as a retrieval cue at test. The consistent finding is that part-list cuing reduces false memories of critical lures (Bäuml & Kuhbandner, 2003; Kimball, Bjork, Bjork, & Smith, 2008; Kimball & Bjork, 2002; Reysen & Nairne, 2002).

In contrast to the factors described above, the effect of other factors on DRM false memories is mixed. The study factors include divided attention and stress, and the test factors include retention interval, test instructions, and language shift. Some researchers have found that divided attention at encoding increases false memories (Pérez-Mata, Read, & Diges, 2002; Seamon et al., 2003), whereas others have found that it decreases false memories (Knott & Dewhurst, 2007). Likewise, stress at the time of encoding was initially found to increase false memories (e.g., Payne, Nadel, Allen, Thomas, & Jacobs, 2002), but this finding has not been replicated in subsequent research (Smeets, Jelicic, & Merckelbach, 2006; Smeets, Otgaar, Candel, & Wolf, 2008; Wenzel, Jostad, Brendle, Ferraro, & Lystad, 2004). Studies regarding the effect of retention interval have shown a complex, but inconsistent pattern; in some studies, false memories remained or even increased when participants were tested again after a delay (i.e., 2 days; McDermott, 1996), while in other studies, retention interval either had no effect on false memories (Toggia, 1999) or reduced false memories

(Lampinen & Schwartz, 2000). The effect of test instructions on false memories largely depends on the instructions used. In particular, instructions emphasising meaning retrieval increase false memories (Brainerd & Reyna, 1998a; Brainerd, Wright, Reyna, & Mojardin, 2001), as do forced instructions (i.e., when participants are required to fill all recall spaces) (McKelvie, 1999, 2001). In contrast, instructions emphasising verbatim retrieval decrease false memories (Brainerd et al., 2001), as does retrieval practice (i.e., when retrieval of a subset of the noncritical lures are practiced before a formal recall or recognition test) (Bäuml & Kuhbandner, 2003; Starns & Hicks, 2004). Finally, in terms of language shifts, some researchers have found that bilingual participants develop more false memories for critical lures in their native language than in the second language (Sahlin, Harding, & Seamon, 2005), whereas others have found that false memories are higher for critical lures in participants' second language than for those in their native language (Marmolejo, Diliberto-Macaluso, & Altarriba, 2009).

Taken together, the results of the studies described above indicate that the mechanism of DRM false memories is complex. When conducting research or comparing relevant studies on DRM false memories, it is necessary to consider and control some of these factors based on the specific research questions of interest.

### **Potential Criticisms of the DRM Paradigm**

The most obvious experimental advantage of the DRM paradigm is that it is easy to manipulate and false memories generated by the DRM paradigm are robust. Despite these advantages, some researchers have criticised the ecological validity of false memories produced by the DRM paradigm and their relevance to real-world false memories (DePrince, Allard, Oh, & Freyd, 2004; Freyd & Gleaves, 1996; Pezdek & Lam, 2007). These researchers have argued that the false memories generated in the DRM paradigm are not the same as real-world false memories, such as memories of child abuse. Although reasonable, this concern is

not supported by the data. In a review, Gallo (2013) summarised three lines of research that provide evidence that DRM false memories are similar to false autobiographical memories. That is, Gallo has shown that some of the cognitive processes that contribute to DRM false memories also play a role in false autobiographical memories.

First, brain damage that affects autobiographical memories can also affect DRM false memories. For example, evidence from neuroimaging studies has shown that people who have suffered medial temporal lobe (MTL) damage exhibit autobiographical memory amnesia, and a corresponding decrease in DRM false memories (e.g., Schacter et al., 1996; Van Damme & d'Ydewalle, 2009). Conversely, people who have suffered prefrontal cortex (PFC) damage exhibit autobiographical confabulations, and an increase in DRM false memories (e.g., Basden, Reysen, & Basden, 2002; Budson et al., 2002; Ciaramelli, Ghetti, & Borsotti, 2009). Second, researchers have also shown that there is a positive correlation between DRM false memories and false autobiographical memories (Clancy, McNally, Schacter, Lenzenweger, & Pitman, 2002; Meyersburg, Bogdan, Gallo, & McNally, 2009; Platt, Lacey, Iobst, & Finkelman, 1998). Platt and colleagues (1998) were the first to report a relation between DRM false memories and autobiographical memories. In their study, participants were contacted on the night of the verdict in the O. J. Simpson trial, and were asked to complete a questionnaire regarding the details of when they heard about the verdict, such as where they were, what they were doing, and how they learned the news. Either 6, 12, or 18 months later, participants were contacted again and asked to complete the same questionnaire. In this way, the accuracy of their subsequent recollection could be established on the basis of their original answers. Approximately 18 months after the O. J. Simpson verdict, 82 participants who had participated in the original study were recruited to participate in a DRM study. Platt et al. found that there was a significant negative correlation between the degree of false recall in the DRM task and the accuracy of their autobiographical memory

for the Simpson verdict ( $r = -.30, p < .05$ ), and a marginally significant negative correlation between the degree of false recognition in the DRM task and accuracy on the autobiographical memory task ( $r = -.23, p = .05$ ).

The final line of research in the Gallo (2013) review regarding the relation between autobiographical false memories and DRM false memories involved the issue of recovered memories. As mentioned earlier, although the authenticity of recovered memories is impossible to determine, evidence has shown that it is more likely for people who claim to have recovered memories to make DRM memory errors than those who do not claim to have recovered memories. For example, Clancy et al. (2002) recruited 11 participants (5 women) who reported recovering memories of an alien abduction and 13 participants (6 women) who never claimed to have experienced alien abduction and tested both groups on the same DRM task. Clancy et al. found that individuals who had recovered memories of an alien abduction were more likely to make DRM false memories than were control participants who did not claim to have experienced alien abduction.

In summary, the three lines of research outlined by Gallo (2013) challenge criticisms of the DRM task as a model of autobiographical memory errors. Although caution is necessary when generalising the results of any laboratory research, the false memories generated by the DRM paradigm provide some insight into false memories that develop in the real world.

### **Theoretical Accounts for DRM False Memories**

How are false memories in the DRM task generated? The answer to this question reflects two perspectives. One perspective is the decision-based perspective, which includes *Shifting Criterion Theory* and *Demand Characteristics Accounts*. The other perspective is the memory-based perspective, which includes *Implicit Associative Response Theory (IAR)*, *Spreading Activation Theory (SAT)*, *Associative Activation Theory (AAT)*, *Activation-*

*Monitoring Theory (AMT)*, and *Fuzzy-Trace Theory (FTT)* (Gallo, 2013). According to the decision-based perspective, the reason why false memories are generated in the DRM task is that participants do not believe that the critical lure is part of the study list based on the memory of the corresponding studied words (e.g., a memory signal; Gallo, 2013). Rather, they believe that the critical lure shares the theme of the list so that they simply rely on their knowledge of the studied words to infer that all the theme-related words (i.e., critical lures) should be presented too. According to the memory-based perspective, on the other hand, participants believe that the critical lure is part of the study list based on their memory of the corresponding studied words, or their subjective experience that the critical lure has been presented in the study phase. Each of the current theoretical explanations for the generation of false memories in the DRM task are reviewed below.

### **Decision-Based Perspectives**

**Shifting criterion theory.** Miller and Wolford (1999) proposed shifting criterion theory to account for the generation of false memories in the DRM paradigm. According to this theory, the generation of false memories could only be due to responding strategies; participants strategically use a more liberal response criterion to any theme-related words (i.e., critical lures) than to unrelated words so as to maximise their test scores (i.e., more *old* responses to critical lures than unrelated words) because participants infer that the theme-related words are more likely to be presented than are unrelated words. To test this idea, Miller and Wolford designed two experiments where critical lures, related words (weakly related to list words), and unrelated words were either studied or unstudied. In the recognition test, the studied critical lures, related words, and unrelated words were regarded as targets while the unstudied critical lures, related words, and unrelated words were regarded as lures. This manipulation allowed for the assessment of sensitivity and response bias based on signal detection theory. The key finding was that the response bias for critical lures was more liberal

than that for related words and unrelated words (-1.19, -.35, and .42, respectively, with lower scores indicating more liberal bias), whereas no significant difference in sensitivity scores was found across different types of words (1.37, 1.63, and 1.34). This finding directly supported the idea that DRM false memories can be generated only through liberal criterion shifts in the retrieval process.

Despite Miller and Wolford's (1999) findings, shifting criterion theory cannot explain why participants who are encouraged to use a very strict criterion still show a high level of false memory. For example, Gallo, Roberts, and Seamon (1997) informed some participants about the false memory phenomenon and strongly encouraged them to avoid making errors. McDermott and Roediger (1998) went further with the same manipulation and provided an example to help participants understand the instructions and avoid false memories. However, in both studies, participants still developed false memories for critical lures and the false memory rate of critical lures was significantly higher than that of unrelated words. These data challenge Miller and Wolford's (1999) shifting criterion theory to account for the generation of false memories in the DRM paradigm.

**Demand characteristics account.** According to the demand characteristics account, the generation of false memories is due to participants' tendency to comply with experimental demands (Orne, 1962). Lampinen, Nenschatz, and Payne (1999) drew on Payne, Elie, Blackwell, and Neuschatz's (1996) study in which participants were asked to recall words that had been presented via a videotape by two speakers. Participants were required to assign a source (e.g., one of the two speakers) to the words they recalled without guessing. Payne et al. found that participants tended to attribute a source to the unrepresented critical lures 87% of the time, which was slightly less often than they attributed a source to the presented words (94%). Lampinen and colleagues (1999) predicted that this result was due to demand characteristics effect. That is, although participants were told not to guess

when they made source attributions, it is very likely that they still made source attributions even when they could not actually recall the source because they believed that this was what the experimenter wanted them to do (i.e., demand characteristics). If the source decisions about the critical lures were made in response to demand characteristics, Lampinen et al. (1999) further predicted that participants would change their source attributions at a rate which should be similar to the rate at which they changed their source attributions for unrelated words because, in both cases, the attributions should be mainly based on guessing. To test this idea, Lampinen et al. told participants that some of their source responses were incorrect and then asked them to change a specified number of the responses. Contrary to the prediction of the demand characteristics account, Lampinen et al. found that participants actually changed fewer attributions for the critical lures and for the studied words than they did for unrelated words. The finding reflected that source attributions made for critical lures seem to be more similar to source attributions made for studied words than to source attributions made for unrelated words. The finding further suggests that false memories cannot be simply accounted for by demand characteristics.

Taken together, neither of the decision-based accounts of DRM false memories are supported by empirical evidence. The rationale behind these accounts is controversial because it simply implies that false memories generated by the DRM paradigm do not reflect true memory errors but rather reflect participants' reporting strategies; participants strategically guess or infer that the strongly-related words (i.e., critical lures) were presented, therefore they can achieve good test scores by simply using a liberal response criterion for all words. Alternatively, participants assume that making source attributions for the unrepresented critical lures may be the experimental goal, so they succumb to the demand characteristics by doing what they think that experimenter wants them to. Although we cannot deny that retrieval processes or retrieval strategies are an important part of the DRM task, they are

definitely not the only cognitive mechanism that determines the production of false memories.

### **Memory-Based Perspectives**

**Implicit associative response theory (IAR).** Underwood (1965) offered one of the earliest theoretical accounts of associative-based false memories. He demonstrated that there were two kinds of implicit responses that are made to the to-be-remembered words. One is called the *representational response*, which refers to the response made directly to the words themselves; the other one is called the *implicit associative response (IAR)*, which refers to the response made to the un-presented words that are associated with the presented words. For example, the un-presented word *sleep* is associated with the presented word *bed*, if participants later report that *sleep* has been presented, according to IAR theory, *sleep* has occurred as an IAR to the representational response to the presented word *bed*. According to IAR theory, the generation of false memories occurs because people confuse an implicit associative response with a representational response. Drawing on Deese's (1959) idea on the crucial role of associative strength in false memories, IAR theory also proposes that an IAR occurring multiple times (e.g., three times) should confuse participants significantly more than an IAR occurring only once. That is, if the list includes not only *bed* but also *rest*, *awake* et al., and *rest* and *awake* induce the same IAR (i.e., *sleep*), it is more likely to yield false memories of *sleep* than a list that includes only *bed*.

The IAR account was first supported by Underwood (1965). He asked adult participants to listen to 100 words, one at a time, and for each word, participants had to judge whether or not it had been heard earlier. The key manipulation was that some un-presented words (e.g., critical lures) were related to the words that had been presented previously (e.g., *sweet* was a critical lure associated to the studied word *sugar*). Underwood's findings supported the predictions of IAR theory; participants were more likely to falsely recognise the critical lures

than the unrelated words, and the greater the number of the studied words, the greater the false memory effect (e.g., hearing *sugar*, *bitter*, and *candy* led to higher recognition rates for the critical lure *sweet* than did hearing only *sugar*).

Robinson and Roediger (1997) later designed two experiments to further test IAR theory. In their first experiment, participants were asked to learn 20 word lists with different numbers of studied words (e.g., 3-, 6-, 9-, 12-, or 15-word lists). After learning each word list, participants were required to recall as many of the words as they could. A recognition test was administered following recall of all 20 word lists. Robinson and Roediger found that as the number of studied words increased, both false recall and false recognition rates increased. They argued that the effect might be due to the list length rather than the number of associative words (note: the number of studied words equalled the number of associative words here), and the two factors were confounded in Experiment 1. To rule out this possibility in Experiment 2, Robinson and Roediger held the list length constant while varying the number of associative words within each list. They used the same lists from Experiment 1 but added unrelated words to some lists to make all lists 15 words in length. The false recall and false recognition rates again increased as the number of associative words increased. In short, the study supported IAR theory, and indicated that false memories elicited by the DRM task might occur because the critical lure was implicitly activated as an implicit associative response to the studied words; the more studied words, the easier it was to confuse the unrepresented critical lure with the presented studied words, resulting in a more robust false memory effect.

Another line of research providing more direct evidence for IAR theory is that false memories occur even in a very fast presentation condition. For example, Seamon, Luo, and Gallo (1998) conducted two experiments in which participants studied eight DRM word lists presented at a fast rate of 20 ms per word, or a slow rate of 2 s per word. They found that

even in the fast presentation condition where participants can hardly remember the studied words, they still falsely recognised the critical lures either in a between-subjects design (Experiment 1) or in a within-subjects design (Experiment 2). Seamon et al. concluded that the generation of false memories at test was mainly due to the process of implicit associative responses to the semantically-related studied words at study.

Although there is considerable empirical evidence to support IAR theory, this theoretical explanation cannot account for the persistence of false memories over time (McDermott, 1996; Seamon, Luo, Kopecky, et al., 2002), especially given that implicit associative activation is thought to decay quickly (Anderson, 1983). Given this, researchers have proposed that the critical lures might not only be activated through implicit association, but also through semantic memory-based processes, which could have a more long-lasting effect (Gallo & Roediger, 2002; Roediger, Balota, & Watson, 2001).

**Spreading activation theory (SAT).** Drawing on a spreading activation theory of semantic processing (Anderson, 1983; Collins & Loftus, 1975), Roediger, Balota et al. (2001) proposed spreading activation theory to explain the generation of false memories. According to this theory, there is a mental dictionary (or lexicon) that stores words and concepts. These words and concepts are thought to be semantically organised so that words with similar meanings have stronger associations than do words that are weakly related. Every word has its corresponding node in the mental lexicon. Processing one word activates the corresponding node, and the activation then spreads to surrounding nodes (Anderson, 1983; Collins & Loftus, 1975). This process results in the activation of semantically-related words and concepts. According to SAT, the generation of false memories in the DRM paradigm occurs because studied words are initially semantically activated, the activation then spreads to semantically-related, but non-presented critical lures. That is, learning the word *bed* in the study phase activates its semantic meaning. The semantic activation of *bed* spreads to the

semantically-associated, but non-presented word, *sleep*, so that *sleep* is also activated and is more likely to be falsely recalled and recognised during the test phase.

Spreading activation theory has been supported by ample evidence (e.g., Howe, Wimmer, Gagnon, & Plumpton, 2009; McDermott & Watson, 2001; Roediger & McDermott, 1995). More importantly, the spreading-activation process between conceptual representations (i.e., nodes) is regarded as the basis of other associative theories, including associative activation theory and activation monitoring theory.

**Associative-activation theory (AAT).** Spreading activation theory emphasises the role of semantic or conceptual association between studied words and critical lures in the production of false memories, whereas the concept of “association” in associative-activation theory (AAT) is more broad, including not only conceptual associations, but also phonological association, orthographic association, property association, and so forth. According to AAT, backward associative strength, which has been shown to be one of the main predictors of false memories, is determined by the relation between studied words and critical lures on the basis of any one dimension of these associations or many overlapping associations (Howe, Wimmer, Gagnon, et al., 2009). AAT resonates with SAT in terms of emphasising the important role of the mental lexicon on false memory production. The related concepts are organised together in the mental lexicon so that one activated concept could further activate its related concepts. Because of their close links, some of these related concepts have not been presented, but are still erroneously activated, resulting in false memories (Gallo, 2013; Howe, Wimmer, Gagnon, et al., 2009). Based on AAT, by continuously learning a series of related words, activation of the critical lures becomes so strong that the critical lures come to mind, and are encoded together with the studied words during the study phase. The process of the summation of activation may be one of the mechanisms that accounts for the long-lasting effect of false memories. That is, the

representation of critical lures could persist over a period of time, especially if participants falsely rehearse the critical lures as having been presented. Alternatively, the long-lasting effect of false memories may also reflect the possibility that the associative activation of critical lures could occur at test (e.g., Coane & McBride, 2006; Marsh & Dolan, 2007). According to this idea, the critical lure could be activated by recalling the studied words in the recall test or by presenting studied words in the recognition test.

AAT also provides an explanation for the age-related increase in false memories. According to AAT, false memories increase with age due to changes in the content and structure of children's knowledge base (e.g., reorganisation of knowledge, increase of associations). This, combined with increasing experience in using concepts, causes increases in the level of automaticity with which children access or activate associative information. In other words, with increased knowledge and experience, the difference in false memories between children and adults is mainly due to the different degree of automaticity with which they access or activate associative information in their knowledge base. As children develop knowledge through learning and practice, they develop a better memory network in which the associative links among related concepts become better organised and integrated. As this happens, related concepts are easier to access (Howe, 2005, 2006; Howe, Wimmer, Gagnon, et al., 2009; Otgaar, Howe, Peters, Smeets, & Moritz, 2014). Evidence supporting the AAT explanation of the age-related increase in false memories will be reviewed in detail in Chapter 2.

Because AAT derives from earlier associative theories (Deese, 1959; Underwood, 1965), evidence showing a positive correlation between false memories and associative strength, especially backward associative strength, also supports AAT (Brainerd, Yang, Reyna, Howe, & Mills, 2008; Roediger, Watson, McDermott, & Gallo, 2001). For example, Roediger, Watson, et al. (2001) found that among seven factors that potentially predicted the

creation of false memories, BAS was the strongest predictor, exhibiting a significant positive correlation with false memories. Additional research has also shown that associative strength is even more important than semantic gist in terms of producing false memories (Buchanan, Brown, Cabeza, & Maitson, 1999; Dewhurst, 2001; Howe, Wimmer, & Blease, 2009; Hutchison & Balota, 2005; Park, Shobe, & Kihlstrom, 2005; Pierce, Gallo, Weiss, & Schacter, 2005; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000). In one study, for example, Buchanan et al. (1999) directly compared the false recognition rate produced by the DRM lists and by categorised lists (e.g., *dog*, *cat*, and *sheep* are the list words for the critical lure *animal* in a categorised list), which were established to be high in semantic gist. They found that the false recognition rate for critical lures was higher in the DRM lists (.37) than in the categorised lists (.19). Likewise, in the word-stem completion task, participants are usually instructed to complete stems with the first word that comes to mind. In one study using this task, Smith, Gerkens, Pierce, and Choi, (2002) employed 8 of the 28 stems corresponding to the critical lures (e.g., if the critical lure is *sleep*, the corresponding stem may be *sle*). Smith et al. (2002) found that the implicit priming effects resulting from the word-stem completion task were shown only for the DRM lists rather than for the categorised lists. They argued that the finding was because the word-stem completion task somehow reflected the associative activation of critical lures; the DRM lists had higher associative strength than did the categorised lists, therefore the corresponding priming effects were only observed for DRM lists.

Park et al. (2005) has also argued that, in addition to the associative strength of the DRM word lists, associative structure is also crucial in the production of false memories. There are at least two types of associative structures in our memory: *coordinate* (or horizontal) associative words at the same level of categorisation (e.g., *window*, *door*, and *pane*); and *subordinate* (or vertical) associative words at different levels of categorisation

(e.g., *apple, orange, and fruit*) (Mandler, 1979). Park et al. (2005) found that false memory was greater when studied words and critical lures were at a coordinate level (e.g., *thread, pin* and *eye* for the critical lure *needle*) than at a subordinate level (e.g., *apple, orange, and kiwi* for the critical lure *fruit*), in the absence of any difference in associative strength.

As mentioned above, AAT extends earlier associative theories by proposing that not only conceptual associations, but also phonological associations, orthographic associations, and so on, can result in the production of false memories. False memories can be elicited by one dimension of these associations or by associations that overlap. According to AAT, the rate of false memory should be greater if it is caused by overlapping associations than if it results from only one dimension of associations. Watson, Balota, and Roediger (2003) provided direct evidence to support this assumption. In their first experiment, words were added to the four original DRM word lists. Take the *sleep* list, for example, the original associative words included *bed, rest, awake, tired, dream, scrub, wake, snooze, dazzle, blanket, doze, and slumber*. In the control condition, three unrelated words, *load, file, and honor*, were added to the original list, increasing the list length to 15. In the SR1 condition, the unrelated word *load* was replaced by the phonologically-related word, *keep*. Similarly, in the SR2 condition, the other two unrelated words, *file* and *honor*, were changed to *weep* and *steep*; in the SR3 condition, the hybrid list consisted of the 12 original words and the three phonologically-related words, *weep, keep, and steep*. Correspondingly, on the basis of the words in the control condition, in the SS1 condition, the word *load* was changed to the semantically-related word *snore*; in the SS2 condition, the words *file* and *honor* were replaced by *drowsy* and *pillow*, and finally, in the SS3 condition, the three semantically-related words *drowsy, snore, and pillow* replaced the unrelated words, *file, load, and honor*.

Watson et al. reported that there was a greater increase in false recall when phonologically-related words were added to the original DRM word list than when

semantically-related words were added. This outcome was especially true when the lists involved three phonologically-related words: the false recall rate for critical lures (.49) was almost double the false recall rate produced by lists with pure semantically-related words (.24). Watson et al. replicated these findings in two additional experiments where they compared the degree of false memory created by the pure lists (either semantic or phonological) with that produced by the hybrid lists. They argued that these over-additive effects might be due to the overlapping associative activation; that is, in addition to semantic activation, phonological activation occurring in the hybrid lists might provide additional access to the critical lures.

Although there is ample evidence to support AAT's propositions, there are three limitations that should be noted here. The first involves the limited scope of the AAT explanation. For example, Brainerd, Reyna, and Ceci (2008) argued that the main explanation of AAT is confined to word-list based tasks (i.e., the DRM task); that is, AAT cannot account for the mechanism of false memories produced by other materials (e.g., pictures; Israel & Schacter, 1997). Second, AAT explains the mechanism under which false memories occur, however, it does not provide any prediction for the ways in which false memories would decrease or be eliminated (*error-suppression mechanisms*; Brainerd, Reyna et al., 2008). Finally, AAT ignore the role that retrieval strategies (i.e., monitoring) in the test phase have on the generation of false memories. It is worth noting that retrieval strategies differ from the ones that are proposed by decision-based theories of the generation of false memories. Here, the use of retrieval strategies, especially referring to monitoring processes, initially rely on encoding and storage of to-be-remembered information. Based on encoding of information, monitoring processes may play a role in inhibiting the production of false memories. On this point, the activation-monitoring theory (AMT) to be discussed next, makes up for AAT.

**Activation-monitoring theory (AMT).** Activation-monitoring theory, as its name suggests, emphasises the combined effect of both activation and monitoring processes on the generation of false memories (Roediger, Watson, et al., 2001). The activation component derives from Underwood's (1965) IAR theory, which contends that activation occurs during the presentation of studied words and spreads to concepts that are not presented, but that are semantically related to studied words (i.e., critical lures) throughout the semantic network. Roediger, Watson, et al. (2001) argue that this activation alone cannot guarantee the generation of false memories because monitoring of memories might also play a role. The idea of monitoring was adapted from Johnson's source-monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981). According to Johnson and colleagues, there are differences between events that actually happen and those that are internally-generated. For example, events that we actually experience have more perceptual details and contextual information, whereas internally-generated events are less likely to have these features, but are more likely to include more cognitive operations (i.e., imagining; Johnson et al., 1993). The goal of monitoring is to take advantage of these differences to distinguish between events that actually happened from those that did not. Moreover, the activation process and monitoring process are not independent. Strong activation may lead unpresented information to share many of the features related to presented information. In this circumstance, monitoring becomes difficult and source-monitoring errors may arise, increasing false memories. In contrast, if the perceptual details and features of the to-be-remembered information are very distinctive, source monitoring becomes easy, decreasing false memories. Although the monitoring process is typically discussed with respect to retrieval, Roediger, Watson, et al. (2001) contend that monitoring of encoding processes might also exist. Research has shown that explicit warnings about the generation of DRM false memories are more effective when those warnings are presented prior to study than

when those warnings are presented just prior to test. Researchers have argued that this finding is obtained because monitoring processes may occur both at encoding and at retrieval in the warning-before-study condition, but monitoring processes may only occur at retrieval in the warning-after-study condition (Gallo et al., 1997; McDermott & Roediger, 1998).

There is considerable experimental support for AMT. For instance, researchers manipulating the presentation duration of studied words have found that false memories are reduced when word presentation duration is increased (McDermott & Watson, 2001; Seamon et al., 2000). According to AMT, this finding occurs because monitoring processes are more effective at reducing false memories when people are given more time to process information. Likewise, false memories are reduced when the studied words are presented several times (i.e., five times) rather than once (Benjamin, 2001; McDermott, 1996; Seamon, Luo, Schwartz, et al., 2002). It has been argued that increasing the number of learning trials enhances the opportunity for participants to distinguish the words that have actually been presented from the words that are internally generated.

Although AMT provides solid theoretical accounts for the results of a large number of studies, it does not account for all of the findings. In particular, AMT does not account for the finding that false memories are more persistent than true memories over a delay; this limitation is a common feature of all associative theories except AAT (Brainerd & Reyna, 2005; Knott, Dewhurst, & Howe, 2012). For example, McDermott's (1996) participants in first experiment, were asked to do a typical DRM false recall task. The key manipulation was that participants were required to return 2 days later to recall the words again. No matter whether the word had been recalled during the original test or not, participants were still required to recall as many words as they could. McDermott (1996) found that, although true and false recall rates were both reduced after the 2-day delay, the false recall rate for critical lures (.20) was still higher than that for studied words (.12). This persistent effect of false

memories cannot be accounted for by AMT. In fact, it leaves some space for another important theory — fuzzy-trace theory (Brainerd & Reyna, 2005; Reyna & Brainerd, 1995).

**Fuzzy-trace theory (FTT).** According to Brainerd, Reyna, et al. (2008), AAT is a one-process account of false memory and cannot explain “error-suppression mechanisms,” however, fuzzy-trace theory (FTT), as a dual-process theory, can explain the mechanism under which false memories would be reduced. According to FTT, there are two representations of information (or traces) in memory (Reyna & Brainerd, 1995). Verbatim traces represent the specificity of information (e.g., the position, pronunciation, and word length of each studied word in the DRM paradigm) (Brainerd & Reyna, 2005). Gist traces, on the other hand, refer to the general semantic meaning of information (e.g., gist-related critical lures in DRM word lists). According to FTT, the generation of false memories is mainly due to gist extraction. Gist extraction is a key term in FTT and denotes the process by which the gist or theme of a word list is encoded and all of the words in a list can be linked together. DRM false memories primarily reflect a process of gist extraction because a critical lure can be regarded as the gist of a word list and all of the words in the list are semantically related to the critical lure. In this sense, the extraction of the gist traces equals the retrieval of the critical lure in the DRM paradigm. True memories, on the other hand, rely on retrieval of both verbatim and gist traces because presented information tends to possess perceptual details as well as the semantic gist of information at the same time.

FTT proposes four principles to predict and account for the various effects found in empirical studies. First, verbatim and gist traces are stored in parallel, which means the processing and storage of verbatim traces proceeds simultaneously with the processing and storage of gist traces (Brainerd & Reyna, 2005). Because of this, participants can store the gist of information irrespective of whether they already retain surface details of information. Second, verbatim and gist traces are retrieved separately; which verbatim or gist traces are

finally accessed, depends on the retrieval cues provided. For example, Brainerd and Reyna (2002) suggested that providing a presented word is an effective retrieval cue for verbatim traces, whereas providing a new word consistent with a gist or theme of a presented word list is an effective retrieval cue for gist traces. Third, verbatim traces decline much more rapidly than gist traces as time goes by. This is because verbatim traces are representations of surface details of information, which becomes more and more obscure over time while the representations of gist information fade relatively slowly (Brainerd & Reyna, 2005; Payne et al., 1996; Toggia, 1999). Finally, although AAT provides a solid theoretical explanation for age-related changes in false memory, in fact FTT was the first to predict the counterintuitive age-related increase in false memory in the DRM paradigm, widely known as developmental reversals in DRM false memories. According to FTT, the age-related increase in DRM false memories is due to the ability to access and extract the gist of DRM word lists developing with age. In essence, young children's immature gist memory protects them from false memory errors in the DRM paradigm. So far, a number of studies have been confirmed the age-related increase in false memories between early childhood and young adulthood in the DRM paradigm (for a review, see Brainerd, Reyna, et al., 2008). In Chapter 2, I will review more extensively the relevant studies that support the FTT explanation of the age-related increase in false memories.

As mentioned earlier, the explanation for the persistence of false memories confers FTT an advantage over associative theories. In addition, FTT explains other research findings, where the experimental manipulations are thought to encourage gist extraction. In one study, for example, Gunter, Ivanko, and Bodner (2005) included some related lures (words from each studied word list) and unrelated lures (words from each nonstudied word list) in their recognition test. They found that the false recognition rate for critical lures was much higher in the unrelated-lure context (.72) than it was in the related-lure context (.57).

According to FTT, this finding occurs because including unrelated words in the recognition test largely encourages gist-based responding, which is assumed to increase false memories (Gallo, 2013), but false memories also occur for abstract pictures which are thought to be perceptually similar but without preexisting semantic associations (Hutchison, 2003; Hutchison & Balota, 2005; Koutstaal, Schacter, Verfaellie, Brenner, & Jackson, 1999). For example, to obtain perceptually-similar abstract pictures, Koutstaal, Schacter, Verfaellie, et al. (1999) initially created prototypes for different categories of pictures according to a set of construction rules and exemplars belonging to the same category were created. There were four category sizes (one, three, six, or nine) in terms of the number of pictures presented at study. In the study phase, participants were asked to rate the complexity of each picture on a 9-point scale. After a 5-minute distraction task, participants completed a *old/new* recognition test. Koutstaal and colleagues found that participants falsely recognised the perceptually-similar abstract pictures, and levels of false recognition were lower when the number of studied pictures was smaller (i.e., one or three) compared to when the number of studied pictures was relatively larger (i.e., six or nine). Although Koutstaal, Schacter, Verfaellie, et al. (1999) did not use the typical DRM word lists, their findings suggested that the generation of false memories is due to gist extraction of information, irrespective of whether the gist of the information is semantically-based or perceptually-based.

In spite of its explanatory power, however, FTT does not adequately explain all of the research findings. For example, FTT cannot explain why false memories for critical lures are accompanied by a strong subjective experience (i.e., *remember* judgments) (Payne et al., 1996; Roediger, McDermott, & Robinson., 1998), particularly as Brainerd and Reyna (2002) stipulated that true memories should be accompanied by recollection of surface details (i.e., *remember*) while false memories should be accompanied by a feeling of familiarity (i.e., *know*). To respond to this criticism, Brainerd et al. (2001) proposed the term, “phantom

recollection,” to account for the strong subjective experience associated with false memories. The procedure conducted to investigate phantom recollection is called conjoint recognition; participants are instructed to answer a verbatim question, a gist question, or a verbatim-plus-gist question for each test word (Brainerd, Reyna, et al., 2008). The general pattern of answers suggests that critical lures are experienced as if they were studied words (Brainerd et al., 2001).

In addition, FTT does not provide an operational definition of gist so it cannot explain why some word lists cause high levels of false memories while others do not (Gallo, 2013; Roediger, Balota, et al., 2001). It is likely that some word lists have more gist relative to others, however, this raises another question: why do these word lists have so much gist? Roediger, Balota, et al. (2001) has suggested that the interpretation of gist might be related to backward associative strength (BAS): “The more the list items are associated to the critical item, the more a gist representation of the critical item is created” (p. 395). Likewise, Gallo (2013) believed that to account for false recall effects, FTT has to rely on associative accounts to explain how critical lures are mentally generated in mind. In this sense, the difference between associative theories of false memory (e.g., AAT) and FTT becomes blurred.

Based on the literature reviewed above, I have summarised in Table 1.1 the main evidence for and against each associative theory and the fuzzy-trace theory. Recall that associative theories are closely related to each other. Thus, evidence supporting or contradicting one associative theory can also be seen as evidence for or against another associative theory. Taken together, the review of memory-based theories of false memory indicates that so far there is no single theory that can explain all of the effects reported in the DRM paradigm; in some cases, associative theories (i.e., *IAR*, *SAT*, *AAT*, and *AMT*) provide a more suitable explanation for the false memory phenomenon, while in other cases, fuzzy-

trace theory provides a better explanation. Perhaps more importantly though, it is worth noting that these theories are not mutually exclusive; it might be possible to incorporate associative theories with fuzzy-trace theory to some extent to provide a better understanding of the mechanism responsible for false memories in the DRM paradigm.

Table 1.1.

*The Evidence For and Against Each Associative Theory and The Fuzzy-Trace Theory*

Theory	Evidence For	Evidence Against
Implicit Associative Response Theory (IAR)	<ul style="list-style-type: none"> <li>As the number of studied words (associative words) increase, false memories increase (Robinson &amp; Roediger, 1997; Underwood, 1965).</li> <li>False memories occur even during a very fast presentation condition (Seamon et al., 1998).</li> </ul>	<ul style="list-style-type: none"> <li>Given that implicit associative activation should decay quickly, IAR cannot explain the persistence of false memories (McDermott, 1996; Seamon, Luo, Kopecky, et al., 2002).</li> </ul>
Spreading Activation Theory (SAT)	<ul style="list-style-type: none"> <li>A positive correlation between BAS and false memories (Brainerd, Young, et al., 2008; Roediger, Watson, et al., 2001).</li> <li>DRM lists produce higher false memories than do categorised lists (Park et al., 2005; Pierce et al., 2005).</li> </ul>	<ul style="list-style-type: none"> <li>Increasing the presentation duration of studied words may not necessarily increase false memories (McDermott &amp; Watson, 2001).</li> <li>Repetition of studied words may not necessarily increase false memories (e.g., Seamon, Luo, Schwartz, et al., 2002).</li> </ul>
Associative-Activation Theory (AAT)	<ul style="list-style-type: none"> <li>Associative strength is more important than semantic gist in the generation of false memories (Dewhurst, 2001; Howe, Wimmer, &amp; Blease, 2009; Hutchison &amp; Balota, 2005; Seamon et</li> </ul>	<ul style="list-style-type: none"> <li>False memories can be created by other materials for which there are no preexisting semantic associations (e.g., abstract pictures; Israel &amp; Schacter, 1997; Koutstaal, Schacter, Verfaellie, et al., 1999).</li> </ul>

	<p>al., 2000).</p> <ul style="list-style-type: none"> <li>• Associative structures play a role in producing false memories (Park et al., 2005).</li> <li>• Overlapping associative activations increase false memories (Watson et al., 2003).</li> </ul>	
<p>Activation-Monitoring Theory (AMT)</p>	<ul style="list-style-type: none"> <li>• Warnings reduce false memories, especially when warnings are presented prior to study (Gallo et al., 1997; McDermott &amp; Roediger, 1998).</li> <li>• False memories are reduced as the presentation duration increases (McDermott &amp; Watson, 2001; Seamon et al., 2000).</li> <li>• False memories are reduced when the studied words are presented multiple times (Benjamin, 2001; Seamon, Luo, Schwartz, et al., 2002).</li> </ul>	<ul style="list-style-type: none"> <li>• False memories are more persistent than true memories over a delay (Brainerd &amp; Reyna, 2005; Knott &amp; Thorley, 2014).</li> </ul>
<p>Fuzzy-Trace Theory (FTT)</p>	<ul style="list-style-type: none"> <li>• Over time, false memories are more persistent than true memories because verbatim traces decline much more rapidly than do gist traces (Payne et al., 1996; Toggia, 1999).</li> <li>• Part-list cuing reduces false memories of critical lures (Brainerd &amp; Reyna, 2002; Kimball et al., 2008; Kimball &amp; Bjork, 2002).</li> <li>• Manipulations that encourage gist extraction increase false memories (Brainerd et al., 2001; Gunter et al., 2005).</li> </ul>	<ul style="list-style-type: none"> <li>• False memories of critical lures usually occur along with a strong subjective experience (Payne et al., 1996; Roediger et al., 1998).</li> <li>• No operational definition of the term “gist” and cannot explain how critical lures are mentally generated in mind (Gallo, 2013; Roediger, Balota, et al., 2001).</li> </ul>

## Chapter 2

### Age-Related Differences in DRM False Memory

“Children are the most dangerous of all witnesses.”

(Whipple, 1911, p. 308)

“...cognitive aging is often associated with increased susceptibility to various kinds of false recollections.”

(Schacter, Koutstaal, & Norman, 1997, p. 229)

Despite a large volume of research, the cognitive mechanism responsible for false memories in the DRM paradigm has not yet been determined. In general, associative theorists (i.e., IAR, SAT, AAT, and AMT) believe that the DRM false memory effect is primarily due to associative-activation processes. Furthermore, theorists who support AMT emphasise the role of retrieval strategies (i.e., monitoring processes) on the generation of false memories. Alternatively, theorists who support FTT believe that the DRM false memory effect is primarily due to encoding and retrieval of thematic or gist information.

What all theorists share in common, however, is an appreciation that these cognitive processes, including associative activation, monitoring, and gist processing, change with age. Relative to young adults, associative processes are not well developed in children, but are intact in older adults; monitoring processes are limited in children, but are impaired in older adults; gist processing is immature in children, but is either intact or enhanced in older adults (e.g., Balota et al., 1999; Brainerd & Reyna, 2005; Gallo, Bell, Beier, & Schacter, 2006; Henkel, Johnson, & De Leonardis, 1998; Howe, 2005, 2006; Tun, Wingfield, Rosen, & Blanchard, 1998). Because the cognitive processes that are involved in false memories change with age, associative theories and FTT may make different predictions regarding age-related differences in DRM false memories. In this sense, developmental studies may provide

an opportunity to pit one theory against the other, and yield additional insights about why spontaneous false memory might occur. In Chapter 2, I will review what we know about age-related changes in DRM performance and what those studies contribute to our understanding of the underlying cognitive mechanisms involved in the creation of DRM false memories.

### **Studies with Older Adults**

A large body of research has shown that older adults (i.e., 60- to 85-year-olds) exhibit an increase in false memories in the DRM paradigm (for a review, see Gallo et al., 2006). At least two cognitive mechanisms are assumed to underpin this age-related increase. First, older adults' ability to process the general features or gist of information may be equivalent or superior to that of young adults (e.g., Kensinger & Schacter, 1999; Koutstaal & Schacter, 1997; Koutstaal, Schacter, Galluccio, & Stofer, 1999; Tun et al., 1998). Second, older adults' ability to monitor whether an event happened or not may be impaired relative to that of younger adults (e.g., Balota et al., 1999; Butler, Mcdaniel, Dornburg, Price, & Roediger, 2004; Raz et al., 1997). Taken together, either one or both of these mechanisms are hypothesised to make the older adults more susceptible to false memories.

In one study with older adults, Tun et al. (1998) manipulated the requirements of the DRM recognition test in such a way that in some circumstances, participants were encouraged to rely on a gist-based strategy (Expt. 1), whereas in other circumstances, participants were required to make verbatim processing responses based on item-specific information (Expt. 2). The authors hypothesised that there would be no reliable difference in the magnitude of false memories when the test condition promoted a gist-based strategy, but that older adults would produce more false memories than younger adults when they were encouraged to use a verbatim-based strategy because under this condition, older adults would be more likely to continue to rely on the general features or semantic gist of information, compared to younger adults.

In Experiment 1, participants ranged in age from 18 to 22 years (younger adults) and from 60 to 85 years (older adults). Participants were asked to remember 10 word lists, each of which contained 12 words. After hearing each list, participants were asked to recall as many words as they could remember from the list and they were then given a 14-word recognition test. Half of the test words had been presented during the study phase while the other half consisted of the corresponding critical lure and unrelated words, which had not been presented. In contrast to a typical recognition test, the key manipulation here was that participants were allowed to use a gist-based strategy; they could respond *yes* to all of the words that were consistent with the theme of the list, and *no* to all of the words that were inconsistent with the theme of the list. In addition to accuracy, the researchers also recorded response latency during the recognition test.

During the recall test, Tun et al. found that older adults recalled fewer studied words than did younger adults, but older adults recalled as many critical lures as did younger adults. Moreover, the level of true and false recognition was consistent between young and older adults. As for response latency, participants in both age groups made *yes* responses to critical lures as fast as those to studied words. However, both younger and older adults took longer to reject critical lures than to reject unrelated words. These findings are consistent with the view that when the DRM task requires gist processing, older adults perform equivalently to younger adults.

In Tun et al.'s (1998) second experiment, the strategy was changed to encourage participants to focus on item-specific information rather than gist-based information. To do this, the test words that had not been presented during the study phase consisted of not only the critical lure and unrelated words, but also three unrepresented words that were weakly associated with the studied words. The inclusion of the weakly-associated words encouraged participants to respond based on the features of the individual words rather than their

semantic associations. Tun et al. predicted that older adults would show faster response latencies to critical lures and to weakly-associated words than would younger adults, but slower response latencies to reject these words. Consistent with the findings from their first experiment, Tun et al. found that the older adults recalled fewer studied words than did the younger adults but the level of false recall was similar between the two age groups. In addition, older adults in the second experiment were more likely than were younger adults to falsely recognise critical lures and weakly-associated words. As for response latency, younger and older adults showed a different pattern; younger adults took more time to falsely recognise critical lures than they did to recognise studied words, whereas there was no significant difference in response latency to the two types of words for older adults. Inconsistent with the authors' predictions, there was no reliable difference between the two age groups in terms of response latency to falsely recognise critical lures or to reject critical lures.

In a third experiment, instead of manipulating the recognition test, Tun et al. manipulated the presentation format of the word lists. More specifically, 20 words from four different word lists were presented randomly to make it difficult for participants to find the theme. The fact that the words came from different lists further complicated the process of gist extraction because there were fewer items to cue a particular theme. Tun et al. predicted that the results of Experiment 3 would replicate those of Experiment 2; older adults would continue to report more false memories than would younger adults. The recall results were consistent with those found in the previous two experiments, with older adults recalling fewer studied words, but as many critical lures as the young adults. However, contrary to the prediction, although younger adults exhibited higher true recognition for studied words compared to older adults, there was no reliable difference in false recognition rates.

Although an age-related increase in false recognition was not consistently observed by Tun et al. (1998), their general notion that older adults' tendency to process the gist of information results in higher false memories relative to younger adults has been supported by a number of subsequent studies (e.g., Kensinger & Schacter, 1999; Koutstaal, Schacter, Galluccio, et al., 1999; Thomas & Sommers, 2005). For instance, Kensinger and Schacter (1999), drawing on McDermott's (1996) study, assumed that repetition of studied words would increase the accessibility of both gist and item-specific information. On this basis, they predicted that older adults' true memories would be increased because true memories rely on retrieval of both gist and item-specific information. If the increase in true memories in older adults depended more on gist information, then compared to younger adults, older adults would be less likely to use item-specific information to suppress false memories. In this sense, the reduction of false memories in older adults as a function of repetition of studied words may not be as significant as that in younger adults.

Consistent with their predictions, Kensinger and Schacter (1999) found that providing older adults with five study/test trials did not reduce false recall and false recognition rates compared to a single study/test trial. Younger adults, on the other hand, showed a reliable decrease of false memories after five study/test trials relative to a single study/test trial. These results provide further evidence that older adults are more dependent on gist memory, and less able to take advantage of verbatim memory to suppress false memories relative to younger adults.

Gallo et al. (2006) reviewed the results of 18 studies in which false recall rates were compared between younger and older adults and 21 studies where false recognition rates were compared. They found that, while a third of the 18 studies showed little or no age-related increase in false recall between younger and older adults, over half of the 21 studies showed little or no age-related increase in false recognition between the two age groups.

Based on the results of their review, Gallo et al. (2006) argued that the age-related increases in false memory might be more pronounced in false recall than in false recognition because recognition tests rely on familiarity/gist-based processing, which is intact in the elderly. Although the particular memory test (i.e., recognition or recall) may be a factor that determines whether age-related increases are found in a given study, the mechanism that underlies age-related increases in false memory is likely to be older adults' tendency to process gist information.

The studies reviewed so far have used a typical recall test and/or an *old/new* recognition test. In other studies, researchers have used measures of recollective experience to investigate the mechanism responsible for age-related increases in false memory during adulthood. For example, Norman and Schacter (1997) compared the recollective experience of younger ( $M_{age} = 19$  years) and older adults ( $M_{age} = 68$  years) in response to list words and crucial lures. To do this, when participants reported that they *remembered* a word, the researchers asked them to write down what they remembered about the presentation of the word at the time of study (e.g., remembering how the word sounded). Norman and Schacter assumed that if participants' false memories relied on feelings of familiarity rather than recollecting specific information, asking them to further explain *remember* responses in detail would help them reject their false *remember* responses. In contrast, if participants indeed recollected specific information when they made *remember* judgments to critical lures, then the proportion of remember responses would not change.

Norman and Schacter (1997) reported three main findings. First, consistent with previous studies, older adults were generally more susceptible to false memories than were younger adults. Second, both younger and older adults still made *remember* judgments to critical lures even when they were encouraged to focus on the details of their recollections. Finally, no reliable difference was detected between younger and older adults in terms of the

explanations of *remember* responses. That is, all participants primarily retrieved associative information (e.g., *thief*: heard word *stop*, thought of screaming *stop thief*) rather than sensory and contextual details to both studied words and critical lures, although younger adults retrieved sensory and contextual details to studied words relatively more frequently than did older adults.

In a second experiment in the same study, Norman and Schacter asked participants to answer six questions for each word that they judged as old in the recognition test. These questions involved memory for sound, list position, neighbouring words, reactions, associations, and thought, respectively. Participants provided their memory assessment by using the numbers from 1 to 7, with 1 referring to *no memory* and 7 referring to *vivid memories*. The results replicated those found in the first experiment; regardless of age, participants remembered associative information better than other detailed information (i.e., sound, list position, and reactions etc.). Furthermore, younger adults showed larger differences in terms of remembering perceptual and contextual details between true and false memories than did older adults. These results indicated that older adults might be more likely to mistakenly attribute perceptual and contextual details associated with studied words to critical lures. In other words, the associative activation process may be intact in older adults, but monitoring abilities may deteriorate with age.

In terms of monitoring processes, researchers have distinguished between two monitoring processes, disqualifying monitoring and diagnostic monitoring (Gallo et al., 2006; Gallo, Weiss, & Schacter, 2004). Disqualifying monitoring refers to the rejection of false memories based on the recollection of logically-inconsistent information (e.g., “I did not see the word because I remember that I generated it on my own”). Through this “recall-to-reject” process, false memories tend to be reduced. Diagnostic monitoring, on the other hand, refers to the rejection of false memories based on the inconsistency of these memories with

expectations (e.g., “I did not see the word because I would have some impression if I had seen it”). Many studies have investigated these two monitoring processes, and there is consensus that older adults are impaired in their ability to adopt disqualifying monitoring to suppress the generation of false memories (for a review, see Gallo et al., 2006).

One method that has been frequently used to investigate a disqualifying recall-to-reject process is to warn participants about the nature of false memories and ask them to avoid being tricked by the critical lures. Previous studies have shown that warnings prior to study significantly reduce young adults’ false memories (Gallo et al., 1997; McDermott & Roediger, 1998). More importantly, participants who could effectively take advantage of warning instructions later reported that they were able to figure out some critical lures at study and tag them as “unpresented” (e.g., “The word was not presented because I remember thinking that it was the common word;” Gallo et al., 1997; Gallo, Roediger, & McDermott, 2001; Neuschatz, Benoit, & Payne, 2003). In this way, participants could easily reject critical lures at test.

Using a similar technique, researchers have also examined age-related differences in disqualifying recall-to-reject monitoring. Considering older adults’ impairment in the use of recall-to-reject strategies, researchers assumed that older adults would be less successful than younger adults in taking advantage of study warnings to reduce their false memories, but it turns out that this is not necessarily the case. For example, Watson, McDermott, and Balota (2004) asked younger and older adults to study four 15-word lists. For half of the participants, the warning instructions were presented prior to study while for the other half, no warning cues were provided. Considering only the first study-test trial, Watson et al. found that the warnings group exhibited reduced false recall rates both in younger and older adults compared to the no-warning group. Inconsistent with the prediction, however, older

adults (.25) were as successful as younger adults (.27) in using warnings to reduce their false recall rates.

In another study, McCabe and Smith (2002) conducted recognition tests to investigate the effect of aging on the use of warnings. The findings of their first experiment were consistent with those found by Watson et al. (2004), showing that both younger and older adults were able to use study warnings to reduce false recognition rates and that all participants used recall-to-reject strategies during the process. However, in their second experiment, McCabe and Smith changed the warning instructions which did not explicitly require participants to identify the critical lures during the study. They found that younger adults were more likely to take advantage of warnings to reduce false recognition. Gallo et al. (2006) later reported a similar age-related increase in impairment in recall-to-reject monitoring.

One possible explanation for the mixed findings on the effect of warnings on reducing older adults' false memories is that younger adults may be more likely than older adults to spontaneously monitor their false memories without explicit warnings, while older adults may be more reliant on experimenter-provided warnings (Watson et al., 2004). This explanation was supported by research conducted by Dehon and Bredart (2004). In their study, 30 younger and 30 older adults were required to remember six 15-word lists. The key manipulation was that participants were also asked to write down any word that had come to mind but that they did not report during the original recall task. The underlying logic of the experiment was that if aging influenced the monitoring processes, older adults would be less likely than younger adults to recall the critical lures in the post-recall test. Consistent with this assumption, older adults recalled fewer critical lures (.33) than did younger adults (.60), suggesting that older adults were less likely to spontaneously use the monitoring strategies to reduce their false memories without the help of explicit warnings. Dehon and Bredart

replicated this finding in a second experiment in which the false recall rates in older adults were lower (.40) than those in young adults (.61) in the post-recall test without the help of explicit warnings. Moreover, like Experiment 2 of Watson et al.'s (2004) study, Dehon and Bredart also found that younger adults were more likely to take advantage of warning instructions (no warning vs warning in younger adults: .16 vs. .04), whereas older adults' false memories were not reliably reduced in the warning condition compared to in the no warning condition (.34 vs. .39). This finding again supports the idea that age-related increases in false memories are somehow due to age-related increases in impairment for recall-to-reject monitoring.

Based on the literature reviewed thus far, it is possible to conclude that age-related increases in false memories between younger adults and older adults may be due to older adults' tendency to process the gist of information, and/or due to older adults' impairment in disqualifying recall-to-reject monitoring. Empirical evidence for the latter explanation is sometimes found, but not always. In terms of the mechanism responsible, one important variable — frontal lobe functioning — may be worth considering. Frontal lobe functioning has long been thought to be associated with retrieval monitoring (Butler et al., 2004; Lyle, Bloise, & Johnson, 2006; Schacter et al., 1996). For example, in one experiment, Butler and colleagues (2004) assigned older participants to high- and low-frontal-lobe functioning groups based on the results of additional tests (e.g., the Wisconsin Card Sort test), which are thought to depend heavily on frontal lobe function (Gallo et al., 2006). They then conducted a typical DRM procedure, comparing the performance of the older adults to the performance of a group of younger adults. Consistent with previous studies, younger adults showed a higher rate of true memories (.62) than did older adults (.53). The key question was whether older adults' performance relied on frontal lobe functioning. As expected, true recall rates in the high-frontal-lobe function group (.57) were significantly higher than those in the low-frontal-

lobe function group (.47), whereas the opposite was true for false recall; the high-frontal-lobe function group recalled fewer critical lures (.23) than did the low-frontal-lobe function group (.35). Furthermore, by comparing older adults in low- or high-frontal-lobe function groups with younger adults, Butler et al. found that the age-related differences in either true memories or false memories were only obtained when comparing younger adults and older adults with low frontal-lobe function, but not when comparing younger adults and older adults with high frontal-lobe function. These findings suggest that whether age-related increases in false memories are found is contingent on whether aging has impaired frontal lobe function within a given sample.

### **Studies with Children**

Although frontal lobe functions are impaired with advancing age, they are not fully developed in younger children. Moreover, younger children's memory performance for studied information is not as good as that of older children or young adults. Both of these factors may make younger children more prone to false memories. In fact, the consequences of children's false memories were proposed a century ago by Whipple who published a series of remarkable reviews concluding that young children's memories were so susceptible to distortion that it caused their testimony to be unreliable and prejudicial (Whipple, 1909, 1911, 1912, 1914). Considering the significance of children's memories in legal situations, a considerable amount of contemporary research has been designed to emulate legal interviewing practices in an attempt to investigate the effect of suggestive information on the authenticity of children's reports (e.g., Ceci & Bruck, 1993, 1995; Ceci, Papierno, & Kulkofsky, 2007; Goodman, 2006). The most frequently used procedure in this line of research is based on the misinformation paradigm where suggestive information is provided during an interview about events or objects (Loftus, 1979; Loftus & Hoffman, 1989). The consistent finding in research of this kind is that there is an age-related decline in false

memories between childhood and adolescence (e.g., Chae & Ceci, 2005; McFarlane, Powell, & Dudgeon, 2002; Young, Powell, & Dudgeon, 2003).

Although studies of this ilk have forensic significance — guiding investigative interviewing protocols to maximise the generation of true memories while minimising the production of false memories — the cognitive mechanisms of false memories caused by suggestive misinformation involve a combination of both an endogenous distortion process (i.e., a process where false memories are caused by participants themselves) and an exogenous distortion process (i.e., a process where false memories are caused by external manipulations, such as providing suggestive misinformation). In that way, the use of external suggestive information and the age-related increase in these false memories reflects an age-related increase in both mechanisms (Brainerd, Reyna, et al., 2008). By comparison, in studies of spontaneous DRM false memories, no exogenous process is involved so age-related changes in false memories can only be due to endogenous distortion processes (e.g., associative activation or gist retrieval) (Brainerd & Reyna, 1998b; Brainerd, Reyna, et al., 2008; Howe, 2005, 2006). In this sense, the cognitive mechanism for DRM false memories is more straightforward than that for suggestive false memories. Because of this, the DRM paradigm has become the most widely-used paradigm to investigate the developmental mechanism of false memories between early childhood and young adulthood. In contrast to an age-related decline in false memories found in the misinformation paradigm, children typically show fewer spontaneous false memories than do adults in the DRM paradigm. This counterintuitive finding is commonly referred to as a developmental reversal effect. What is the mechanism of the developmental reversal effect in DRM false memories? Two theories, Fuzzy-Trace Theory (FTT; Brainerd, Reyna, & Kneer, 1995; Brainerd & Reyna, 2005) and Associative Activation Theory (AAT; Howe, 2005, 2006), have been proposed to account for it.

As described in Chapter 1, FTT was the first theory to predict an age-related increase in DRM false memories. According to FTT, the age-related increase in false memory is due to an age-related increase in memory for gist while verbatim memory remains relatively constant (Brainerd & Reyna, 2005). In reality, both verbatim memory and gist memory improve between early childhood and young adulthood, and the improvements are independent of each other (e.g., Bouwmeester, Vermunt, & Sijtsma, 2007; Brainerd & Reyna, 2004; Brainerd, Reyna, & Forrest, 2002; Brainerd, Reyna, et al., 2008; Reyna, 1996). Therefore, whether false memories decrease with age, increase with age, or remain unchanged largely depends on whether a particular paradigm is more sensitive to age-related changes in verbatim memory or age-related changes in gist memory (for reviews, see Brainerd & Reyna, 2007; Brainerd & Reyna, 2005; Brainerd, Reyna, et al., 2008). Given the defining feature of the DRM paradigm — that all the list words are related to each other, and they are all semantically related to a corresponding critical lure — FTT stipulates that the DRM paradigm is a paradigm that is more sensitive to age variability in gist memory than to age variability in verbatim memory. As such, FTT predicts that there should be an age-related increase in spontaneous false memories.

To test the predictions of FTT, Brainerd and colleagues (2002) conducted a series of studies. They initially recruited 60 5-year-old children to examine possible difference in false recall between young children and adults. Children heard ten randomly-presented 12-word lists. Each word of the list was presented according to its BAS value (from high to low). Immediately after the presentation of each list, children were asked to orally recall as many words as they could remember. As predicted, 5-year-olds were not susceptible to DRM false memories; false memories of critical lures were at near-floor level (i.e., were reported on only 6% of the lists). By comparison, false memories of the critical lures occurred after 40% of the lists in adults who were tested with the same materials (Roediger & McDermott, 1995). This

result indicated a quantitative difference in false recall between young children and adults. Furthermore, Brainerd and colleagues also observed a qualitative difference between the two age groups. Specifically, adults typically recalled very few words unrelated to the theme of the lists (e.g., Payne et al., 1996; Roediger & McDermott, 1995). However, for young children, the false recall rate for unrelated words (.22) (i.e., words that are weakly related to the studied words but not the critical lures) was as high as their true recall rate of studied words (.23). This finding suggested that the false memories of 5-year-olds were not dominated by an understanding of the theme of information. In other words, young children were unable to extract the gist of information.

Brainerd et al. (2002) had two goals in the second experiment of their study. First, they wanted to see whether any differences between the performance of young children and adults could be observed under conditions that were known to produce high or low levels of false recall in adults. Second, considering the crucial developmental period between 5- and 7-years of age in terms of major changes in learning and memory, they wanted to examine possible age-related changes in false memories between 5- and 7-year-olds. To do this, they used 16 word lists; on the basis of research with adults, eight lists were known to yield high levels of false recall (i.e., the eight critical lures were *window, sleep, smell, doctor, sweet, chair, smoke, and rough*) and eight lists were known to yield relatively low levels of false recall (i.e., the eight critical lures were *shirt, high, army, man, thief, lion, fruit, and king*). Fifty 5-year-old children and 50 7-year-old children participated in the experiment and the experimental procedure was the same as that used in Experiment 1. There were three key findings. First, although the high false-recall lists yielded an almost threefold increase in adults' false recall (.58 vs .22; see Stadler, 1999), they had no impact on the false recall rate of children (.04 vs .05 and .08 vs .09, for 5- and 7-year-olds, respectively). Second, although 7-year-olds recalled more studied words than did 5-year-olds, there was no age-related

difference in false recall between the two groups of children. Third, similar to the first experiment, 5-year-old children were more likely to recall unrelated words than to recall critical lures, while 7-year-old children had similar false recall rates for both unrelated words and critical lures. These results suggested that both 5- and 7-year-old children have difficulty in extracting the gist of the DRM word lists.

Given that 7-year-old children, like 5-year-old children, are less likely to produce false memories in the DRM paradigm, a question arises in terms of at what age does children's false memory begin to be comparable to that of adults? To answer this question, in their third experiment, Brainerd et al. (2002) added a sample of 11-year-old adolescents and a sample of undergraduate students. They assumed that increased levels of false recall should be observed in adolescence because, by that age, many semantic-processing strategies, such as elaboration or organization, which are of importance in the generation of false memories, are well developed. Furthermore, they also included a recognition test because prior research had indicated that recognition tests were more sensitive to gist memory than were recall tests. Brainerd et al. predicted that an age-related increase in false memories should be detected at least in recognition tests.

The findings were largely consistent with all of the authors' predictions. In terms of recall performance, false recall rates increased between early childhood and young adulthood. Children had similar rates of false recall for high- and low-false-recall lists, whereas adolescents and young adults showed higher rates of false recall for high-false-recall lists than for low-false-recall lists. Moreover, unlike children, adolescents and adults were more likely to recall critical lures relative to unrelated words. Performance on the recognition test showed a similar pattern of results. False recognition rates increased between early childhood and adolescence, and remained stable between adolescence and adulthood. Additionally, children's false recognition rates did not differ between high and low lists, but adolescents'

and adults' false recognition rates were reliably higher for high lists than for low lists. Brainerd et al. (2002) were the first to document age-related increases in false memories between early childhood and young adulthood and their findings mainly supported FTT's argument that the lower false memory rate in children is due to a failure to extract the gist of DRM word lists.

Despite Brainerd et al.'s (2002) findings, age-related increases in false memories between early childhood and young adulthood are not always observed. In one study, for example, Ghetti, Qin, and Goodman (2002) asked 48 5- and 7- year-olds and 24 young adults to learn 15 7-word lists. Half of the participants in each age group studied list words with corresponding pictures, and half studied only list words. Ghetti et al. found that 5-year-olds exhibited more false recall than did adults but there was no reliable age-related difference in false recognition. Directly comparing the two studies is somewhat problematic given that the different results might simply be due to differences in experimental procedures, however, similar to Brainerd et al. (2002), the participants in Ghetti et al. also consisted of 5- and 7-year-olds, and young adults, but the studied words were presented pictorially as well as orally in Ghetti et al., while the words were only presented orally in Brainerd et al.'s study. It is very likely that presenting pictures might reduce false memories in adults by encouraging item-specific processing of information (i.e., facilitating verbatim memory). Therefore, in this condition, an age-related increase in false memories is less likely to occur. Moreover, Ghetti et al. used ten 7-word lists rather than 12-or 14-word lists. Prior studies with adults have shown that short lists reduce task difficulty and make it easier to extract the gist of information relative to long lists. In this sense, it is likely that short lists may be not as sensitive as long lists in terms of detecting age-related increases in false memories between early childhood and young adulthood.

Some researchers have argued that the age-related increase in Brainerd et al.'s (2002) study may not be due to the long lists used in the study, but rather due to children's inability to connect the gist of DRM word lists because these lists are normally constructed according to free-association norms collected with adults rather than children. A potential problem of using word lists normed with adults for children is that children may be unable to understand the meaning of some of the studied words, let alone successfully retrieve the gist of studied words or associatively activate the semantically-related critical lures (Anastasi & Rhodes, 2008; Carneiro, Albuquerque, Fernandez, & Esteves, 2007; Metzger et al., 2008). To solve this potential problem, researchers initially constructed semantically-associated word lists that were normed with children rather than adults, and then used these child-normed lists to investigate age-related changes in DRM false memories. For example, Carneiro et al. (2007) used 16 critical lures and their corresponding studied words that were selected on the basis of free-association norms that were specific to the age of participants. There were four age groups: one adult group (64 young adults;  $M_{\text{age}} = 24$  years) and three child groups including 128 pre-schoolers ( $M_{\text{age}} = 4.17$  years), 64 second-graders ( $M_{\text{age}} = 7.75$  years), and 64 pre-adolescents ( $M_{\text{age}} = 12.42$  years). The critical lures were the same for the four age groups, but the studied words differed across age groups in terms of list length (i.e., 8, 10, 12, and 15 studied words for pre-schoolers, second graders, pre-adolescents, and adults, respectively). All participants received an immediate recall test and a final recognition test. Preschool children exhibited the lowest level of false recall and false recognition, compared to the other three groups. It should be noted that participants in each age group only learned and were tested on their age-specific normed word lists, making it impossible to directly compare the performance of children and adults on both child- and adult-normed lists.

Anastasi and Rhodes (2008) emphasised the importance of directly comparing children's and adults' performance on child- and adult-normed lists. They hypothesised that

if the age-related increase in DRM false memories is due to the use of adult-normed lists, then using child-normed lists should increase false memories in children, thus reducing age-related differences in false memories between children and adults. However, if there is no difference in false memories between the adult- and child-normed lists, this would strongly support the generality of the reported age-related increase in DRM false memories.

To test their hypothesis, Anastasi and Rhodes (2008) used 12 15-word lists taken from Roediger and McDermott (1995) that had been normed with adults, and 12 15-word lists taken from Anastasi, Lewis, and Quinlan (2007) (cited in Anastasi & Rhodes, 2008) that had been normed with children. The 12 child-normed lists and the 12 adult-normed lists shared the same critical lures. In the study, 30 children between 5- and 8-years old and 32 young adults ( $M_{\text{age}} = 24.7$  years) received 6 adult-normed lists and 6 child-normed lists. Overall, children exhibited a lower level of false memory than did adults on both recall and recognition tests. More importantly, an age-related increase in DRM false memories was obtained for both adult- and child-normed lists. Furthermore, adults showed lower levels of false recall and false recognition for child-normed lists than for adult-normed lists.

Taken together, these findings indicated that the typical age-related increase in DRM false memories cannot be simply due to the specific type of lists used, but rather must be due to age-related changes in gist retrieval (as suggested by FTT) or to age-related changes in the associative activation of information (as suggested by AAT). More specifically, according to FTT, the lower level of false memories exhibited by children may be because young children are less likely to extract the gist of the word lists. According to AAT, on the other hand, the lower probability of false memories for the child-normed lists may be because the associative relations between studied words and critical lures are relatively weaker for these lists than for adult-normed lists. In addition, it is possible that adults do not activate associative words of child-normed lists as automatically as they activate associative words of adult-normed lists in

their knowledge base because of the age-inappropriate semantic structure of the child-normed lists (Nelson, 1977).

AAT's explanation that the developmental changes in false memories are due to the level of automaticity of associative activation has been supported by empirical evidence. For example, in the third experiment of Metzger et al.'s (2008) study, the task demands were manipulated by presenting long (16 words per list) and short (8 words per list) lists. These long and short child-generated lists were presented to second, fifth, and eighth graders (6- to 14-year-olds) as well as to college students. Metzger et al. found that, regardless of whether they were presented with short or long lists, second graders reported the lowest level of false memories. The performance of fifth and eighth graders was similar to that of adults when they were in the short list (low demand) condition, while their performance was similar to younger children when they were in the long list (high demand) condition. Metzger et al. argued that relative to the low-demand condition, the high-demand condition required fifth and eighth graders to engage in more effortful processing. The findings obtained by Metzger et al.'s study support AAT's argument that younger children's lower level of false memory occurs because they do not activate the associative links between the studied words and critical lures as automatically as do older children and adults (Howe, 2005, 2006).

According to AAT, children's lower level of false memory in the DRM paradigm may be due to the fact that they do not activate the associative links between the words on the DRM lists and critical lures, a process that occurs relatively automatically in adults. This theoretical explanation was specifically tested in Howe (2005) with 5-, 7-, and 11-year-olds. Howe's key manipulation was that children in each age group were provided with either a directed-forgetting instruction or a directed-remembering instruction. Although participants in both conditions were asked to remember two word lists, those in the directed-forgetting group were instructed to forget the studied words on the first list and remember the second

word list carefully, and those in the directed-remembering group were told to remember the words that had just been presented and to also remember the next ones carefully. Howe assumed that if the generation of false memories was relatively effortful, and less automatic in children compared to in adults, then the explicit directed-forgetting instruction may reduce children's false memories but have no effect on adults' false memories. Consistent with their prediction, although the true memories of both children and adults were reduced in the directed-forgetting condition, only children's false memories were impaired by the directed-forgetting instruction compared to the directed-remembering instruction. This finding supports the AAT's theoretical explanation regarding the age-related increase in DRM false memories.

In sum, although FTT and AAT offer different theoretical accounts for the age-related increase in false memories between early childhood and young adulthood, both theories have received ample empirical support. Generally speaking, studies in which a manipulation is conducted to help younger children connect gist information (e.g., providing exemplars or labels of word lists) have shown an age-related decrease in false memories. These studies support FTT (Brainerd & Reyna, 2007; Brainerd, Forrest, Karibian, & Reyna, 2006; Brainerd & Reyna, 2005). On the other hand, studies in which a manipulation is conducted to enhance the level of automaticity with which younger children activate associative information have shown an age-related decrease in false memories. These studies support AAT (e.g., Howe, 2005, 2006, 2007). However, one common issue with these studies is that, although the key aspects of one theory have been manipulated, key points of another theory have not been controlled. As a result, even though some findings are more likely to support one theoretical account or the other, they cannot completely rule out the alternative explanation.

To pit one theory against the other, it is necessary to manipulate either semantic connections or the automaticity of associative activation while also controlling either the

automaticity of associative activation or semantic connections. To the best of our knowledge, only a few developmental studies have taken this approach. For example, in his first experiment, Howe (2006) asked 5-, 7-, and 11-year-old children to learn either the standard 14-word DRM lists (e.g., sweet list: sour, candy, sugar, bitter, etc.) or 14-word category lists (e.g., dog list: cat, horse, tiger, cow, etc.). Compared to DRM word lists, the theme-related gist of category lists is thought to be easier to retrieve (Gallo, 2013; Howe, Wimmer, Gagnon, et al., 2009; Knott & Dewhurst, 2007). Howe (2006) found a consistent age-related increase in false memories for both DRM lists and the category lists. However, regardless of age, false memories did not differ as a function of list type. In other words, increasing relational processing had no impact on children's false memories, which is inconsistent with FTT's claim.

As mentioned earlier, one issue with Howe (2006)'s first experiment is that although category lists are thought to be high in gist, we have no idea whether the associative strength of these lists has been controlled compared to that of DRM word lists. To solve this problem, Howe used only category word lists in his second experiment, but half of the children were provided with category labels before list presentation (label condition, e.g., "all of the words on this list are names of animals," p. 1116), and the other half of the children were just instructed to remember the words presented on the list (no-label condition). By doing so, Howe (2006) hypothesised that the associative strength of the lists was controlled across two conditions, however, theme-related gist should be easier to retrieve in the label condition than in the no-label condition. If children's ability to retrieve the gist of lists is the case in terms of the generation of false memories, as FTT suggests, then children in the label condition should exhibit more false memories than those in the no-label condition, regardless of age. In addition, the effect of category labels should be more pronounced in younger children than older children, thus reducing the age-related increase in false memories in the label condition.

Once again, the findings were inconsistent with FTT's predictions; only a main effect of age was found; 11-year-olds falsely recalled more critical lures than did 7-year-olds, who in turn, falsely recalled more critical lures than did 5-year-olds, regardless of label condition. Taken together, the results of Howe (2006)'s first two experiments indicated that gist retrieval (or relational processing) may not be the critical mechanism for children's false memories. To investigate whether associative processing plays a key role in the generation of children's false memories, Howe (2006) conducted a third experiment. Rather than increasing theme-related processing, Experiment 3 was designed to reduce associative processing while keeping theme-related processing intact. To do this, the 14-item category lists that were used in Experiment 2 were presented pictorially in Experiment 3. Pictorial presentation is an ideal manipulation because it reduces associative processing, but does not impair semantic processing (Hutchison, 2003; Hutchison & Balota, 2005). If associative processing is the main mechanism for children's false memories as AAT suggests, then false memories should be reduced in Experiment 3 (pictorial presentation) compared to in Experiment 2 (verbal presentation). Consistent with AAT's predictions, false memories were lower in Experiment 3 than those in Experiment 2, regardless of age.

Although the findings of Howe (2006) are more consistent with AAT than FTT, the number of developmental studies that have been specifically designed to test the different theoretical explanations between AAT and FTT is very limited. Given that, it seems impossible to draw the simple conclusion that false memories are due to associative activation (as suggested by AAT) rather than gist retrieval (as suggested by FTT). Additional studies are required to replicate and expand Howe's (2006) study, and to further test the theoretical accounts between AAT and FTT.

## Chapter 3

### False Memory and Emotion

“Music evokes emotion and emotion can bring its memory.”

–Oliver Sacks

Psychologists have long recognised that many factors influence what we remember; one important factor is the emotional salience of the information. Events that elicit emotional reactions tend to be remembered better than do events that lack emotional significance (for a review, see Kensinger, 2009). For example, we have enduring memories for emotional events with significant personal significance, such as birthday, celebrations, weddings, the birth of children, and the death of loved ones. We can also remember where we were and what we were doing when witnessing a serious accident or experiencing a natural disaster (e.g., an earthquake). In these situations, emotional reactions play a highly adaptive role in enabling the significance of an event to impact the strength of the memories of that event. As William James originally hypothesised, “An experience may be so exciting emotionally as to almost leave a scar on the cerebral tissue” (James, 1890, p. 670).

James was concerned about the relation between emotion and true memory, but what about the effect of emotion on false memory? To address this question, I will first review the experimental methods that have been used to induce emotion in laboratory settings. I will then review empirical studies on the effect of emotion on memory. In these studies, some researchers have found an interaction between not only emotion and true memory but also emotion and false memory. In the last part of Chapter 3, I will review recent studies that have been specifically designed to investigate the interaction between emotion and false memory.

#### **Eliciting Emotions**

Over the past five decades, a number of mood-induction procedures (MIPs) have been devised to elicit positive- and negative-emotional states (i.e., moods) under controlled

laboratory conditions so that investigators are able to explore the relation among moods, cognition, and behaviours without interference from additional extraneous variables.

**The Velten procedure.** In 1968, Velten created one of the most popular mood-induction techniques. In this procedure, participants read 60 self-referent statements describing either positive or negative self-evaluations (or 60 neutral statements). For the negative-mood-induction group, the statements consisted of two categories: those concerned with self-devaluation (e.g., “I’ve doubted that I’m a worthwhile person”) and those concerned with somatic states (e.g., “Every now and then I feel so tired and gloomy that I’d rather just sit than do anything”). For the positive-mood-induction group, there was only one category (e.g., “I am a worthwhile person”). Based on self-reports, Velten found that most participants in either the negative- or positive-mood group reported that their mood could be influenced by this method.

**Music.** In this procedure, participants usually listen to a piece of music while being encouraged to get into the mood expressed by the music. Although in the first study using the musical induction procedure, Sutherland, Newman, and Rachman (1982) allowed participants to choose a piece of music that they believed to be best suited for putting them into the intended mood, most of the time, the music has been determined by experimenters who used the same piece of music for participants in a particular mood group. For example, Bach’s *Brandenburg Concerto No. 3* ([www.youtube.com/watch?v=Xq2WTXtKurk](http://www.youtube.com/watch?v=Xq2WTXtKurk)) is often chosen to induce positive moods, while Prokofiev’s *Alexander Nevsky: Russia Under the Mongolian Yoke* ([www.youtube.com/watch?v=UTfWxskmi9c](http://www.youtube.com/watch?v=UTfWxskmi9c)) is often chosen to induce negative moods (e.g., Chepenik, Cornew, & Farah, 2007; Clark & Teasdale, 1985; Jiang, Scolaro, Bailey, & Chen, 2011; Rowe, Hirsh, & Anderson, 2007). Sometimes music alone may not automatically induce a desired mood state. To ensure that participants achieve an appropriate mood, experimenters either ask participants to use additional methods (e.g., write down

something they thought about while listening to the music) or combine music with other techniques (e.g., self-imagery) (e.g., Corson & Verrier, 2007).

**Imagery.** In this procedure, participants are instructed to imagine situations that would make them feel either sad, happy, or neutral. This mood-induction technique is also called *autobiographical recall* if the to-be-imagined situation has actually happened in the real life. No matter whether the event is hypothetical or real, the main procedure is the same: participants are asked to think about the thoughts they would think and to feel the same feelings they would feel in a certain situation (Martin, 1990; Wright & Mischel, 1982). If the participants are children, there is an additional step: experimenters ask them to describe the event before they begin to imagine to ensure that children recall an event that is likely to be associated with negative or positive moods (Brenner, 2000). As for neutral moods, some experimenters asked children to count or think about a neutral object for a period of time (e.g., Kenrick, Baumann, & Cialdini, 1979; Rosenhan, Underwood, & Moore, 1974), and others ask children to describe their route to school or ask them a series of neutral questions (e.g., Barnett, King, & Howard, 1979; Eisenberg et al., 1988). Furthermore, the valence and arousal dimensions of a particular mood can be systematically manipulated in the imagery mood-induction procedure. For example, children in the positive-high arousal condition can be asked to recall an event that made them feel so happy that they wanted to jump up and down. In contrast, children in the positive-low arousal condition can be asked to recall an event that made them feel so happy that they just wanted to sit and smile (Masters, Barden, & Ford, 1979).

**Video clips.** In this procedure, participants watch video clips that are often selected from TV shows or popular movies. For example, Forgas, Burnham, and Trimboli (1988) induced happy and sad moods using segments from TV shows, *Gilligan's Island* and *Lassie*. Goldenberg and Forgas (2012) used segments from the comedy, *Fawlty Towers*, to induce

positive moods and segments from the film, *Angela's Ashes*, to induce negative moods. Recently, to ensure the reliability and validity of the video clip mood-induction procedure, Zhang et al. (2017b) selected several excerpts from classic movies and current programs and asked an independent group of 24 participants (12 children and 12 young adults) to view the clips and then to rate their feelings for each clip. Zhang et al. selected the video clips that produced the most consistent and clear-cut mood effects; positive and negative moods were induced by two segments from *Lion King*. These video clips were effective at inducing positive and negative moods in both children and adults. In addition to inducing positive, negative, and neutral moods in general, video clips can also be used to induce other moods. For example, Bland, Howe, and Knott (2016) showed participants a clip from the movie *My Bodyguard* to induce *anger* and a clip from the film *The Shining* to induce *fear*. In terms of inducing neutral moods, participants usually watch a nature documentary (e.g., Bland et al., 2016; Brenner, 2000). Normally the selected video clips are between 4 and 6 min in duration. Rebeck and Lohaus (1986) also found that the video clips as brief as 2.5-min long were effective in inducing moods in children and adults.

### **Effectiveness of Mood-Induction Procedures**

The effectiveness of mood-induction procedures can be evaluated using a number of different criteria. Some researchers have been concerned that induced moods are not sufficiently intense, while other researchers have been concerned that the observed effects are simply due to compliance inherent in the experimental procedure, such as demand characteristics (e.g., Brenner, 2000; Buchwald, Strack, & Coyne, 1981; Westermann, Spies, Stahl, & Hesse, 1996).

**Demand characteristics.** Demand characteristics refer to the possibility that participants' responses in an experiment result from their tendency to comply with experimental demands (Orne, 1962). For example, participants may not actually feel in a

negative mood (e.g., sad or angry) when they read the negative self-referent statements, but when asked how happy or unhappy they were, participants may say they felt negative because they assumed that this is what the experimenters expected. In other words, participants' responses are not due to the mood-induction method per se, but simply due to participants' tendency to satisfy experimental demands.

Although concerns about demand characteristics may apply to all mood-induction procedures, most of the discussion regarding the effect of demand characteristics on mood induction has focused on the Velten (1968) procedure, where participants read positive or negative self-referent statements. Larson and Sinnett (1991), for example, found that the effect size for the Velten mood-induction procedure was larger when truthful cover stories were provided than when deceptive cover stories were provided. This finding supports the assumption that the effect of the Velten procedure might be partially due to demand characteristics. In this and other studies that supported the demand-characteristics hypothesis, self-report measures of mood were typically used after the mood-induction procedures. In fact, the self-report measures themselves might be more susceptible to demand characteristics relative to physiological or neural measures.

**Range of induced moods.** Generally speaking, all of the mood-induction methods that I have reviewed above could be used to induce positive (happy), negative (sad), and neutral moods. In this way, each of these methods can be selected to induce participants' moods if the research goal has nothing to do with examining the effect of a specific mood on cognition and behaviour. Nevertheless, if a specific mood (i.e., anxiety) is required to test the research question, it is necessary to think about the range of these mood-induction procedures. It has been demonstrated that *imagery* and *video clips* can be used to induce the widest range of induced moods, including *fear*, *anger* and *anxiety*, while *the Velten*

*procedure* and *music* can be used to induce happy, sad, and neutral moods, in general (Bland et al., 2016; Brenner, 2000; Corson & Verrier, 2007; Martin, 1990).

**Intensity of induced moods.** Only a few studies have specifically investigated the relative intensity of induced moods resulting from different mood-induction procedures. For example, Sutherland et al. (1982) found that sad moods were more intense when they were induced by music than by self-statements (i.e., Velten procedure), and Brewer, Doughtie, and Lubin (1980) found that participants felt happier after happy self-generated imagery than those who received self-statements. From a clinical perspective, researchers mainly consider whether negatively-induced moods are related to clinical depression. Mixed results have been obtained in this line of research. For example, Hertel and Rude (1991) found that scores on the Depression Adjective Checklist were higher in a group of negative-mood-induced participants who experienced the Velten procedure than were scores in a group of depressed patients. Raps, Reinhard, and Seligman (1980), however, found the opposite pattern. Martin (1990) used visual analogue scales for clinically-depressed patients and normal individuals to rate their level of sadness, anxiety, and happiness before and after two mood-induction procedures: self-statement and music. These two procedures produced a level of reported depressed moods in normal individuals equivalent to an intermediate clinical level of depressed mood (Martin, 1990).

From the valence-arousal dimensional perspective, on the other hand, mood intensity is basically identical to mood arousal (Kensinger, 2004). Whether the induced moods should be high or low in arousal largely depends on the specific research question. For instance, to investigate the relative influence of valence and arousal on false memories, Corson and Verrier (2007) used music combined with guided imagery to induce a positive-high-arousal (happy) mood, a positive-low-arousal (serene) mood, a negative-high-arousal (anger) mood, and a negative-low-arousal (sad) mood.

**Success rate.** The percentage of participants who actually achieve a particular mood following mood induction is a very important factor for research on the effect of emotion on memory. Although there is no gold standard in terms of judging the success of a mood-induction procedure for any individual study, one widely-used criterion is that a mood-induction procedure is considered to be successful as long as a mood state changes in the predicted direction from pre-induction to post-induction. Using this criterion, the success rate of procedures involving music, imagery, and video clips is more than 75%, while the success rate of the Velten procedure is approximately 50% (Martin, 1990).

### **The Effect of Emotion on Memory**

When experimental research on memory initially began, few researchers considered the impact of emotion on memory. Hermann Ebbinghaus, who was the first scientist to systematically investigate human memory, argued that researchers should examine the retention of information stripped of emotional meaning or personal importance to understand memory processes. Ebbinghaus examined his own memories of nonsense syllables, which were devoid of meaning and personally-relevant information (Ebbinghaus, 1964). Using this method, he established a series of now-famous learning and forgetting functions. Although Ebbinghaus' work had a major impact on our understanding of human memory, researchers soon turned to memory for materials and procedures that were more relevant to everyday memory and forgetting, and much of this remembering and forgetting includes events that are emotional in nature.

**Flashbulb memory.** Each of us has experienced plenty of events in the course of our lives, but the truth is that we only remember a fraction of them. Given this, what kind of information is most likely to be remembered? It has been argued that the emotional salience of to-be-remembered information might be one of the critical factors that determine whether information might be remembered or not. Brown and Kulik (1977) created a term, *flashbulb*

*memories*, to capture this idea. Flashbulb memories refer to a phenomenon whereby memory can be considered to be sometimes like a photograph, taken with a flashbulb that preserves everything around us when a highly surprising, emotionally-charged event takes place. In their seminal demonstration of this phenomenon, Brown and Kulik capitalised on the opportunity to interview participants fourteen years after the assassination of John F. Kennedy, which was a highly surprising, highly emotional event. In their study, 40 white Americans and 40 black Americans were asked to report everything that they could remember about when they learned of the assassination, including where they were, what they were doing at that time, how they received the news, etc. Although these reports based on participants' own memories may not be entirely accurate, almost all of them reported the details of when they heard of the event, vividly and confidently. Brown and Kulik described the indelible, vivid nature of their participants' memories as *Print Now*.

Since Brown and Kulik's seminal publication in 1977, there have been a number of studies replicating and extending their findings in both adults and children (e.g., Bahrck, Parker, Fivush, & Levitt, 1998; Christianson, 1989; Peterson & Bell, 1996). In recent years, event or autobiographical memories about the 9/11 World Trade Centre attack have attracted much research attention, in particular (Budson et al., 2004; Budson et al., 2007; Paradis, Florer, Solomon, & Thompson, 2004; Pezdek, 2003; Talarico & Rubin, 2003). In one study for example, Paradis et al. (2004) examined the consistency of individuals' recollections of their personal circumstances at the time that they learned about the attack (9/11), the day after the attack (9/12), and the day before the attack (9/10). All of the participants were recruited from a college in Manhattan. They were asked to report what they were doing when they learned about or saw the World Trade Centre attack, and also to recall what they were doing at the same time on 9/12 and 9/10. Similar questions were asked again twice, one week and one year after the attack, respectively. Paradis et al. found that participants' memories about

activities that happened on the day of the attack and the day after the attack (9/11 and 9/12) were highly consistent, whereas their memories about activities that happened on the day before the attack (9/10) were not. This finding not only replicated previous ones by showing that participants established vivid and consistent flashbulb memories about emotionally-charged events, but also indicated that the consistency may be influenced by their highly-emotional nature.

It is worth noting that one common feature of the participants who developed flashbulb memories in Paradis et al. (2004) is that they were all highly involved in the attack, being that they were recruited from a college in Manhattan. A question arises regarding whether flashbulb memories would vary with the extent of participants' involvement? Intuitively, it might be hypothesised that flashbulb memories would be much robust and vivid if a participant was personally involved in the experience. This hypothesis has been confirmed by empirical evidence (e.g., Pezdek, 2003; Smith, Bibi, & Sheard, 2003). Pezdek (2003) assessed adults' memories for the 9/11 attack in the seventh week after the attack using questionnaires. Participants' degree of personal involvement was indexed by their proximity to New York City. University students were recruited from: Manhattan (n = 275; high involvement), California (n = 167; medium involvement), or Hawaii (n = 127; low involvement). All participants completed the same questionnaires. Pezdek predicted that, for New York students who were more personally involved in the attack, their memories of the attack would be more accurate than would the memories of the Californian and Hawaiian students. Consistent with the predictions, the accuracy of event memories increased with the increase of personal involvement (Pezdek, 2003). Moreover, Pezdek found that participants in all three groups constructed false memories of the attack: 73% of the participants falsely recalled that they saw the videotape of the first plane striking the first tower on September 11, but in fact, it was not broadcast until September 12. This finding is consistent with prior

research (e.g., Neisser & Harsch, 1992; Ost, Vrij, Costall, & Bull, 2002), and suggests that even though emotion influences the vividness and the subjective experience of our memories, it may not necessarily guarantee their accuracy.

### **The Effect of Emotional Arousal on Memory**

One feature of the events that typically lead to flashbulb memories is that they are all highly arousing in nature. Although these events also tend to be negatively charged, researchers have shown that the memory enhancements are primarily due to emotional arousal rather than to the valence of emotions elicited (Hamann, 2001; Mather, 2007; Mather & Sutherland, 2009; Phelps, 2006). The relation between emotional arousal and memory makes sense considering the adaptive significance of emotional arousal. From an evolutionary perspective, an emotionally-arousing event or stimulus is more likely to be related to personal survival and reproductive success than a non-emotionally-arousing event or stimulus. As such, memory enhancements for emotionally-arousing events or stimuli are highly adaptive (Hamann, 2001).

What is the cognitive mechanism responsible for the memory enhancements that sometimes occur for emotionally-arousing information? Prior research has demonstrated that emotional arousal may initially influence encoding of to-be-remembered stimuli through the modulation of attention (e.g., Kensinger, 2004; Phelps, 2006). In other words, in a sea of sensory information, our attention is more likely to be focused on the emotionally-arousing information. This idea dates back to 1959 when Easterbrook originally proposed that information central to the source of emotional arousal would be encoded and processed while memories for the peripheral details would not because emotional arousal would restrict the focus of attention to the related stimuli (Easterbrook, 1959).

The effect of emotional arousal on encoding has been widely known as “weapon-focus” effect in the literature (e.g., Loftus, 1979; Loftus, Loftus, & Messo, 1987). Weapon-

focus refers to the fact that witnesses tend to pay attention to a weapon (e.g., a gun or knife) at the expense of remembering other details around them (e.g., the perpetrator's clothing or vehicle) during a crime. In one study, Loftus et al. (1987) asked half of their adult participants to watch a series of weapon slides where a man pulled a gun on the cashier and the cashier gave him some money, whereas the other half of the participants watched a series of control slides where a man gave the cashier a check and the cashier gave the man some money. Eye movement data were collected while participants watched the slides. Loftus found evidence for the weapon-focus effect; participants in the weapon group concentrated their looking on the gun significantly more do than participants in the control group concentrated their looking on the check. Participants in the weapon group also spent more time looking at the gun than participants in the control group spent looking at the check. In turn, participants in the weapon group were less likely to identify the perpetrator of the crime, and less likely to answer specific questions about the perpetrator accurately relative to participants in the control group. That is, memory enhancements for the emotionally-arousing information due to selective attention are often at the expense of memory for details of other important information that is part of the same event.

What happens if attention is limited? Limited attention is often achieved in laboratory settings by asking participants to engage in two tasks at the same time. Compared to a control group who only completes one task, memory for the information in the first task is often found to be reduced as a result of the simultaneous presence of the second task (Naveh-Benjamin & Guez, 2000). That is, memory is impaired by limited attention. What happens if the to-be-remembered information is emotionally charged? Kensinger and Corkin (2004) asked participants to remember words that were emotionally arousing or non-arousing (i.e., neutral), at the same time, they were also asked to complete a discrimination task. Kensinger and Corkin found that although memories for the neutral words were reliably reduced by the

second task, memories for the emotionally-arousing words were not. This finding indicated that emotionally-arousing information is less likely to be influenced by limited attention relative to non-emotionally-arousing information.

In addition to the effect of emotional arousal on encoding, emotional arousal can also influence memory consolidation. “Consolidation is a storage process by which memories become more stable over time...” (Phelps, 2006, p. 34). Evidence across species has demonstrated that the effect of emotional arousal on memory consolidation mainly relies on interaction between the amygdala and the hippocampus (McGaugh, 2000, 2004; McGaugh & Roozendaal, 2002). More specifically, emotional arousal causes the release of norepinephrine and activation of beta-adrenoceptors in the amygdala, which in turn influences hippocampal processing via the action of stress hormones. This process may finally result in the enhancement of memory consolidation for the emotionally-arousing information (McGaugh, 2000, 2004; McGaugh & Roozendaal, 2002; Phelps, 2006). For instance, Dolcos, LaBar, and Cabeza (2004) asked adult participants to view emotionally-arousing and non-arousing pictures, and to rate each picture in terms of pleasantness using a 3-point scale. fMRI data were collected while participants viewed the pictures. Participants were not aware that their memory would be tested. Dolcos et al. found that among the pictures that had been remembered, the correlation between activation the amygdala and the hippocampus was greater for the aroused pictures than for the non-aroused ones. Further evidence for the importance of the interaction between the amygdala and the hippocampus in the processing of emotionally-arousing information has also been collected in clinical research; patients with amygdala damage do not show the normal memory enhancements for emotionally-arousing information (e.g., Adolphs, Cahill, Schul, & Babinsky, 1997; Cahill, Babinsky, Markowitsch, & McGaugh, 1995), and patients with amygdala damage fail to show memory enhancements for emotionally-arousing information over time (e.g., Labar & Phelps, 1998).

In sum, emotional arousal affects memory through encoding or consolidation processes. With regards to encoding processes, memory enhancements are mainly due to selective attention of the emotionally-arousing information. When attention is limited, memory enhancements are due to the preferential processing of emotionally-arousing information. With regards to consolidation processes, on the other hand, memory enhancements for emotionally-arousing information may result from the interaction between the amygdala and the hippocampus. One point that should be noted here, however, is that although we focus on the effect of emotional arousal on memory enhancements, when the level of emotional arousal is too high our memories may be damaged (Hamann, 2001).

### **The Effect of Emotional Valence on Memory**

In addition to emotional arousal, empirical evidence has shown that emotional valence can also influence memory. The effect of emotional valence on memory is not to boost or impair memory performance in general, but to influence memories for the details of information (Adelman & Estes, 2013; Kensinger, 2004, 2009; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Kensinger & Corkin, 2003; LaBar & Phelps, 1998). For example, Kensinger and Corkin (2003) investigated adult participants' recognition for negative and neutral words in two experiments. They found that negative words were better recognised than were neutral words. Moreover, the results from the source memory test showed that participants accurately reported more details (i.e., the color of the font that the words were presented in) about the negative words than about the neutral words.

It is important to note, however, that the negative words differed from the neutral words in not only emotional valence but also emotional arousal. Therefore, it is impossible to determine whether the observed effect was due to valence and arousal or due to only valence per se. To tease apart the relative contributions of emotional valence and arousal, in their third experiment, Kensinger and Corkin (2003) controlled the arousal of the to-be-

remembered words by using negative words that were different from the neutral words only in valence. The findings with these stimuli replicated the findings of the first two experiments: there was a higher recognition rate for negative words than for neutral words, and participants accurately remembered more details about the negative words than about the neutral words.

Similar findings have also been reported in studies where memories for negative information are compared with those for positive information. These studies have shown that participants are more likely to *remember* the details of negative information, whereas they are more likely to *know* that the positive information was presented (e.g., Dewhurst & Parry, 2000; Ochsner, 2000); participants remember more visual details about negative information (e.g., snake) than about neutral information (e.g., cake; Kensinger, Garoff-Eaton, & Schacter, 2007); and participants are better able to distinguish presented information from self-imagined information if the information is negatively charged (e.g., Kensinger, O'Brien, Swanberg, Garoff-Eaton, & Schacter, 2007). Taken together, all of these studies indicate that negative valence promotes memories for the details of information compared to positive or neutral valence.

Although there is consensus that individuals remember more details about negative information than about positive or neutral information, we have no idea when during the process of encoding or retrieval, emotional valence exerts its influence. Neuroimaging studies provide one way to explore this issue. For example, Mickley and Kensinger (2008) asked 20 adult participants to study negative-high-arousal, positive-high-arousal, and neutral words. fMRI data were collected during the time when participants were studying these words. Approximately 30 min later, a surprise recognition test was conducted. Participants were asked to judge whether they could vividly *remember* a word, or *know* a word that had been presented but did not recall any details of its presentation, or believed that a word was *new*.

Mickley and Kensinger found that the encoding of negative words that were later *remembered* activated the temporo-occipital regions to a significantly greater extent than did the encoding of the positive and neutral words that were later *remembered*. In contrast, the encoding of positive words that were later *known* activated the cingulate gyrus, the prefrontal cortex, and the parietal lobe more than did the negative and neutral words that were later *known*. The temporo-occipital regions are known to be associated with sensory processing while the cingulate gyrus, the prefrontal cortex, and the parietal lobe are known to be associated with semantic retrieval and self-referential processing. The finding suggested that there may be a link between negative valence and sensory processing and a link between positive valence and conceptual processing at encoding. Moreover, emotional valence may exert at least some of its influence, if not all, on memory encoding.

In addition to the encoding process, emotional valence may also play a role in the retrieval of memories. Researchers have long known that when there is a match between the encoding and the retrieval process, retrieval of information is facilitated (e.g., Craik & Lockhart, 1972; Tulving & Thomson, 1973). Given this, it is reasonable to predict that there may be an overlap in the effect of emotional valence on encoding and retrieval processes. That is to say, a link between negative valence and sensory processing and a link between positive valence and conceptual processing would also be revealed in the process of memory retrieval. This prediction has been supported by a few studies, which have shown that the retrieval of negative information activates more posterior sensory areas while the retrieval of positive information activates more frontal regions associated with conceptual processing (Addis, Leclerc, Muscatell, & Kensinger, 2010; Kensinger, 2009; Markowitsch, Vandekerckhove, Lanfermann, & Russ, 2003; Piefke, Weiss, Zilles, Markowitsch, & Fink, 2003).

In sum, both behavioural and neuroimaging data reflect the effect of emotional valence on memory: negative valence promotes memory for sensory details while positive valence promotes conceptual and semantic memory; and emotional valence exerts its effect at memory encoding as well as memory retrieval.

### **The Effect of Emotion on False Memory**

In light of the research outlined above, it is reasonable to assume that memories for highly emotional events should also be highly accurate. In contrast to this assumption, more and more research has shown that emotional memories may not necessarily be accurate. Considering the flashbulb memory literature, for example, although participants' memories are associated with emotionality and high confidence, they also show a high rate of errors (e.g., Neisser & Harsch, 1992; Ost et al., 2002; Pezdek, 2003). What do we know about the relation between emotion and false memory? The DRM paradigm is an ideal method and has been extensively used to investigate the effect of emotion on false memory in the laboratory settings. There are three categories of research in this area.

In the first category, researchers have tested participants using emotionally-laden word lists in the absence of mood induction (i.e., participants are in their natural mood) (Brainerd, Holliday, Reyna, Yang, & Toggia, 2010; Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Howe, 2007; Howe, Candel, Otgaar, Malone, & Wimmer, 2010). The purpose of these studies is to examine the effect of the emotional content of the target material on false memories. For example, Brainerd, Stein, et al. (2008) initially analysed the emotional word lists used in prior research (e.g., Budson et al., 2006) for emotional arousal and valence, and found that these lists not only differed in valence but in arousal as well. To control the emotional arousal of word lists, they created a pool of 6 positive, 6 negative, and 6 neutral 15-word lists varying in valence but not in arousal using Nelson, McEvoy, and Schreiber's (2004) norms of word association and the Affective Norms for English Words (ANEW)

database. Adult participants were asked to learn 12 lists (4 lists of each valence), followed by a 5-min distraction task, and finally, to complete a conjoint-recognition test in which participants judged studied words, critical lures, and unrelated words on whether each word had been presented. Moreover, each word was accompanied by a verbatim question (i.e., “Was it presented earlier?”), a gist question (i.e., “Is it an unrepresented item with the same meaning as presented items?”), or a verbatim-plus-gist question (i.e., “Is it either a presented item or an unrepresented item with the same meaning as presented items?”) (Brainerd, Stein, et al., 2008, p. 920). Brainerd, Stein, et al. found that participants exhibited higher false recognition rates for critical lures associated with negative word lists than for those associated with positive or neutral word lists. Through conjoint-recognition analyses, Brainerd, Stein, et al. argued that the high false recognition rate for negative lists was because the negatively-charged lists generated high levels of meaning familiarity, and participants were less able to use item-specific true memories to inhibit false recognition of negative lists.

Brainerd, Stein et al. (2008)’s findings were replicated and further extended in their developmental research where Brainerd et al. (2010) systematically varied emotional arousal (high vs low) and emotional valence (positive vs negative) of word lists for 7-year-olds, 11-year-olds, and young adults. Each child learned a total of 12 lists (3 lists of each of the four arousal  $\times$  valence combinations). There were four steps for children. For each step, children learned 3 word lists, followed by a 30s distractor task, and finally they completed a recognition test. In contrast, each young adult learned a total of 24 lists (6 lists of each of the four arousal  $\times$  valence combinations) and there were 8 steps for them. The DRM procedure for each of the 8 steps was identical to that used for children. Negative lists yielded more false recognition than did positive lists, regardless of age. The typical age-related increase in false recognition was also found: young adults made more false recognition errors than did 11-year-olds, who in turn made more false recognition errors than did 7-year-olds. More

importantly, Brainerd et al. (2010) found an interaction between valence and age, that is, the age-related increase in false memory was greater for negative lists than for positive lists. These findings suggested that emotional valence of to-be-remembered information may influence the typical age-related increase in false memories.

In the second category of research investigating the effect of emotion on false memory, researchers have induced a particular mood in participants and then tested them using traditional, non-emotional, DRM word lists (Corson & Verrier, 2007; Storbeck & Clore, 2005). The purpose of these studies is to examine the effect of the emotional state of the rememberer on false memories. For example, Storbeck and Clore (2005) drew on the affect-as-information hypothesis which proposes that positive moods encourage relational processing while negative moods encourage item-specific processing. They predicted that relational processing of positive moods may promote gist retrieval, thus increasing false memory. In contrast, item-specific processing of negative moods may reduce false memory. To test their hypothesis, Storbeck and Clore randomly allocated adult participants either to a positive-mood group or to a negative-mood group. Positive moods were induced by listening to *Eine Kleine Nacht Musik* by Mozart while negative moods were induced by listening to *Adagietto* by Mahler. Each piece of music was played for 8 min. When the music ended, participants learned a word list, followed by an immediate recall test. The study-recall procedure was repeated for all 36 lists. After the DRM task, participants were required to complete a questionnaire assessing the mood manipulation. Consistent with their prediction, Storbeck and Clore found that participants in a positive mood had a higher false recall rate for critical lures than did those in a negative mood.

In the third category of research, researchers have manipulated both the emotional content of the word lists and participants' mood (Bland et al., 2016; Knott & Thorley, 2014; Ruci, Tomes, & Zelenski, 2009). In some cases, the participants' mood is not manipulated by

experimenters but is naturally occurring (i.e., depression; Howe & Malone, 2011; Joormann, Teachman, & Gotlib, 2009; Moritz, Gläscher, & Brassen, 2005). The third category of research is inspired by practical situations (i.e., in the courtroom or the clinic) where the to-be-remembered information is usually emotionally charged and is often retrieved when the participant is in a certain mood. The purpose of these studies was to explore the impact of emotional content and emotional state on the generation of false memories. In one study, for example, Howe and Malone (2011) recruited 24 participants with clinical depression as an experimental group and 24 normal participants as a control group. Participants in both groups learned neutral, negative, positive, and depression-relevant lists. A recognition test was conducted after all the lists had been presented. Howe and Malone found that for participants with depression, negative and depressed word lists were better remembered than were neutral and positive lists. Furthermore, participants with depression tended to falsely recognise more depression-relevant lures than other non-depressed lures, showing a mood-congruent effect in false memories.

Bower (1981) was the first to investigate the mood-congruent memory effect. In his seminal study, participants were induced in a happy or sad mood and were required to read a story about two fictional characters, Jack and Andre. Jack is an unhappy character who has a series of sad experiences (e.g., losing his girlfriend), whereas Andre is a happy character who has many positive experiences (e.g., winning at tennis). Participants reported as much of the story as they could remember, 24 hours later. Bower found that participants who were induced in a sad mood recalled more about sad Jack than about happy Andre, whereas participants who were induced in a happy mood recalled more about happy Andre than about sad Jack. This finding suggested that people tend to remember more information that is consistent with their mood than information that is inconsistent with their mood. The phenomenon is widely known as the mood-congruent memory effect.

Bower (1981) explained the mood-congruent memory effect using associative network theory. According to the theory, there is an associative network between mood and memory. In this network, a certain mood, such as sadness or happiness, is represented as a node in memory that collects many other aspects of the mood, such as the verbal labels. When the node is activated, all related aspects are activated in the associative network. Due to the associative activation process, people in a certain mood tend to retrieve the corresponding mood-related information, thus generating the mood-congruent memory effect (Bower, 1981). According to Bower's theory, moods may act as a source of activation that combines with semantic activation in the associative network of mood and memory, finally resulting in more mood-congruent information than mood-incongruent information being retrieved at test. However, is only the encoded information activated and retrieved during the process? According to spreading activation theory, the answer is no; the activation of studied information may also spread to semantically-related but unrepresented information (i.e., critical lures). In other words, if the unrepresented information is mood-congruent and semantically-related information, this kind of information is also very likely to be retrieved at test, resulting in a mood-congruent false memory effect.

The mood-congruent false memory effect has captured the attention of researchers in recent years. In contrast to the body of work with clinical populations, in only a few studies have researchers examined the effect of mood on false memories of emotional word lists in non-depressed participants. For example, Ruci et al. (2009) induced normal adult participants in a happy or sad mood using a narrative, "*The Lottery Ticket*," and then asked them to learn three negative, three positive, and three neutral word lists. Immediately after learning each list, participants had 1 min to recall the words that they remembered from the list. The 81-word recognition test was finally conducted after the ninth study-recall cycle. Participants were also asked to make *remember/know* judgments for the words they judged as *old*. Ruci

and colleagues found that when the valence of the critical lures matched their mood, participants were more likely to falsely recall or recognise the critical lures, showing a robust mood-congruent false memory effect. Moreover, participants were more likely to believe that they could *remember* rather than just *know* these critical lures.

In another study, Knott and Thorley (2014) wanted to explore whether mood-congruent false memories, as false memories, would persist for a period of time. To answer this question, they randomly assigned adult participants to either a negative or a neutral mood condition. The negative mood was induced by the video clip of *Dancer in the Dark*, and the neutral mood was induced by a wildlife documentary. Each participant learned 6 neutral and 6 negative lists, followed by the recognition test that was administered twice. The first recognition test took place immediately after learning 12 lists, while the delayed recognition test took place one week later. As in Ruci et al. (2009), participants were asked to make further *remember/know* judgments for the words they judged as *old*. Consistent with the finding of Ruci et al. (2009), the mood-congruent false memory effect was found for *remember* judgments in the immediate recognition test. In addition, this effect was also found when the test occurred one week later, which indicated that mood-congruent false memories, like false memories, can persist over time.

It should be noted that both in Ruci et al.'s (2009) and Knott and Thorley's (2014) studies, moods were categorised as positive, negative, and neutral from a dimensional perspective. Bland et al. (2016) wanted to see whether there would be a discrete mood-congruent false memory effect when moods were categorised into *fear* and *anger*. To this end, adult participants were randomly assigned to either the *fear* group or the *anger* group. *Fear* and *anger* were induced by film clips. Participants learned two 10-word lists that were related to *fear* and two 10-word lists that were related to *anger*. Following this, the neutral video clip was presented to both mood groups to recover participants' moods so that the

moods differed only at encoding, but not at retrieval. Finally, participants completed the *old/new* recognition test, followed by *remember/know/guess* judgments. The mood-congruent false memory effect was observed for discrete emotions; participants in the *fear* group had a higher false *remember* rate for *fear* lists than for *anger* lists, whereas participants in the *anger* group had a higher false *remember* rate for *anger* lists than for *fear* lists. In summary, although a few studies have shown that false memories tend to be higher when the valence of to-be-remembered word lists matches the participant's mood state in the DRM paradigm, this branch of research is still in its infancy.

The overarching goal of my PhD is to further investigate the effect of emotional content and emotional state on spontaneous DRM false memory in both children and adults, and to explore the methods that might be used to reduce emotional false memories in laboratory settings. To these ends, In Experiment 1 (Chapter 4), I set up the normed emotional DRM word lists in which all the list words and the corresponding critical lure share the same emotional valence, with controlling BAS and emotional arousal. I then compared the magnitude of false memory produced by these normed emotional DRM word lists with that produced by the word lists used in previous studies in Experiment 2, and further explored the effect of emotional content (i.e., normed emotional DRM word lists) on false recall in Experiment 3(Chapter 5). In Experiment 4 (Chapter 6), I used mood induction procedures to elicit a particular mood and asked young adults to learn the normed emotional DRM word lists to assess the effect of emotional content and emotional state on false memory. In Experiment 5 (Chapter 7), I tested different theoretical predictions regarding the effect of participants' mood on the age-related increase in DRM false memories for emotional word lists. In the last two experiments, I assessed whether warnings about the false memory phenomenon would reduce adults' emotional false memories (Chapter 8), and

whether directed-forgetting cues would reduce children's emotional false memories (Chapter 9).

## Chapter 4

### Emotional DRM Word Lists

As described earlier, the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995) is the most widely-used procedure to investigate false memories in the laboratory. In this paradigm, participants learn a number of DRM word lists in which all the studied words (e.g., bed, rest, pillow) are semantically associated with a critical lure (e.g., sleep) that is not presented as part of the list. On subsequent testing, participants often falsely recall and recognise critical lures as frequently as they do studied words. Moreover, when participants are asked to make remember/know judgments about those words that they believe they have remembered in the study phase, they tend to make more “remember” than “know” judgments for the critical lures (Roediger & McDermott, 1995).

In the studies where false memories were first found to be produced by the word lists (Deese, 1959; Roediger & McDermott, 1995), the creation of the word lists were originally based on Russell and Jenkins’s (1954) word association norms. In one study, for example, Stadler et al. (1999) summarised and analysed 36 15-word lists constructed from the Russell and Jenkins norms. They found that there was a considerable difference between the word lists in terms of generating false memories. For example, the false recall rate for the list where *king* was the critical lure was only .10, but for the list where *window* was the critical lure, the false recall rate was .65. The Russell and Jenkins’s (1954) word association norms were subsequently modified by Nelson et al. (2004), and the Nelson et al. (2004) word association norms are now commonly used in research (e.g., Brainerd et al., 2010; Budson et al., 2006; Howe & Malone, 2011).

Table 4.1.

*Critical Lures of the 19 Word Lists From Gallo and Roediger (2001)*

Beautiful	Citizen	Lamp	Trouble
Bitter	Command	Long	Whiskey
Butterfly	Cottage	Mutton	Whistle
Cabbage	Health	Stove	Wish
Carpet	Justice	Swift	

Although it is easy to directly compile DRM word lists based on Nelson et al.'s (2004) word association norms, most of the time, the normed data were not sufficient; researchers have had to collect their own norms for some missing words by drawing on the procedures outlined by Nelson et al. For example, Roediger, Watson, et al. (2001) explored the seven factors that influence the magnitude of DRM false memories. To do it, they investigated 55 15-word lists, 36 of which were from Stadler et al. (1999) constructed from the Russell and Jenkins norms and 19 of which were from an unpublished study (see Table 4.1; Gallo & Roediger, 2001, cited in Roediger, Watson, et al., 2001). The seven influential factors that were identified by Roediger, Watson, et al. (2001) included *word length*, *frequency*, and *concreteness* of each critical lure, and *Forward Associative Strength* (FAS), *Backward Associative Strength* (BAS), *connectivity*, and the *true recall rate* of each list. Similarly to many researchers, Roediger, Watson, et al. took advantage of the word association norms of Nelson et al. and prior research (Gallo & Roediger, 2001; Stadler, et al., 1999) to obtain data on the relative contribution of each of seven factors. For some lists, however, the BAS data were missing. For these lists, Roediger and colleagues collected their own norms. To do this, 75 adult participants were initially asked to write down the first word that came to mind when seeing a given word (i.e., a critical lure). Then, the probability that each reported word elicited the corresponding critical lure was calculated. Finally, Roediger

and colleagues obtained the mean BAS score for each list by averaging the probability of each word that was reported that elicited the critical lure.

In addition to the mean BAS score, Roediger, Watson et al. (2001) also obtained data on *connectivity*—the associative strength among list words— for each list. There were two steps to calculate connectivity. First, a  $15 \times 15$  matrix of list words for each list was constructed, giving 225 pairs of list words, excluding the 15 self-connections. Second, participants were asked to assess the possibility that they could think of the other word in a pair when seeing the first word in the same pair (the possibility is ranged from 0 to 1). For simplicity, any nonzero possibility was scored as 1 (e.g., if the possibility is 0.3, 0.4...). A higher connectivity score for a list reflects stronger associative strength among the corresponding list words.

Using these procedures, Roediger and colleagues found that the seven factors accounted for approximately 68% of the variance in false recall. BAS was the strongest predictor compared to the other factors and was positively correlated with false recall. This finding indicates the importance of taking BAS into consideration in false-memory research using the DRM paradigm.

### **Emotional DRM Word Lists**

The work by Roediger, Watson, et al. (2001) not only underscored the importance of BAS in the generation of false memories, but it also provided the standard procedures that are necessary to obtain BAS and connectivity. In fact, these procedures have been widely used in research on emotional false memories where emotional DRM word lists are compiled.

Table 4.2 provides a summary of the emotional word lists (except neutral lists) that have been created thus far in the literature. There are generally two categories of emotional word lists. One is based on the dimensional perspective of emotion, which divides emotional word lists in terms of valence, such as a *negative* or *positive* list. The other category is based

on the discrete perspective of emotion, which divides emotional word lists in terms of discrete emotion, such as an *anger* or *sad* list. Compare to the second category, the first one has been extensively investigated in the literature so far, but in these studies, valence has often been confounded with arousal in the most of studies (Budson et al., 2006; Howe & Malone, 2011; Palmer & Dodson, 2009; Ruci et al., 2009), and only in a very limited number of studies has arousal been systematically controlled (e.g., Brainerd et al., 2010; for a review, see Bookbinder & Brainerd, 2016).

Table 4.2.

*Emotional Word Lists (Except Neutral Lists) that Have Been Used in the Literature*

**Budson et al. (2006)**

<i>Negative</i>	<b>Alone</b>	<b>Anger</b>	<b>Cry</b>	<b>Danger</b>	<b>Hell</b>
	Single	Mad	Tears	Fear	Devil
	Isolated	Rage	Sad	Caution	Satan
	Solitary	Annoyed	Tissue	Trouble	Evil
	Apart	Furious	Sorrow	Warning	Damned
	Separate	Bothered	Eyes	Risk	Sin
	Quite	Wrath	Weep	Hazard	Demon
	Detached	Hate	Sob	Alarm	Heaven
	Self	Mood	Unhappy	Help	Judgment
	<b>Hungry</b>	<b>Lie</b>	<b>Rape</b>	<b>Sick</b>	<b>Thief</b>
	Food	Fib	Sex	Cough	Steal
	Starve	Cheat	Man	Fever	Robber
	Famine	Truth	Violate	Ill	Crook
	Empty	False	Blame	Flu	Burglar
Stomach	Mislead	Struggle	Vomit	Money	
Poor	Trick	Date	Doctor	Cop	
Eat	Fake	Force	Health	Purse	
Pangs	Betray	Shame	Dizzy	Mugger	

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**Palmer & Dodson (2009)***Negative*

<b>Kill</b>	<b>Pain</b>	<b>Sad</b>
Assassinate	Suffer	Depressed
Slay	Hurt	Melancholy
Slaughter	Ouch	Cheerless
Murder	Anguish	Somber
Execute	Pleasure	Miserable
Massacre	Harm	Lonely
Stab	Distress	Upset
Behead	Back	Gloomy
Homicide	Death	Hopeless
Shoot	Blood	Desolate

*Positive*

<b>Beautiful</b>	<b>Happy</b>	<b>Love</b>
Gorgeous	Glad	Adore
Stunning	Elated	Affection
Picturesque	Content	Passion
Breathtaking	Joyful	Heart
Pretty	Pleased	Kiss
Lovely	Ecstatic	Like
Exquisite	Laugh	Attraction
Striking	Enjoyment	Care
Attractive	Satisfied	Devoted
Elegant	Enjoyable	Admire

**Howe & Malone (2011)***Negative*

<b>Mislead</b>	<b>Hell</b>	<b>Thief</b>
Lie	Devil	Steal
Error	Satan	Robber
Trick	Evil	Crook
Deceive	Damned	Burglar
Follow	Sin	Money
Mistake	Lucifer	Cop
Path	Demon	Bad

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	Wrong	Heaven	Rob
	Annoy	Soul	Jail
	Away	Judgement	Gun
<i>Positive</i>	<b>Admire</b>	<b>Excel</b>	<b>Gentle</b>
	Like	Good	Giant
	Respect	Brilliant	Soft
	Envy	Achieve	Kind
	Beauty	Best	Caring
	Her	Exceed	Lamb
	Idol	Win	Man
	Love	Better	Ben
	Them	Correct	Mild
	Admiral	Elite	Quite
	Adore	Excess	Smooth

<i>Depression</i>	<b>Depression</b>	<b>Failure</b>	<b>Alone</b>
	Sad	Success	Single
	Anxiety	Exam	Isolated
	Sadness	Pass	Abandoned
	Anger	Loss	Solitary
	Down	Break	Apart
	Low	Crisis	Lonesome
	Blackness	Degree	Separate
	Boredom	Fail	Quiet
	Disaster	Fault	Detached
	End	Flop	Solo

**Dewhurst, Anderson, & Knott (2012)**

<i>Negative</i>	<b>Sick</b>	<b>Lie</b>	<b>Anger</b>	<b>Fear</b>	<b>Evil</b>
	Ill	Fib	Rage	Terror	Wicked
	Flue	Deceive	Hostility	Doubt	Devil
	Nausea	Untrue	Fury	Panic	Villain
	Virus	Bluff	Frustration	Fright	Demon

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Hospital	Truth	Temper	Anxiety	Satan
Fever	Rumour	Tantrum	Afraid	Witch
Disease	Deception	Violent	Scared	Corrupt
Healthy	Dishonest	Fight	Monster	Sin
Vomit	Betray	Annoy	Horror	Taboo
Germ	Deny	Argument	Coward	Cruel
Well	Cheat	Irritate	Scream	Good
Cough	FALSE	Conflict	Hide	Hell
<b>Cry</b>	<b>Pain</b>	<b>Hate</b>	<b>Alone</b>	<b>Danger</b>
Weep	Agony	Despise	Isolated	Hazard
Sob	Hurt	Dislike	Solo	Risk
Tears	Discomfort	Love	Secluded	Beware
Emotional	Headache	Revenge	Lonely	Caution
Upset	Pleasure	Prejudice	Single	Warning
Sorrow	Sore	Enemy	Private	Safe
Sensitive	Relief	Disgust	Individual	Harm
Grief	Dentist	War	Withdrawn	Help
Sad	Sharp	Kill	Bored	Threat
Misery	Soothe	Insult	Empty	Trouble
Laugh	Cut	Condemn	Together	Jeopardy
Tissue	Cramp	Shun	Without	Deadly

**Brainerd et al. (2010)**

	<b>Anger</b>	<b>Cold</b>	<b>Dead</b>	<b>Hurt</b>
<i>Negative/High arousal</i>	Mad	Hot	Alive	Pain
	Fear	Snow	Gone	Cut
	Hate	Warm	Cold	Ouch
	Rage	Winter	Funeral	Cry
	Temper	Ice	Asleep	Injury
	Fury	Wet	Bury	Life
	Ire	Frigid	End	Sick
	Wrath	Chilly	Grave	Fall
	Happiness	Heat	Sad	Harm

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	Fight	Weather	Still	Hit
	Hatred	Freeze	Animal	Sore
	Hostile	Air	Cemetery	Stop
	Calm	Shiver	Deceased	Wound
	Emotion	Arctic	Die	Upset
	Enrage	Frost	Duck	Ache
	<b>Needle</b>	<b>Rough</b>	<b>Spider</b>	<b>Thief</b>
	Thread	Smooth	Web	Steal
	Pin	Bump	Insect	Robber
	Eye	Road	bug	Crook
	Sewing	Tough	Fright	Burglar
	Sharp	Sandpaper	Fly	Money
	Point	Jagged	Arachnid	Cop
	Prick	Ready	Crawl	Police
	Thimble	Coarse	Tarantula	Rob
	Haystack	Uneven	Poison	Jail
	Thorn	Riders	Bite	Gun
	Harm	Rugged	Creepy	Villain
	Injection	Sand	Black window	Crime
	Syringe	Beard	Monkey	Bank
	Cloth	Ground	Feelers	Bandit
	Knitting	Gravel	Tiny	Criminal
Negative/Low arousal	<b>Sick</b>	<b>Fat</b>	<b>Shy</b>	<b>Dirt</b>
	Ill	Skinny	Quiet	Mud
	Well	Thin	Outgoing	Sand
	Cold	Cat	Timid	Clean
	Hospital	Ugly	Bashful	Soil
	Vomit	Lady	Scared	Dirty
	Doctor	Big	Bold	Filth
	Bed	Cow	Person	Ground
	Flu	Slim	Introvert	Bath
	Illness	Albert	People	Black

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	Fever	Slob	Me	Grime
	Nurse	Boy	Loud	Bike
	Medicine	Man	Afraid	Brown
	Nausea	Pig	Boring	Grease
	Virus	Diet	Coy	Mess
	Pills	Large	Extrovert	Unclean
	<b>Board</b>	<b>Trash</b>	<b>Glass</b>	<b>Fall</b>
	Wood	Garbage	Window	Spring
	Chalk	Waste	Cup	Leaves
	Surf	Can	Drink	Winter
	Room	Refuse	Break	Down
	Game	Sewage	Clear	Autumn
	Nail	Bag	Jar	Hurt
	Plane	Junk	Crystal	Frosty
	School	Rubbish	Mug	Summer
	Ship	Sweep	Bottle	Catch
	Walk	Scraps	Fragile	Cool
	Two-by-four	Pile	Plastic	Trip
	Black	Dump	Sharp	Drop
	Boat	Landfill	Eye	Rise
	Build	Debris	House	Stand
	Bulletin	Litter	Juice	Trees
<i>Positive/High arousal</i>	<b>God</b>	<b>Baby</b>	<b>Love</b>	<b>Music</b>
	Jesus	Child	Hate	Note
	Heaven	Cry	Kiss	Sound
	Love	Small	Like	Piano
	Almighty	Bottle	Happy	Sing
	Church	Cute	Heart	Radio
	Lord	Infant	Care	Bandit
	Religion	Mother	Admire	Melody
	Creator	Crib	Adore	Horn
	All-knowing	Doll	Close	Concert

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	Bible	Little	Friendship	Instrument
	Damn	Boy	Girl	Symphony
	Devil	Adult	Happiness	Jazz
	Faith	Diaper	Hug	Orchestra
	Good	Girl	Kindness	Art
	Holy	Young	Life	Rhythm
	<b>City</b>	<b>Beach</b>	<b>Hug</b>	<b>Pretty</b>
	Town	Sand	Kiss	Ugly
	Crowded	Sun	Love	Girl
	State	Ocean	Squeeze	Beautiful
	Capital	Water	Embrace	Cute
	Streets	Towel	Affection	Adorable
	Subway	Ball	Hold	Attractive
	Country	Summer	Cuddle	Flower
	New York	Girls	Arms	Gorgeous
	Village	Swim	Bear	Hot
	Metropolis	Fun	Caress	Model
	Big	Wave	Tight	Pink
	Chicago	Blanket	Touch	Appealing
	Suburb	Bump	Warmth	Sweet
	County	Coast	Clinch	Charming
	Urban	Short	Clutch	Lovely
Positive/Low arousal	<b>Soft</b>	<b>Green</b>	<b>Nice</b>	<b>Sleep</b>
	Hard	Grass	Mean	Bed
	Light	Yellow	Sweet	Rest
	Pillow	Blue	Good	Awake
	Plush	Color	Bad	Tired
	Load	Red	Kindness	Dream
	Cotton	Leaf	Pleasant	Wake
	Fury	Arrow	People	Snooze
	Touch	Clover	Friendly	Blanket
	Fluffy	Frog	Smile	Doze

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Warm	Vegetables	Happy	Slumber
Furry	Apple	Friend	Snore
Downy	Bean	Pretty	Nap
Kitten	Elf	Nasty	Peace
Skin	Go	Delightful	Yawn
Tender	Dollar	Polite	Drowsy
<b>Bird</b>	<b>Grass</b>	<b>Fish</b>	<b>River</b>
Nest	Green	Water	Water
Parrot	Curt	Swim	Stream
Eagle	Lawn	Sea	Lake
Feather	Mow	Scales	Mississippi
Animal	Hopper	Smell	Boat
Wings	Pot	Cod	Tide
Canary	Mower	Food	Canoe
Cage	Weed	Trout	Flower
Sing	Grow	Gold	Run
Dog	High	Ocean	Barge
Flight	Roots	Fry	Creek
Song	Smoke	Shark	Brook
Blue Jay	Turf	Tank	Bend
Tree	Yard	Bass	Bridge
Robin		Bowl	Wind

**Moritz et al. (2005)**

	<b>Betrayal</b>		<b>Loneliness</b>
<i>Delusion-relevant</i>	Disappointment	<i>Depression-relevant</i>	Sad
	Deceit		Alone
	Backstabbing		Silence
	Trust		Sorrow
	Mistrust		Isolation
	Loyalty		Emptiness
	Intrigue		Longing

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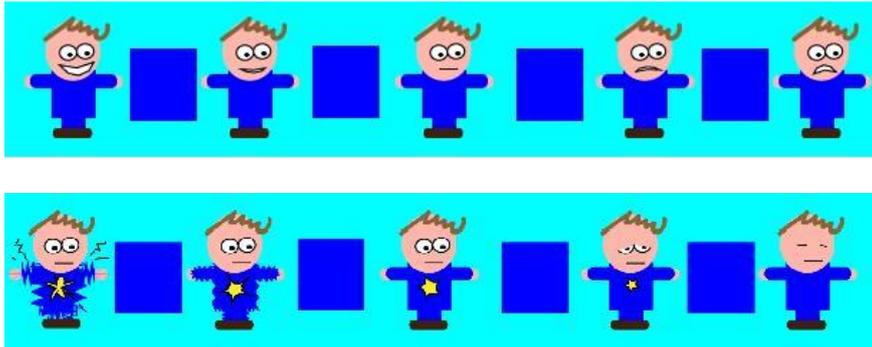
	Enemy		Boring	
	Secret		Depression	
	State		Dull	
	Dishonest		Cold	
	Spy		Hermit	

**Bland et al., (2016)**

	<b>War</b>	<b>Anger</b>		<b>Fear</b>	<b>Danger</b>
<i>Anger</i>	Battle	Mad	<i>Fear</i>	Terror	Risk
	Bomb	Frustrate		Fright	Caution
	Fight	Hate		Anxiety	Warning
	Revolution	Rage		Afraid	Safe
	Nuclear	Temper		Panic	Daring
	Missile	Fury		Scared	Trouble
	Soldier	Ire		Horror	Zone
	Gun	Wrath		Monster	Fire
	Destruction	Fight		Scream	Accident
	Defeat	Hatred		Darkness	Harmful

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Neutral lists are normally chosen from the typical DRM word lists described previously. Researchers often take advantage of the Affective Norms for English Words (ANEW, Bradley & Lang, 1999) to find emotional valence and arousal data for each word or obtain their own data by asking participants to assess the valence and arousal of each word using Bradley and Lang's (1999) Self-Assessment Manikins (SAM). The SAM contains graphic scales representing different emotional dimensions on a 9-point scale: the valence SAM ranges from a happy, smiling figure (1) to an unhappy, frowning figure (9), similarly, the arousal SAM ranges from an excited, wide-eyed figure (1) to a relaxed, calm figure (9) (see Figure 4.1, for examples).



*Figure 4.1.* Modified versions of valence (top) and arousal (bottom) Self-Assessment Manikins (SAM) used in Experiment 1 of the present thesis, which were edited based on Bradley and Lang’s (1999) original graphic scales.

There are two common issues with the emotional word lists that have been used in prior research. First, not every word on a particular list reflected the target emotion. For example, the negative-emotional word lists used by Knott and Thorley (2014) were taken from Dewhurst et al. (2012) where the word “truth” is an associate of the critical lure “lie,” “together” is an associate of the critical lure “alone,” and “tissue” is an associate of the critical lure “cry.” These list words (truth, together, and tissue) do not have a negative emotional valence. Second, although data from databases, such as the ANEW or from Nelson et al.’s (2004) word association norms, have contributed to the construction of word lists in many significant studies, not every word that has been used on word lists in DRM research can be found in the existing database and previous researchers have not collected their own data for the missing words on the lists (Budson et al., 2006; Howe & Malone, 2011). Where researchers have collected their own data for the word lists that they constructed (Palmer & Dodson, 2009), they usually only collected data to establish BAS values without also collecting data to determine the arousal and valence of the words on the lists. Given that both valence and arousal could influence false memories (Corson & Verrier, 2007; Kensinger & Corkin, 2004), to examine the effect of valence per se (i.e., happy or sad), it is important to hold arousal constant.

Taken together, in no single study have the list words shared the same emotional valence as the corresponding critical lure, and in no single study have both arousal and BAS been equated across the different emotionally-laden list words and critical lures. Given this, the goal of Experiment 1 in the present thesis was to construct emotional word lists that did not differ in level of arousal and BAS values while at the same time every word on a particular list reflected the target emotion.

## **Experiment 1**

### **Method**

#### **Participants**

Sixty 18- to 35-year-old undergraduate university students (30 female) from a moderate-sized city in New Zealand participated in the experiment. Each participant was paid \$25 for participating. All of the participants were native English speakers with normal or corrected-to-normal vision, and had no history of mood disorders.

#### **Materials**

Five positive and 7 negative critical lures that had been used in previous research (Brainerd et al., 2010; Budson et al., 2006; Howe & Malone, 2011; Joormann et al., 2009; Ruci et al., 2009; Thijssen, Otgaar, Howe, & de Ruiter, 2013) and 7 neutral critical lures from Roediger, Watson, et al. (2001) were selected for this experiment. Any critical lures for which there had been any previous confusion about emotional valence were excluded. For example, in some studies, “sweet” and “needle” have been regarded as positive and negative critical lures, respectively; however in other studies, both of these critical lures have been regarded as neutral. Next, list words to accompany these critical lures were selected. Words that were part of multiple lists or words that were different in valence from the corresponding critical lure were avoided (e.g., “happiness” and “emotion” in the “anger” list).

#### **Procedure**

Participants were tested in groups of up to 10. They were told that they would be shown a series of target words, and for each word, they would be required to write down the first word that came to mind. If they could not think of a response, they were told to write “0” in the space. The basic procedure to obtain the main BAS value for each word list was modelled after Nelson et al. (2004) and Roediger, Watson, et al. (2001).

MediaLab (Jarvis, 2012) was used to present participants with a total of 233 words,

one after the other, in a random order. After participants had typed their response to each target word, they were asked to assess the emotional valence and arousal of the word using adapted versions of Bradley and Lang's (1999) Self-Assessment Manikins (SAM). The procedure to obtain emotional valence and arousal values for each word was modelled after Bradley and Lang (1999).

**Data analysis.** MediaLab recorded participants' responses to each word. Spelling errors were corrected and then rules were constructed to pool items that could be put together using the same approach as Nelson et al. (2004). For example, *fib* produced *lie* as the dominant response, however, several participants also reported *lies*. These two responses were treated the same so the count for *lies* was pooled with the count for *lie*. In general, pooling was used very infrequently (76 times out of 7270 responses).

For each word, a mean score for BAS, valence, and arousal was calculated. The list words' mean BAS score was then averaged to get the mean BAS value for each list. Considering the importance of BAS values in false memory research, word lists were then chosen based primarily on their BAS values. As such, the 4 negative, positive, and neutral word lists that had the highest overall BAS values were selected and the list words were sorted in descending order of their BAS values (i.e., highest BAS to lowest BAS). For each list, the top 10 list words according to their BAS value were chosen (see Appendix B).

Based on the selected list words, an independent group of 30 young adults (18 female;  $M$  age = 19.97 years,  $SD$  = 1.07) was recruited to further estimate a connectivity value for each list. There were 1080 pairs of studied words, excluding 120 self-connections. Each participant was asked to type a number from 0 to 1 to indicate how likely he or she thought of a target word after seeing the cue word. High connectivity scores indicate greater associative strength between list words.

## Results and Discussion

Recall that the goal was to create lists in which the emotional valence varied across the three list types (positive, negative, neutral), but arousal and BAS did not. To examine whether the lists met this criteria, three separate one-way ANOVAs were conducted where type of word lists was the independent variable (positive, negative, neutral) and the scores for BAS, emotional valence, and arousal were the dependent variables. Emotional valence and arousal were indexed by 9-point scales. Lower scores referred to more positive valence (happiness) and higher arousal (excitement). Emotional valence and arousal were assessed using 9-point scale, As shown in Figures 4.2 and 4.3, there was no significant difference in BAS or arousal values as a function of type of word lists,  $F(2, 9) = .84, p > .05, \eta_p^2 = .16,$  power = .15, and  $F(2, 9) = 2.24, p > .05, \eta_p^2 = .33,$  power = .34, respectively. In contrast, there was a significant difference in valence,  $F(2, 9) = 127.05, p < .001, \eta_p^2 = .97.$  Post hoc tests (LSD) revealed that the negative word lists had significantly higher emotional valence values than did the neutral word lists and the neutral word lists had a significantly higher emotional valence than did the positive word lists (see Figure 4.4).

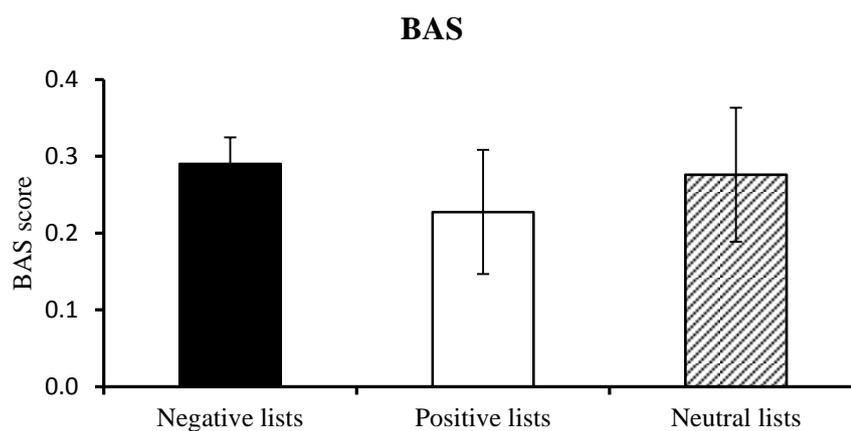


Figure 4.2. The mean BAS scores (+/-1SE) as a function of type of word lists.

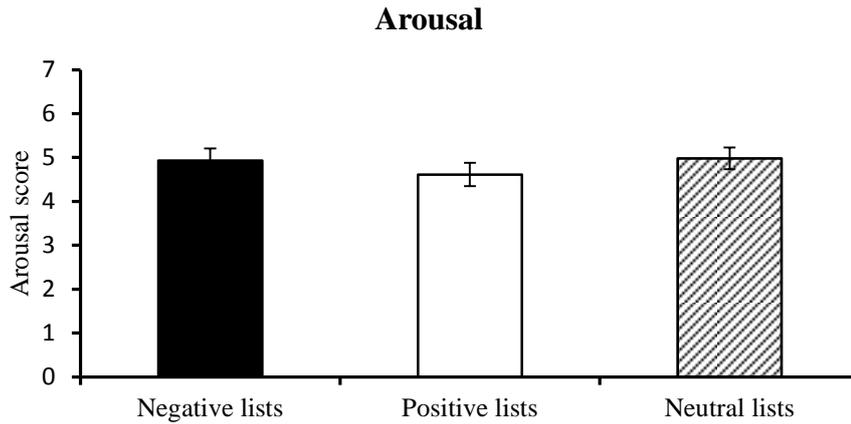


Figure 4.3. The mean emotional arousal scores (+/-1SE) as a function of type of word lists.

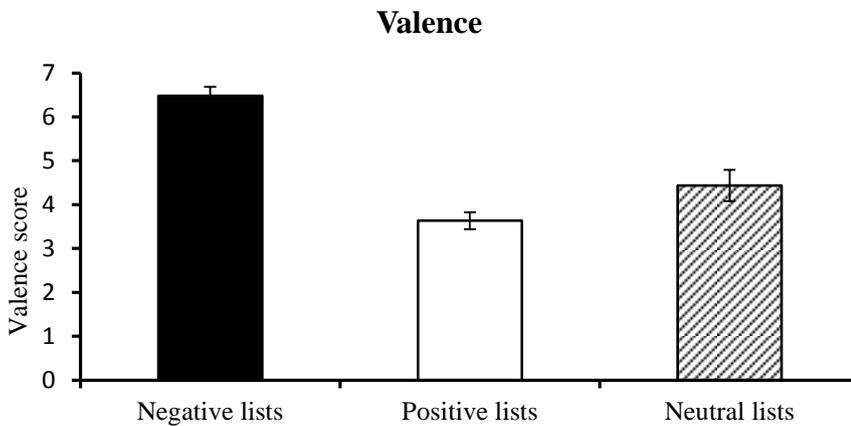


Figure 4.4. The mean emotional valence scores (+/-1SE) as a function of type of word lists.

The emotional arousal and valence of the critical lures were also compared as a function of word list; there was no significant difference in arousal values between the three types of critical lures,  $F(2, 9) = 3.55, p > .05, \eta_p^2 = .44, \text{power} = .51$ , however, there was a significant difference in valence values,  $F(2, 9) = 40.35, p < .001, \eta_p^2 = .90$ . Post hoc tests (LSD) revealed that the negative critical lures had significantly higher emotional valence values ( $M = 6.20, SD = .22$ ) than did the neutral critical lures ( $M = 4.26, SD = .22$ ), and the neutral critical lures had significantly higher emotional valence than did the positive critical lures ( $M = 3.46, SD = .22$ ).

As for connectivity, there was no significant difference in connectivity as a function

of emotional word list,  $F(2, 11) = 2.19, p = .168$ . The connectivity mean scores (and SD) of the negative, positive, and neutral word lists were .66 (.03), .59 (.04), and .60 (.07), respectively.

Taken together, the results indicate that the new word lists satisfied the criteria; that is, every word on the lists had the assigned emotional content (positive, negative, neutral), and the lists were matched in terms of arousal, BAS, and connectivity. This set of standard word lists provided an opportunity to better explore emotional false memories in the studies to follow. In the next Chapter, I initially compared the false memory generated by these “pure” emotional lists and that generated by previous ones (Experiment 2), and then investigated the effect of the new emotional lists on false recall, in particular (Experiment 3).

## Chapter 5

### False Memories for the Emotional DRM Word Lists

In many real-life situations when people are required to report their memories (e.g., in the courtroom or the clinic), the to-be remembered information is usually emotionally charged (i.e., negative). Given this, it is important to understand how the emotional content of information influences the generation of false memories. Although a few researchers have used emotional pictures as experimental materials (e.g., Bookbinder & Brainerd, 2017), the most common method in this area of research has been to use emotional word lists in the DRM paradigm.

Table 5.1 summarises the representative studies using the emotional DRM word lists. Budson and colleagues (2006) originally modified some of the typical DRM word lists, which are neutral, by adding several negative list words and negative critical lures into the lists (e.g., *mad*, *rage*, *annoyed*, *furious*, and *hate* were the list words associated with the critical lure *anger*). They compared the false recognition rate generated by the negative lists with that generated by the neutral lists in younger adults, older adults, and patients with Alzheimer's disease. Considering the younger adults, in particular, there was an increase in true recognition for the negative lists relative to the neutral lists. False recognition, on the other hand, did not differ as a function of list valence. It should be noted, however, the negative lists used by Budson et al. (2006) were more arousing than were the neutral lists. That is, the negative lists were different from the neutral lists in not only valence, but also arousal. In addition, the sample size in the study was small (only 19-20 per group), which may result in a smaller effect size compared to other relevant studies (for review, see Bookbinder & Brainerd, 2016).

Table 5.1.

*Studies Regarding the Effect of Emotional DRM Word Lists on False Memories*

<b>Author(s)</b>	<b>Valence comparisons</b>	<b>Arousal</b>	<b>Memory test</b>	<b>Main results (false memories)</b>
Budson et al. (2006)	Negative vs neutral	Not controlled	Recognition	Negative $\approx$ neutral lists
Howe (2007)	Negative vs neutral	Not controlled	Recall & recognition	Recall: negative < neutral lists Recognition: negative > neutral
Palmer & Dodson (2009)	Negative vs positive vs neutral	Not controlled	Recall	Negative $\approx$ positive < neutral lists
Sharkawy, Groth, Vetter, Beraldi, & Fast (2008)	Negative vs neutral	Not controlled	Recall & recognition	Recall: negative $\approx$ neutral lists Recognition: negative > neutral
Howe, Candel, et al. (2010) (Expt. 1)	Negative vs neutral	Not controlled	Recall & recognition	Recall: negative < neutral lists Recognition: negative > neutral
Brainerd, Stein et al. (2008)	Negative vs positive vs neutral	Controlled	Recognition	Negative > neutral > positive
Dehon, Larøi, & Van der Linden (2010)	Negative vs positive vs neutral	Controlled	Recall & recognition	Recall: negative $\approx$ positive > neutral Recognition ( <i>remember</i> ): negative > positive > neutral
Brainerd et al. (2010)	Negative vs positive	Factorial manipulated	Recognition	Negative > neutral > positive

Howe and colleagues explored the same research question with larger samples of children and adults, respectively (Howe, 2007; Howe, Candel, et al., 2010). In both studies, recall and recognition tests were conducted and recall always preceded recognition. The emotional arousal of lists was not controlled. Although Howe and colleagues observed a significant difference in false memories for emotional versus neutral lists, the difference varied as function of the type of memory test. That is, false recall rates were lower for the negative lists than for the neutral lists. In contrast, false recognition rates were higher for the negative lists than for the neutral lists.

The false recall results reported by Howe and his colleagues were not replicated in Sharkawy et al. (2008), although a similar experimental procedure was used. Sharkawy et al. found that there was no reliable difference in false recall for emotional versus neutral lists. Consistent with Howe, Candel et al. (2010), however, Sharkawy et al. found that false recognition was higher for the negative lists than for the neutral lists. But like many prior studies, the emotional arousal of lists was not controlled.

What would happen if arousal was controlled across emotional word lists? Dehon et al. (2010) controlled arousal levels across the negative, neutral, and positive word lists and found a similar pattern of results for false recognition as previous studies; the false recognition rate for the negative lists was higher than that for the positive lists, which in turn was higher than the false recognition rate for neutral lists. However, the findings regarding false recall were totally different from those in previous studies (Howe, 2007; Howe, Candel, et al., 2010; Sharkawy et al., 2008); false recall rates for the negative and positive lists were higher than (rather than lower than or similar to) the false recall rate for the neutral lists.

Summing up, the studies reviewed thus far have shown that the effect of emotional word lists on *false recognition* is consistent and replicable, but the findings regarding the valence effect on *false recall* are mixed. The mixed findings may be due to the confounding

effects of valence and arousal rather than valence per se. It is very likely that false recall may be more sensitive to the impact of arousal, compared to false recognition. In addition, as noted earlier, one common issue in these studies is that the order of recall and recognition tests was not counterbalanced. Research has shown that recognition is influenced by prior recall tests. In this sense, although the finding of false recognition is consistent, we cannot guarantee the consistent finding is reliable in the absence of prior recall testing. In another two studies where arousal of emotional word lists was either controlled or factorially manipulated, Brainerd and colleagues reported similar, but more reliable findings, regarding false recognition (Brainerd et al., 2010; Brainerd, Stein, et al., 2008). In their studies only recognition tests were used. Under these conditions, the negative lists again yielded more false recognition than did the neutral and positive lists.

Although a few studies have addressed the issue of controlling arousal of emotional word lists, in no single study have all of the list words shared the same emotional valence as the corresponding critical lure. It is possible that when all the list words are semantically related to each other, and share the same valence (i.e., “pure” emotional lists), the links among the list words would be much closer in mental lexicon (as suggested by the associative theories, such as Associative-Activation Theory; AAT) or gist retrieval for the list words would be better than that for “hybrid” emotional lists (as suggested by Fuzzy-trace theory; FTT, a review, see Bookbinder & Brainerd, 2016). Moreover, FTT argues that “verbatim and gist retrieval *both* support true memory for experienced items, either because the corresponding experiences are specifically recollected (verbatim retrieval) or because items’ meanings are familiar” (p.166, Brainerd & Reyna, 2002). Therefore, according to both theories, true memories for the “pure” emotional lists should be greater than those for the “hybrid” emotional lists. As for false memories, the story is a bit different between AAT and FTT. According to AAT, “pure” emotional lists should produce more false memories than

did “hybrid” emotional lists because better retrieval of list words in “pure” lists than in “hybrid” lists may lead to greater associative activations of emotionally- and semantically-related critical lures. Alternatively, according to FTT, better gist memories would directly lead to more false memories for pure lists compared to hybrid lists. However, according to FTT, it is also possible that better true memories of list words may serve as a cue to suppress false memories of critical lures, thus false memories for “pure” lists might be lower rather than higher than those for “hybrid” lists.

In Experiment 2, I wanted to test these theoretical predictions by comparing the false recognition rate generated by “pure” emotional lists to that generated by “hybrid” emotional lists. Moreover, I wanted to see whether the prior finding of false recognition could also be replicated when using the “pure” emotional lists. In Experiment 3, I wanted to extend the prior studies (e.g., Dehon et al., 2010; Palmer & Dodson, 2009) to see if false recall would be influenced by “pure” emotional DRM word lists, when arousal levels of the lists had been well controlled.

## Experiment 2

### Method

#### Participants

Sixty 17- to 23-year-old undergraduate university students (30 female) were recruited from an Experimental Participation Pool. They had not participated in relevant studies before. All of the participants were native English speakers with normal or corrected-to-normal vision, and had no history of mood disorders.

#### Design

A 2 (Word lists: hybrid vs pure)  $\times$  2 (List valence: negative vs positive)  $\times$  3 (Word type: studied words, critical lures, and unrelated words) mixed design was conducted. The first factor was manipulated between subjects while the other two were manipulated within subjects. The dependent variables were true recognition rates of studied words and false recognition rates of critical lures and unrelated words, respectively.

#### Materials and Procedure

Hybrid emotional lists were chosen from the Cornell/Cortland Emotional Lists (CEL; Brainerd et al., 2010; Brainerd, Stein, et al., 2008), which is a pool of 32 emotional word lists with high or low valence and arousal levels. To rule out the influence of backward association strength (BAS) and other extraneous variables (e.g., arousal), I selected the “*love*” list which was positive valence/high arousal and the “*nice*” list which was positive valence/low arousal in CEL. Likewise, the “*anger*” and “*sick*” list were selected as a negative valence/high arousal list and a negative valence/low arousal list, respectively. Furthermore, I used the first 10 words in these lists to make the list length of the hybrid emotional lists the same as that of our pure emotional lists.

Given that the goal of Experiment 2 was to compare the level of false memories created by the hybrid emotional lists with those created by the pure emotional lists, I held the

critical lures of the two word-list types constant. Therefore, the two positive lists, “*love*” and “*nice*”, and the two negative lists, “*anger*” and “*sick*,” which share the same critical lures to the hybrid lists selected from the CEL, were chosen from the emotional word lists constructed in Experiment 1 (see Appendix B for more details of the word lists used in the present experiment).

In the both hybrid and pure emotional lists, all of the words were shown in the descending order of their BAS values. That is, the first word in each list was the one most associated with the critical lure, the second word was the one next most associated, and as on. The presentation order of word lists was counterbalanced across participants, with half of the participants learning 2 negative word lists, followed by 2 positive word lists, and the other half of the participants learning the word lists in the reverse order.

Participants were tested in groups of up to 8. Each word was presented for 2 s on a computer monitor. After all of the words in the word list were presented, a message came up warning the participant that the next word list was about to appear. Between the study and test phase, participants completed a 5-min subtraction exercise. The recognition test contained 40 words in total, including 20 studied words--from serial positions 1, 2, 4, 8, and 9 of each word list; and 4 critical lures, and 16 unrelated words—the 8 positive and 8 negative unrelated words were taken from Brainerd et al. (2010). The order of presentation of these 40 test words was completely random. Participants were asked to make “old/new” judgments by pressing “1” if they thought that the word had been presented in the study phase or pressing “2” if they believed that the word had not been presented.

## Results and Discussion

The data for each dependent variable was first subjected to separate 2 (word list: hybrid vs pure)  $\times$  2 (list valence: negative vs positive) mixed factor analyses of variance (ANOVAs). Pairwise comparisons were then conducted to see whether negative lists would create more true and false memories than would positive lists, and to see whether pure emotional word lists would induce greater true and false memories than would hybrid emotional word lists.

### True recognition of studied words

The proportion of times that participants recognised a studied word is shown in Figure 5.1 as a function of word list and list valence. There was a main effect of list valence,  $F(1, 58) = 31.19, p < .001, \eta_p^2 = .35$ , true memories were higher for the negative word lists ( $M = .77$ ) than for the positive word lists ( $M = .64$ ). Likewise, there was a main effect of word list,  $F(1, 58) = 48.50, p < .001, \eta_p^2 = .46$ , the true recognition rate for the pure emotional word lists ( $M = .82$ ) was higher than that for the hybrid emotional word lists ( $M = .59$ ). The main effects of list valence and word list was qualified by a List Valence  $\times$  Word List interaction,  $F(1, 58) = 19.71, p < .001, \eta_p^2 = .25$ . Pairwise comparisons showed that when all of the words on the list shared the same emotional valence (i.e., pure emotional lists), there was no valence effect on true recognition; the true recognition rate for the negative lists was similar to that for the positive lists. However, the true recognition rate was higher for the hybrid negative lists than for the hybrid positive lists ( $p < .001$ ). In addition, the true recognition rates for the pure emotional lists were higher than those for the hybrid emotional lists, regardless of list valence (both  $p \leq .001$ ).

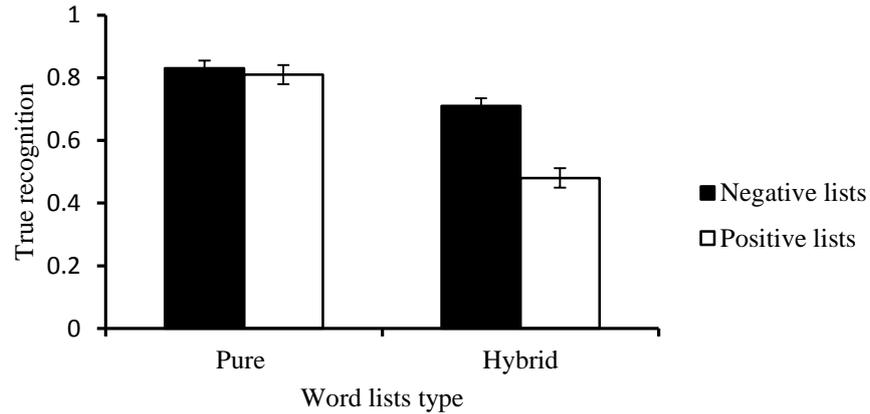


Figure 5.1. Proportion of true memories (+/-1SE) as a function of word list and list valence

### False recognition of critical lures

There were main effects of list valence,  $F(1, 58) = 9.93, p < .05, \eta_p^2 = .15$ , the false recognition rates were higher for the negative lists ( $M = .81$ ) than for the positive lists ( $M = .66$ ); and word list,  $F(1, 58) = 10.46, p < .05, \eta_p^2 = .15$ , the false recognition rate for the pure emotional lists ( $M = .63$ ) was lower than that for the hybrid emotional lists ( $M = .84$ ), but no significant List Valence  $\times$  Word List interaction,  $F(1, 58) = 1.96, p = .17, \eta_p^2 = .033$ , power = .281 (see Figure 5.2).

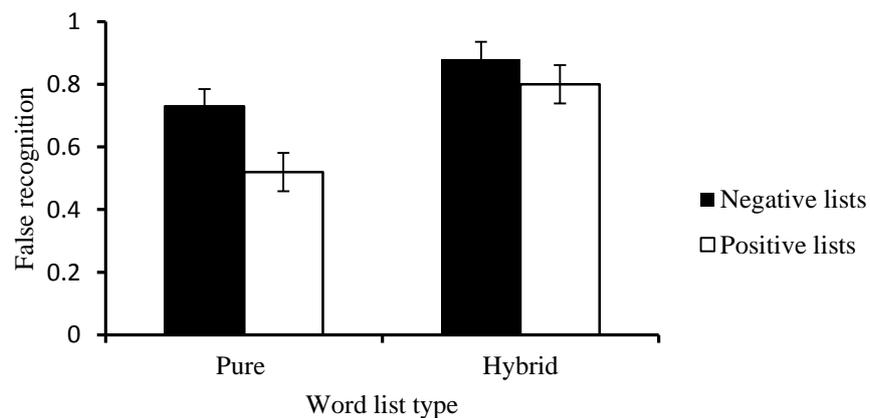


Figure 5.2. Proportion of false memories (+/-1SE) as a function of word list and list valence

### **False recognition of unrelated words**

Generally the false recognition rates for unrelated words were very low (all  $M$ 's  $< .10$ ). No significant difference in false recognition rate was found as a function of word list or list valence (all  $F$ 's  $< 1.88$ , *ns*).

In sum, compared to the hybrid emotional lists, pure emotional lists produced more true recognition but less false recognition, regardless of list valence. This finding supports the assumptions of FTT. According to FTT, higher true memories may result in lower false memories because the better verbatim memories of list words may serve as a cue to suppress false memories of critical lures. In this sense, the lower false recognition rate for the pure emotional lists compared to that for the hybrid emotional lists may be due to the fact that participants took advantage of their better true memories to help them distinguish the words that had been presented from those that had not been presented. It is important to note, however, that because we did not collect independent arousal data for the words on the pure and hybrid lists used in Experiment 2, we do not know whether arousal was well controlled. We took this limitation into consideration in the pilot study for Experiment 3.

### Pilot Study for Experiment 3

The goal of Experiment 3 was to investigate whether false recall would be influenced by “pure” emotional DRM word lists, when the arousal levels of emotional word lists were well controlled. The two neutral lists, “*mountain*” and “*music*” were selected from the new emotional word lists that had been constructed in Experiment 1. The negative and positive lists were the same as those in Experiment 2.

To confirm that the arousal of the six selected lists was similar, an independent sample of participants ( $n = 10$ , 5 female) were asked to rate the emotional arousal of each list word and each critical lure using adapted versions of Bradley and Lang’s (1999) Self-Assessment Manikins (SAM). Table 5.2 shows the arousal scores of list words and critical lures as a function of list valence.

Table 5.2.

*The Mean and Standard Deviations (SD) of Arousal Scores of List Words and Critical Lures as a Function of List Valence*

	List words		Critical lures	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Negative	5.11	.12	4.95	.07
Positive	5.09	.01	4.95	.21
Neutral	4.87	.21	5.05	.21

There was neither a significant difference in the arousal level of list words as a function of list valence,  $F(2, 3) = 1.74, p > .05$ , nor in the arousal level of critical lures,  $F(2, 3) = 0.21, p > .05$ . The finding indicated that arousal of word lists used in Experiment 3 was well controlled.

## **Experiment 3**

### **Method**

#### **Participants**

Thirty 17- to 26-year-old undergraduate university students (21 female) were recruited from an Experimental Participation Pool. They had not participated in any relevant studies before. All of the participants were native English speakers with normal or corrected-to-normal vision, and had no history of mood disorders.

#### **Design**

A 3 (List valence: negative, positive, and neutral)  $\times$  2 (Word type: studied words and critical lures) within-subjects design was used. The dependent variables were the true recall rate of studied words and the false recall rate of critical lures.

#### **Materials and Procedure**

There were 6 word lists used in Experiment 3, including the “anger” list, “sick” list, “love” list, “nice” list, “mountain” list, and “music” list. The presentation order of word lists was partially counterbalanced across participants, with half of the participants studying 2 negative lists, 2 neutral lists, followed by 2 positive lists, and the other half of the participants studying 2 positive lists, 2 neutral lists, followed by 2 negative lists.

Each word was presented for 2 s on a computer monitor. After each list had been presented, participants completed a 30s distractor task and were then asked to recall as many of the words from the list as they could remember in 1 min.

## Results and Discussion

The data were analysed using a 3 (List valence: negative, positive, and neutral)  $\times$  2 (Word type: studied words and critical lures) ANOVA with repeated measures over list valence. The true recall rates of the studied words and the false recall rates of the critical lures are shown in Table 5.3 as a function of list valence.

Table 5.3.

*The Mean and SD of the True Recall Rates and the False Recall Rates as a Function of List Valence*

List valence	Studied words		Critical lures	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Negative	.74	.019	.30	.057
Positive	.61	.020	.13	.041
Neutral	.74	.024	.05	.028

There were main effects of list valence,  $F(2, 58) = 10.75, p < .001, \eta_p^2 = .27$ , the negative lists ( $M = .52$ ) yielded a higher true recall rate than did the positive ( $M = .37$ ) and the neutral lists ( $M = .40$ ); and word type,  $F(1, 58) = 343.76, p < .001, \eta_p^2 = .92$ , the true recall rate of the studied words ( $M = .70$ ) was significantly higher than the false recall rate of the critical lures ( $M = .20$ ); and a List Valence  $\times$  Word Type interaction,  $F(2, 58) = 8.04, p = .001, \eta_p^2 = .22$ . Pairwise comparisons showed that the true recall rate was higher for the negative and neutral lists than for the positive lists (both  $p < .001$ ), and there was no reliable difference in true recall between the negative and neutral lists. The false recall rate, on the other hand, was higher for the negative lists than for the positive and neutral lists ( $p = .03$  and

$p = .001$ , respectively), and there was no significant difference in false recall between positive and neutral lists ( $p = .13$ )

The present finding replicates an earlier one (Dehon et al., 2010) by showing that negative lists generate more false recall than do neutral lists when the arousal of the to-be-remembered emotional lists is well controlled. More importantly, we extended previous studies by using pure emotional word lists rather than hybrid emotional word lists and found that the false recall rate for the negative lists was not only higher than that for the neutral lists, but was also higher than the false recall rate for the positive lists.

## General Discussion

There were two main findings in Experiment 2: (1) regardless of list valence, true recognition rates for the pure emotional lists were higher than those for the hybrid emotional lists; false recognition rates, on the other hand, were lower for the pure emotional lists than for the hybrid emotional lists, and (2) the valence effect on false recognition was generally found in Experiment 2; the negative lists yielded more false recognition than did the positive or neutral lists. However, this valence effect was more robust in the pure emotional lists than in the hybrid emotional lists. In Experiment 3, the valence effect of emotional content was also found for false recall when arousal of emotional content was controlled. This finding suggests that the valence effect of emotional content on false memories may not be restricted to a specific memory test.

Both Associative-Activation Theory (AAT; Howe, 2005, 2006) and Fuzzy-Trace Theory (FTT; Brainerd & Reyna, 2005) can account for why true memories for the pure emotional lists were better than those for the hybrid emotional lists. According to AAT, when all of the list words are semantically related to each other, and share the same valence, the links among these list words should be much closer in the mental lexicon. As such, the retrieval of list words should be much easier making the retrieval of true memories of list words more likely in pure lists than in hybrid lists. Alternatively, according to FTT, because each list word not only shares similar meaning, but also shares the same valence in the pure emotional lists, gist retrieval for these list words should be better than that for the list words in the hybrid lists. As a result, true memories for the pure emotional list words should be greater than those for the hybrid emotional lists.

Although both theories make similar predictions about true memories, AAT and FTT make different predictions about false memories for the pure and the hybrid lists. According to AAT, better retrieval of list words on the pure lists would lead to greater associative

activation of emotionally- and semantically-related critical lures. Thus, false memories for the pure lists should be higher than those for the hybrid lists. According to FTT, on the other hand, better true memories of list words may serve as a cue to suppress false memories of critical lures. Thus, false memories for the pure lists would be lower than those for the hybrid lists. The present findings are most consistent with FTT's prediction; although pure lists generated better true memories, false memories generated by the pure lists were actually lower than those generated by the hybrid lists.

In addition to the composition of the lists, the present findings also lead to conclusions about the effect of valence on false memories. Although a consistent finding in prior research is that negative lists usually generate more false recognition than do positive or neutral lists (Brainerd et al., 2010; Brainerd, Stein, et al., 2008; Dehon et al., 2010; Howe, 2007; Howe, Candel, et al., 2010; Sharkawy et al., 2008), we have no idea whether this pattern is reliable because the emotional lists used in prior research are not comprised of purely emotional words. Experiment 2 confirmed that false recognition is higher for the negative lists than for the positive lists. More importantly, the valence effect was more robust in the pure emotional lists than that in the hybrid emotional lists. This finding indicated that the ideal way to investigate the valence effect of to-be-remembered information on false recognition is to use pure, rather than hybrid, emotional information.

As for the valence effect on false recall, the findings have been mixed in the literature. Some researchers have found that the negative lists yield less false recall than do the neutral lists when the arousal of emotional lists is not controlled (e.g., Palmer & Dodson, 2009). In contrast, when other researchers controlled the arousal of emotional lists, they found that the negative lists yielded more false recall than did the neutral lists (e.g., Dehon et al., 2010). In both kinds of studies, there was no significant difference in false recall generated by the negative lists and that generated by the positive lists. However, as mentioned earlier, one

common issue in both kinds of studies is that the emotional lists used were not purely emotional. In Experiment 3, I took advantage of the pure emotional lists and controlled arousal of these lists to see how emotional valence influences false recall and found that the negative lists do yield more false recall than do the positive and neutral lists.

The finding for false recall was the same as that found for false recognition, which in turn suggests that the valence effect of emotional lists on false memories may be not due to the memory test per se, but rather due to the semantic density of emotional information. Research has found that negative information has greater semantic density, compared to positive or neutral information (e.g., Kensinger & Schacter, 2008; Talmi & Moscovitch, 2004). According to AAT, the greater semantic density of negative information allows the associative links among negative studied words to spread more easily to negative critical lures (Howe, 2007; Howe et al., 2010), and according to FTT (Brainerd et al. 2010; Brainerd, Stein, et al., 2008), it also renders gist information easier to retrieve. Therefore, no matter whether memory is tested using a recognition test or a recall test, negative lists should generate more false memories, than do positive or neutral lists.

So far, we have tested the effect of emotional content on false memories, and found that negative information tends to yield more spontaneous false memories in the DRM paradigm than does positive or neutral information. In many contexts (e.g., in the courtroom or the clinic), the to-be-remembered information is not only emotionally charged, but it is retrieved in a distinctive emotional context or mood. Therefore, next, I investigated the effect of both emotional content and emotional context on spontaneous DRM false memories.

## Chapter 6<sup>1</sup>

### The Effect of Mood on False Memory for Emotional DRM Word Lists

Over the past three decades, researchers have shown that human memory is often highly fallible. Sometimes we recall the gist of a particular event, but the details of that event are incorrect (Lindsay, 1990; Loftus, 2005; Loftus & Hoffman, 1989; Roediger, Jacoby, & McDermott, 1996; Sutherland & Hayne, 2001) and sometimes we report entirely false memories for an event that never occurred (Hyman, Husband, & Billings, 1995; Loftus & Pickrell, 1995; Pezdek, Finger, & Hodge, 1997). On many occasions, our memory errors are of little significance, but sometimes they can have dire consequences, particularly if those memory errors are reported in court (Brainerd & Reyna, 2005; Ceci & Bruck, 1995; Hood et al., 2001; Otgaar, Candel, Scoboria, & Merckelbach, 2010).

Given the real-life consequences of some memory errors, it is important to understand the conditions under which they are most likely to occur. As noted earlier, the DRM paradigm is the most widely-used procedure to investigate false memories in the laboratory. Numerous studies have consistently found the DRM false memory effect: critical lures are often falsely recalled and recognised (see review, Brainerd & Reyna, 2005; Gallo, 2013), and the effect has also been found to persist over time (Seamon, Luo, Kopecky, et al., 2002).

In many contexts in which false memories really matter (e.g., in the courtroom or the clinic), the memories themselves are not only emotionally charged, but they are retrieved in a distinctive emotional context or mood. Given this, researchers have specifically examined the effect of emotional word lists and participants' moods on false memories in the DRM paradigm. In one category of research, researchers have tested participants using emotionally-laden word lists in the absence of mood induction (i.e., participants were in their natural

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<sup>1</sup> This chapter is published as Zhang, Gross, & Hayne (2017a). As the paper is reproduced in its full published form, there is some duplication with material presented in previous chapters.

mood). The purpose of these studies was to examine the effect of the emotional content of the target material on false memories. For example, Brainerd, Stein et al. (2008) found that participants had higher false recognition rates for critical lures associated with negative word lists than those associated with positive or neutral word lists. In another category of research, researchers have induced a particular mood in participants and then tested them using traditional, non-emotional, DRM word lists. The purpose of these studies was to examine the effect of the emotional state of the rememberer on false memories. For instance, Storbeck and Clore (2005) used music to induce positive or negative moods in participants and then asked them to learn word lists consisting of neutral words. They found that participants in a positive mood falsely recalled the critical lures more often than did participants in a negative mood.

At first blush, it is difficult to reconcile the data reported by Brainerd, Stein et al. (2008) and by Storbeck and Clore (2005): Brainerd, Stein et al. found that negative word lists yielded greater false memory, while Storebeck and Clore found that a negative mood reduced false memory. It is important to note, however, that the authors of each study only manipulated one aspect of emotion when they investigated the effect on false memories, making direct comparison difficult. What happens to the rate of false memories when we manipulate both the emotional content of the word lists and the participant's mood? In most of the studies designed to answer this question, researchers have tested participants with depression--a naturally-occurring mood manipulation (e.g., Howe & Malone, 2011; Joormann et al., 2009; Moritz et al., 2005). The primary finding in these studies has been that participants who suffer from depression have higher false memory rates for negative or depression-relevant word lists than they do for positive or neutral word lists, suggesting that they make more memory errors when their mood and the emotional valence of the word lists match.

In contrast to the body of work with clinical populations, in very few studies have researchers examined the effect of mood on false memories of emotional word lists in non-depressed participants. In one study, Ruci et al. (2009) used happy or sad narratives to induce a positive or negative mood in normal participants and then presented them with positive, negative, and neutral word lists. During the test, participants were tested for both recall and recognition. They were also asked to make “remember/know” judgments for the words they judged as “old.” When the critical lure matched the mood, participants were more likely to falsely recognise the lure and they were more likely to indicate that they remembered it. In another study, Knott and Thorley (2014) only found a mood-congruent false memory effect when participants were asked to make remember judgments for critical lures; they did not find this mood-congruent false memory effect for general recognition.

Given that in prior research, not every word on a particular list reflected the target emotion (Knott & Thorley, 2014; Palmer & Dodson, 2009; Ruci et al., 2009), and the two important variables, arousal and BAS, have not been equated across the different emotionally-laden list words and critical lures, to explore the combined effect of emotional word lists and induced moods on false memories, I used the standard emotional word lists generated in Experiment 1 in the present experiment. The lists met the following criteria: 1) the words in a list (e.g., rage, mad, enrage) were all related to a target word (e.g., anger); 2) the emotional valence of the words in a given list matched (i.e., for a negative word list, all of the words had a negative emotional valence); and 3) the word lists did not differ in level of emotional arousal. I hypothesised that participants would show higher true and false recognition rates for emotional word lists that were consistent with their current mood.

## Experiment 4

### Method

#### Participants

Ninety-three 17- to 33-year-old undergraduate university students (66 female) from a moderate-sized city in New Zealand participated in the experiment. Participants were recruited from an Experimental Participation Pool and they had not participated in any other similar study before. All of the participants were native English speakers with normal or corrected-to-normal vision, and had no history of mood disorders. They satisfied a small portion of course assessment by completing a worksheet based on the experiment.

#### Materials and Procedure

Participants were randomly assigned to one of the three mood conditions (positive, negative, or neutral;  $n = 31$  participants in each condition). Mood was induced using music combined with self-imagery. Participants in the positive and negative mood conditions listened to a piece of music and were asked to generate thoughts that were consistent with the corresponding music. Participants in the positive mood-induction group listened to 8 minutes of Bach's *Brandenburg Concerto No. 3* and participants in the negative mood-induction group listened to 8 minutes of Prokofiev's *Alexander Nevsky: Russia Under the Mongolian Yoke*. During the imagery phase, participants were also allowed to write down any words that came to mind (Becker & Leininger, 2011). This optional task was designed to maintain participants' focus during the mood-induction procedure. The results from subsequent item analyses (see below) showed that the words that participants wrote down during the mood-induction phase did not influence their performance on the subsequent memory tasks (see Results for more details). The positive (or negative) piece of music continued to play softly throughout the subsequent DRM procedure to maintain participants' mood.

Participants in the neutral group were asked to read a collection of basic facts about

New Zealand, including population size, gross national product, cultures, etc. This exercise took 8 minutes to complete based on normal reading speed. These mood-induction manipulations were modelled directly on those used in previous studies, in which researchers attempted to induce positive, negative, and neutral moods (Chepenik et al., 2007; Jiang et al., 2011; Rowe et al., 2007). Immediately following the mood-induction phase, participants completed the same 9-point Self-Assessment Manikins used in Chapter 4 to assess how happy (1) or sad (9) and how excited (1) or calm (9) they were (i.e., valence and arousal, respectively).

I used 12 word lists which were chosen based on the findings of Experiment 1. Each list was 10-words long and the words on each list were shown in the same serial order to all participants. Four of the word lists contained negative words, four contained positive words, and four contained neutral words. All of the words in each list were shown in the descending order of their BAS values. In other words, the first word in each list was the one most associated to the critical lure, the second word was the one next most associated, and so on.

Participants were tested in groups of up to 6. All of the tasks were presented through individual headphones. The presentation order of word lists was partially counterbalanced across participants; that is, half of the participants in each mood group learned 4 negative word lists, followed by 4 neutral word lists, followed by 4 positive word lists, and the other half of the participants learned the word lists in the reverse order (see also, Howe et al., 2010; Knott & Thorley, 2014; Ruci et al., 2009). Each word was presented for 2 s on a computer monitor. After all the words in the word list were presented, a message came up warning the participant that the next word list was about to appear. Participants were asked to remember all 12 word lists. Between the learning phase and the test phase, participants completed a 5-min subtraction exercise.

The recognition test contained 36 studied words--from serial positions 1, 4, and 8 of

each word list; and 12 critical lures, and 24 non-related lures--the positive and negative non-related lures were taken from Brainerd et al. (2010); the neutral ones were taken from Roediger, Watson, et al. (2001). The order of presentation of the 72 test words was completely random. If participants made an “Old” decision, they were then asked to make a further “Remember/Know” judgment. “Remember” judgments indicated that participants had a subjective feeling of having seen the words and had a vivid recollection of their details; “Know” judgments indicated that participants had an impression of the words but could not recollect their actual presentation (Rajaram, 1993). Although some researchers have also included a “Guess” option, Remember/Know judgments alone can reflect recollection and familiarity, respectively when participants are given training and instruction in the distinction as I used here (Migo, Mayes, & Montaldi, 2012).

## Results

### Mood manipulation check

Recall that participants' level of emotional arousal and the valence of their mood were indexed by 9-point scales. Lower scores referred to higher arousal (excitement) and more positive valence (happiness). Two separate one-way ANOVAs across the three mood groups were conducted using the arousal scores and valence scores as dependent variables. There was no significant difference in participants' arousal scores as a function of their mood induction group,  $F(2, 90) = 1.32, p > .05, \eta_p^2 = .028, \text{power} = .28$ . Overall, participants in the negative ( $M = 6.29, SD = 1.64$ ), positive ( $M = 5.61, SD = 1.99$ ), and neutral ( $M = 6.13, SD = 1.48$ ) mood groups had similarly moderate levels of emotional arousal. There was, however, a significant effect of mood induction on participants' mood scores,  $F(2, 90) = 73.15, p < .001, \eta_p^2 = .62$ . The positive mood group ( $M = 3.03, SD = 1.14$ ) reported being more happy than were the neutral mood group ( $M = 4.45, SD = .99$ ) who in turn were more happy than were the negative mood group ( $M = 6.61, SD = 1.36$ ).

### Recognition Test Analyses<sup>2</sup>

Table 6.1 shows the mean proportions and standard errors for true and false recognition as a function of *remember* and *know* judgments. We used the same data analysis strategy for every dependent variable. First, the data for each dependent variable was subjected to separate 3 (participant mood: negative, positive, neutral)  $\times$  3 (word valence: negative, positive, neutral) mixed-factor ANOVAs with repeated measures over word valence (Greenhouse-Geisser correction factor). We then used a series of separate one-way ANOVAs to compare across participant mood and across word valence (Alpha set at .05). Any significant effects were examined using the Bonferroni correction for pairwise-comparisons.

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<sup>2</sup> We also used signal detection analyses to determine whether the negative mood-congruent false memory effect was due to discrimination sensitivity ( $A'$ ) or response bias ( $C$ ). There was no significant difference in  $C$  for any dependent variable and the results of  $A'$  were the same as those obtained from mixed-factor ANOVAs. Given that the signal detection analyses did not provide any additional information, we have only reported results from the mixed-factor ANOVAs here.

## True recognition of studied words

Recall that on the recognition test, participants were first asked to indicate whether the word was old or new. The proportion of times that participants recognised a studied word is shown in Figure 6.1 as a function of participant mood and word valence. For *old* responses, there was no effect of mood,  $F(2, 90) = 1.81, p > .05, \eta_p^2 = .039, \text{power} = .37$ . Thus, although the music continued to play softly during the DRM procedure in the negative and positive mood conditions, it did not interfere with participants' ability to encode the words on the lists. There was a main effect of word valence,  $F(2, 180) = 5.93, p < .05, \eta_p^2 = .06$ , and a Mood  $\times$  Word Valence interaction,  $F(4, 180) = 4.33, p < .05, \eta_p^2 = .088$ . Participants had higher true recognition rates for negative studied words than for positive and neutral studied words when they were in the negative mood,  $t(30) = 2.34, p < .05$ , and  $t(30) = 3.38, p < .05$ , respectively. This mood-congruent effect was not due to higher true memories for negative studied words in the negative mood,  $|t|'s \leq 0.63, p's > .05$ , but it was due to a lower true recognition rate for positive studied words in the negative mood than that in the positive mood,  $t(60) = -2.08, p < .05$ , and a lower true recognition rate for neutral studied words in the negative mood than that in the neutral mood,  $t(60) = -2.88, p < .01$ .

Table 6.1.

*The Proportions of True and False Recognition as a Function of Word Type, Word Valence and Induced Mood*

Word valence	Negative mood			Positive mood			Neutral mood		
	Negative	Positive	Neutral	Negative	Positive	Neutral	Negative	Positive	Neutral
Studied words									
Remember	.60 (.04)	.49 (.05)	.47 (.05)	.54 (.04)	.55 (.05)	.49 (.05)	.55 (.04)	.50 (.05)	.65 (.05)
Know	.17 (.03)	.19 (.03)	.10 (.02)	.20 (.03)	.23 (.03)	.16 (.02)	.23 (.03)	.22 (.03)	.14 (.02)
Critical lures									
Remember	.45 (.06)	.30 (.05)	.25 (.05)	.48 (.06)	.46 (.05)	.39 (.05)	.33 (.06)	.36 (.05)	.44 (.05)
Know	.28 (.05)	.26 (.05)	.19 (.04)	.24 (.05)	.24 (.05)	.23 (.04)	.35 (.05)	.35 (.05)	.17 (.04)
Unrelated words									
Remember	.07 (.02)	.05 (.02)	.05 (.02)	.03 (.02)	.03 (.02)	.04 (.02)	.03 (.02)	.02 (.02)	.02 (.02)
Know	.08 (.02)	.06 (.02)	.05 (.02)	.08 (.02)	.07 (.02)	.07 (.02)	.06 (.02)	.05 (.02)	.09 (.02)

*Note:* Standard errors (SE) in parentheses

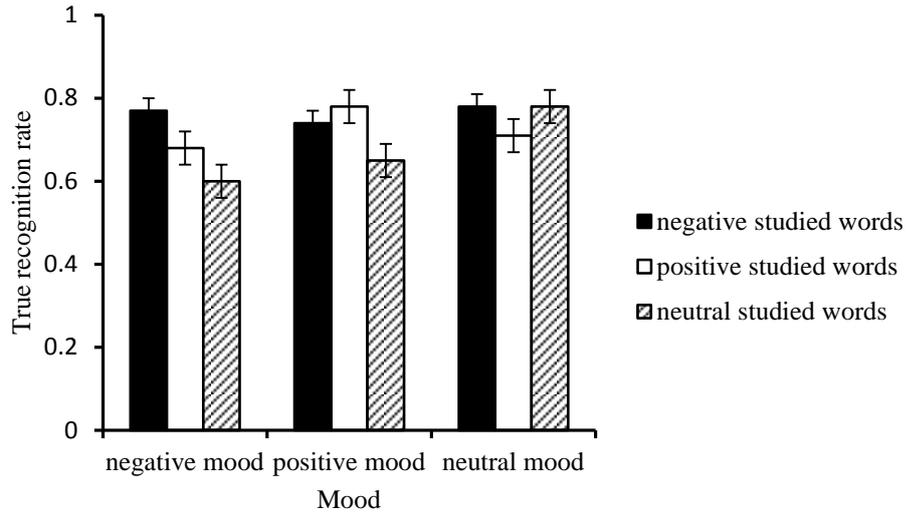


Figure 6.1. Proportion of true memories (+/-1SE) as a function of mood and word valence.

For each word that participants indicated was old, we were also interested in whether participants had a vivid recollection of its details (*remember* judgments) or merely had an impression of it (*know* judgments). For true *remember* judgments, there was a significant Mood  $\times$  Word Valence interaction,  $F(4, 180) = 4.77, p < .05, \eta_p^2 = .096$ . Participants in the negative mood condition made more correct remember judgments for negative studied words compared to positive and neutral studied words (both  $p < .05$ ). In addition, true remember judgements for neutral studied words were higher in the neutral mood group compared to the positive and negative mood groups (both  $p < .05$ ) (see Table 6.1). For true *know* judgments, there was no effect of mood and no mood  $\times$  word valence interaction (both  $F$ 's  $< 1.11$  ns), but there was a significant main effect for word valence,  $F(2, 180) = 8.97, p < .05, \eta_p^2 = .091$ . Participants made more know judgments for negative ( $M = .20$ ) and positive studied words ( $M = .21$ ) than for neutral studied words ( $M = .13$ ). There was no difference in know judgments between negative and positive studied words.

In sum, the true recognition data reflected a selective mood-congruent memory effect. The effect was only observed for participants in the negative mood condition. Moreover, in the negative mood condition, the mood-congruent effect was due to *lower* true recognition

rates for positive and neutral studied words rather than to *enhanced* true recognition rates for negative studied words.

### **False recognition of critical lures**

For *old* responses (see Figure 6.2), there was no effect of mood on false recognition,  $F(2, 90) = 2.04, p > .05, \eta_p^2 = .043$ , power = .41, but there was a significant main effect of word valence,  $F(2, 180) = 13.48, p < .05, \eta_p^2 = .13$ , and a Mood  $\times$  Word Valence interaction,  $F(4, 180) = 2.47, p < .05, \eta_p^2 = .052$ . As shown in Figure 6.2, the false recognition rate for negative lures was equally high for participants in all three mood conditions,  $F(2, 90) = .61, p > .05$ . In addition, participants in the negative mood condition had a significantly higher false recognition rate for negative critical lures than for positive and neutral critical lures,  $t(30) = 3.02, p < .01, t(30) = 5.22, p < .001$ , respectively. In contrast, participants in the positive and neutral mood conditions had a similarly high false recognition rate for all three kinds of critical lures (both  $F$ 's  $< 1.97, ns$ ). Finally, the false recognition rate for the positive and neutral critical lures was lower for participants in the negative mood condition compared to participants in the positive and neutral mood groups (both  $p < .05$ ).

For false *remember* judgments, there were no effects of mood or word valence (both  $F$ 's  $< 1.73, ns$ ), but there was a Mood  $\times$  Word Valence interaction,  $F(4, 180) = 3.82, p < .05, \eta_p^2 = .078$ . Participants in the negative mood condition exhibited a higher number of false remember judgments for negative critical lures than for positive and neutral critical lures,  $t(30) = 2.67, p < .05, t(30) = 3.63, p < .01$ , respectively. Moreover, false remember judgements for positive and neutral critical lures were more likely for participants in the positive and neutral mood groups compared to participants in the negative mood group (both  $p < .05$ ). For false *know* judgments, there was no effect of mood and no mood  $\times$  word valence interaction (both  $F$ 's  $< 1.51, ns$ ), but there was a significant main effect of word valence,  $F(2, 180) = 5.36, p < .05, \eta_p^2 = .056$ . Further analyses showed that, regardless of mood state,

participants made more false know judgments for negative ( $M = .29$ ) and positive critical lures ( $M = .28$ ) compared to neutral critical lures ( $M = .20$ ).

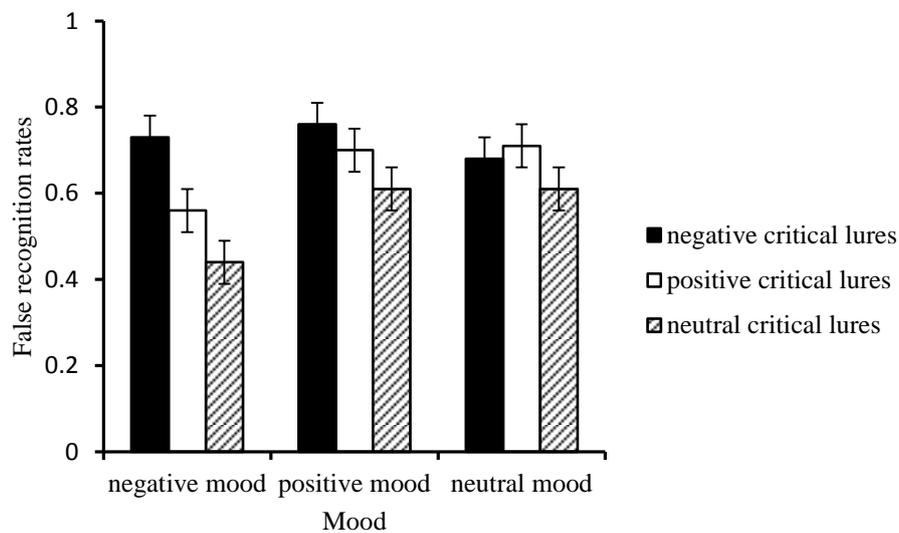


Figure 6.2. Proportion of false memories ( $\pm 1$ SE) as a function of mood and word valence

Finally, we explored whether the words that participants wrote down during the mood induction task influenced their memory for the studied words and the critical lures. A total of 10 out of 31 participants in the positive mood group wrote the word “happy” during the mood induction procedure; “happy” was the only positive critical lure that they recorded. A total of 9 out of 31 participants in the negative mood group wrote the word “sad” during the mood induction procedure; “sad” was the only negative critical lure that they recorded. We re-analysed the data removing the false recognition rates for the critical lures “happy” and “sad” as well as the true recognition rate for their corresponding list words. When we then analysed the data across the remaining 3 positive lists, 3 negative lists and 4 neutral lists, the results of this analysis were consistent with the original ones for both true and false recognition. These data rule out the possibility that the mood-congruent effects reported here were due to proactive interference by words that were generated by participants during mood induction (cf. Ruci et al., 2009).

In sum, the present data reflect a selective mood-congruent false recognition effect.

Consistent with the true memory data, participants in the negative mood condition had lower false recognition rates for positive and neutral critical lures, rather than *enhanced* false recognition rates for negative critical lures.

### **False recognition of non-related words**

Overall, false recognition rates for non-related words were low and there were no significant effects for any dependent variable (all  $F$ 's < 1.35 *ns*).

## Discussion

The overarching goal of the present experiment was to examine the effect of participant mood on true and false recognition of emotional word lists using the DRM paradigm. Overall, false recognition of the critical lures was consistently high across mood condition. When participants were in a positive or neutral mood, their false memory rate did not vary as a function of the emotional valence of the words on the list. In contrast, when participants were in a negative mood, there was a mood-congruent effect on false memory. This effect was due to a *decrease* in false recognition of the positive and neutral lures, rather than to an *increase* in false recognition of the negative lures. A similar pattern of results was also found for participants' true recognition of the words on the lists.

Why might there be differences in the way in which positive and negative moods influence participants' recognition of positive and negative words? Is there something about the positive and negative word lists per se rather than the relation between the word lists and the participants' moods that contributed to the different pattern of results? For example, it is possible that there was a higher degree of semantic relatedness for the positive word lists than for the negative and neutral word lists that we used here. That is, "lovely" was a list word for the beautiful list, and "love" was a critical lure for another positive word list. Although greater semantic-relatedness has been used as an argument to account for enhanced emotional false memories (Howe et al., 2010), if differences in semantic relatedness played a role in the present results, we would have expected increased true and false memory for positive word lists compared to negative and neutral word lists. This was not the case. The effect of connectivity on false memories remains unresolved (McEvoy et al., 1999; Palmer & Dodson, 2009; Roediger, Watson, et al., 2001); additional research is still required to quantify differences in the strength of the connections between the emotional list words to determine whether these differences influence emotional false memories.

It is also possible that the differences in the potency of either the mood manipulation or word lists may have influenced our results. For example, the mean difference between the valence scores of the negative and neutral word lists (2.05) was greater than the mean difference between the valence scores for the neutral and positive word lists (.80). Similarly, the mean difference between negative and neutral mood scores (2.16) was also greater than that between positive and neutral mood score (1.42). If the greater potency of either the mood manipulation or the word lists influenced true and false memories, then participants' true and false memories for negative studied words and negative critical lures would be higher when participants were in negative mood than when they were in positive or neutral mood. We did not find this pattern of results. Instead, there was no significant difference in neither the true nor false memories for negative words across the three mood groups.

Two major theories have been used to explain the development of false memories in the DRM paradigm and either theory could potentially account for the present data. According to fuzzy-trace theory, for example, there are two qualitatively different representations of information in memory — gist representation and verbatim representation. Gist representations are thought to increase false memory because they focus on the general semantic meaning of information (e.g., gist-related critical lures in the DRM paradigm), whereas verbatim representations of information focus on specificity of information (e.g., the position, pronunciation, and word length of each list word in the DRM paradigm) (Brainerd & Reyna, 2005). According to fuzzy-trace theory, the generation of false memories in the DRM paradigm is due to the fact that participants rely more on gist than verbatim memory—falsely recognising words that share the semantic meaning of the words that appear on the list.

According to the spreading-activation theory, on the other hand, the production of false memories in the DRM paradigm is due to semantic activation of list words. This

activation then automatically spreads to semantically-related, but non-presented critical lures (Roediger, Balota, et al., 2001). For example, learning the word *bed* in the study phase activates its semantic meaning. The semantic activation of *bed* spreads to a semantically-associated, but non-presented word, *sleep*, so that *sleep* is also activated and is more likely to be falsely recalled and recognised in the test phase.

How might these theories account for the differential effects of different moods on false recognition? According to fuzzy-trace theory, we would argue that negative moods selectively promote gist representation of negative information, but enhance verbatim representation of positive and neutral information. Consistent with a large body of prior research, we found that when participants were in a positive or neutral mood, they exhibited a high rate of false memory, irrespective of the nature of the words on the list. Apparently, when in a positive or a neutral mood, participants rely primarily on gist when storing and recognising the words on the list. In contrast, we would argue that when participants were in a negative mood, they were more likely to process item-specific information, but only for positive and neutral word lists. When the lists were comprised of negative words, participants in a negative mood apparently relied on gist—which led to false memories of negative word lists.

Spreading-activation theory also provides a possible explanation for the effects of positive and negative moods on false memories. For example, prior research has shown that positive moods lead to a heuristic processing mode, which is characterised by a broad activation of remote and weakly-associated information, whereas negative moods lead to a systematic processing mode, which is characterised by a relatively restricted activation of close and strongly-associated information (Bolte, Goschke, & Kuhl, 2003; Schwarz, 2001). In the present experiment, when participants were in a positive mood, we propose that activation spread not only to mood-congruent information, but also to remote and weakly-associated

information. When in a negative mood, on the other hand, activation spread primarily to information that was congruent with the participant's mood.

One way to begin to garner evidence for one theoretical explanation over the other would be to examine the relation between true and false recognition rates as a function of word valence. In other words, according to the spreading-activation theory, activation of the list (as measured by true recognition) should increase the probability that participants would report the critical lure associated with that list. In the present experiment, across mood conditions, true recognition rates for negative, positive, and neutral list words were positively correlated with false recognition of negative, positive, and neutral lures, respectively (i.e.,  $r = .45, .32, \text{ and } .34$ , all  $p$ 's  $< .05$ ). Although this finding does not rule out an interpretation based on fuzzy-trace theory, these correlations do provide some circumstantial support for the role of activation in the results reported here.

The current findings set the stage for additional research. It is important to note that although we used the general term "negative mood," we specifically used the music-induction procedure to induce a "sad mood." The question remains as to whether the present findings would also generalise to other negative mood states. There is some evidence to suggest that they might not. Some researchers have argued that different negative emotional states (e.g., sad, anger) lead to different modes of cognitive processing (Bolte et al., 2003; Corson & Verrier, 2007; Schwarz, 2001). Sadness is thought to promote a systematic processing mode, while anger, like positive moods, leads to a heuristic processing mode (Corson & Verrier, 2007). If this is the case, we would predict that anger would not result in a mood-congruent false memory effect in the DRM paradigm because angry participants, like happy participants, would rely on heuristic processing which would promote the spread of activation to both mood-congruent and mood-incongruent information. Further research is required to understand the effect of a full range of emotions on both true and false memory.

It is also interesting to speculate about the mechanisms responsible for the effectiveness of the mood induction procedure. In the present experiment, we used music and self-generated imagery to induce participants' mood. Theoretically, exposure to the music and imagery may have generated mood-specific thoughts, mood-specific feelings, or both, which subsequently led to a change in mood. In practice, it is impossible to know whether the music and imagery altered participants' thoughts or feelings; the key finding, however, is that the mood-induction procedure altered their mood. Furthermore, the mood-induction procedure used in the present experiment yielded larger differences in participants' ratings of their positive or negative mood than has been reported previously using mood induction through narratives (cf. Ruci et al., 2009). The effect of different mood induction procedures on mood congruent memory is another important avenue for additional research, particularly as we attempt to induce mood states that go beyond happy and sad.

The present findings have at least two important practical implications. First, although the data show that participants who are in a negative mood exhibited a high degree of true recognition of negative information--potentially enhancing the detailed nature of their accounts of negative events in some contexts--these same participants also made more negative errors. This finding has important implications particularly in legal contexts where it is generally assumed that a witness will have a better memory for emotional information than for neutral information (Kensinger & Corkin, 2003; Sharot, Delgado, & Phelps, 2004), leading jurors and judges to give more credibility to emotional testimony in court. The results of the present experiment suggest that emotional witnesses describing emotional events might provide more complete accounts, but those accounts may not be highly accurate.

The second practical implication of the present findings is relevant to the issue of depression. It is noteworthy that our findings on the effect of experimentally-induced negative mood on participants' false memories is identical to that reported in prior studies

with participants who suffer from depression, a naturally-occurring negative mood (Howe & Malone, 2011; Joorman et al., 2009; Moritz et al., 2005). That is, when participants were in a negative mood, they were more likely to remember negative information—both true and false information. This kind of negative bias undoubtedly enhances the negative effects of rumination and affects retrieval of positive memories that could be used to combat depression. Although we recognise that the participants in a transient negative-induced mood in the present experiment are different from individuals with longstanding depressive mood, our ability to induce such a strong negatively-biased processing in the laboratory may help to explain how easily differences in cognitive processing can contribute to a chronic and debilitating negative mood state.

## Chapter 7<sup>3</sup>

### The Effect of Mood on Age-Related Differences in Emotional DRM False Memory

Although there is ample evidence that many of our memory skills improve between early childhood and young adulthood (Brainerd & Reyna, 2005; Brainerd, Reyna, et al., 2008; Gallo, 2013), there are also conditions under which they actually get worse. For example, in the Deese-Roediger-McDermott (DRM) paradigm, participants are presented with a series of word lists in which all of the words on each list (e.g., bed, rest, and pillow) are semantically related to a critical lure (e.g., sleep; Deese, 1959; Roediger & McDermott, 1995). Adults typically exhibit a higher rate of true memory for the studied words than do children, but they also exhibit a higher rate of false memory for the unrepresented, critical lures; this finding has been referred to as a developmental reversal effect (Brainerd et al., 2002; Brainerd, Reyna, et al., 2008; Howe, 2005, 2006).

The counterintuitive developmental reversal in the rate of false memory has puzzled researchers for decades; at least two theories have been put forward to explain it. According to Fuzzy-Trace Theory (FTT; Brainerd & Reyna, 2005), there are two distinct traces involved in memory. Verbatim traces focus on item-specific information (e.g., position, pronunciation, or word length of each list word), which helps to reduce false memories. Gist traces, on the other hand, promote false memories by emphasising meaning-based information (i.e., information that is shared by the list words and the critical lures). According to FTT, the age-related increase in false memories occurs because children's ability to encode and retrieve gist information is inferior to that of adults (Brainerd & Reyna, 2005). In essence, young

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<sup>3</sup> This chapter is published as Zhang, Gross, & Hayne (2017b). As the paper is reproduced in its full published form, there is some duplication with material presented in previous chapters. References to Zhang et al. (2017a) in the current chapter refer to Experiment 1 and 4 in Chapter 4 and 6, respectively.

children's immature gist memory protects them from false memory errors in the DRM paradigm.

The second theory that has been put forward to explain the developmental reversal effect is Associative-Activation Theory (AAT; Howe, 2005, 2006). According to AAT, children's knowledge base develops over time, resulting in more efficient and automatic activation of related concepts. According to AAT, children's lower level of false memory in the DRM paradigm is due to the fact that they do not activate the associative links between the words on the DRM lists and critical lures, a process that occurs relatively automatically in adults (Howe, 2005, 2006; Howe, Candel, et al., 2010).

The key question is whether developmental reversals of DRM false memories are due to age-related changes in gist processing or to age-related changes in the automaticity of associative activation. To date, no single developmental study has allowed us to differentiate between FTT and AAT; in fact, the bulk of the data are completely compatible with both (e.g., Brainerd et al., 2006; Brainerd & Reyna, 2005; Howe, 2005, 2006). Here, we took a novel approach, using what we know about the combined effect of emotional word lists and participants' extant mood on false memory to generate a testable hypothesis that might allow us to differentiate between these theoretical explanations of the developmental reversal effect.

In terms of the word lists used in the DRM paradigm, negative information has greater semantic density compared to positive or neutral information (e.g., Kensinger & Schacter, 2008; Talmi & Moscovitch, 2004). According to FTT, the greater semantic density of negative information renders its gist easier to encode and retrieve, thus the developmental reversal effect should be more pronounced for negative information relative to positive or neutral information. Similarly, according to AAT, the greater semantic density of negative information allows the associative links among negative words on the list to spread more easily to the negative critical lures. Overall, this might increase false memory for negative

word lists in all age groups, but given that adults have a more connected knowledge base than do children, ATT would also lead to the prediction that the developmental reversal effect should be more pronounced for negative information. Consistent with both theories, participants of all ages generally exhibit higher false memories for negative information than they do for positive or neutral information, and the age-related increase in false memories is more pronounced for negative information than that for positive and neutral information, particularly when arousal of the to-be-remembered information is well controlled (Brainerd et al., 2010; Brainerd, Stein, et al., 2008; Howe, 2007; Howe, Candel, et al., 2010). Thus, manipulating information content alone does not allow us to differentiate between FTT and AAT, because both theories make exactly the same prediction.

In addition to the words on the list, another important factor that helps to determine what participants remember is their mood. Mood has long been thought to change the way that we process information, but FTT and AAT may lead to different predictions about the effect of mood on false memories. For example, the standard theoretical interpretation of the memory effects of positive and negative moods is that positive moods promote relational processing while negative moods impair relational processing and foster item-specific processing (Arndt & Reder, 2003; Hege & Dodson, 2004; Storbeck & Clore, 2005; 2011). Within this interpretive framework, FTT predicts that false memories will be lower when participants are in a negative mood and higher when they are in a positive mood. Furthermore, developmental studies have shown that older children and adults have greater item-specific (i.e., verbatim memory) and relational processing ability (i.e., gist memory) than do younger children (for review, see Brainerd, Reyna, et al., 2008). Thus, the opportunity for negative moods to increase item-specific processing is potentially greater in older children and adults than in younger children. As such, the decrease in false memories

should be greater in older children and adults than in younger children. In other words, developmental reversals should be reduced or eliminated in negative moods.

Likewise, FTT also predicts that the opportunity for positive moods to promote relational processing is potentially greater in older children and adults than in younger children and in turn, should increase false memories more in the older age groups. That is, according to FTT, developmental reversals should be maintained or even increased when participants are in a positive mood. Summing up, assuming that the standard theoretical interpretation of negative and positive moods is correct, FTT makes two predictions: (i) false memories will be lower when participants are in a negative mood compared to when they are in a neutral mood and higher when they are in a positive mood compared to a neutral mood, and (ii) developmental reversals will be smaller when participants are in a negative mood and will be maintained or even larger when they are in a positive mood relative to a neutral mood.

Like FTT, AAT also yields predictions about the relation between mood and false memory. For example, we know that moods influence the level of automaticity needed to process information (Bless et al., 1996; Bolte et al., 2003; Corson, 2002; Isen, Daubman, & Nowicki, 1987; Mackie & Worth, 1989). Positive moods are thought to lead to a heuristic processing mode, which requires fewer cognitive resources and less effort. In contrast, negative moods are thought to lead to a systematic processing mode, which requires more cognitive resources and more effort. In terms of false memory, the heuristic processing mode of positive moods is characterised by a broad activation of remote and weakly-associated information (e.g., both positive and non-positive information), whereas the systematic processing mode of negative moods is characterised by a relatively restricted associative activation of close and strongly-associated information (e.g., negative information) (Zhang et al., 2017a). According to AAT, the typical age-related increase in false memories should be reduced or even eliminated when participants are in positive moods, whereas this increase

should be maintained when participants are in negative moods. That is, when they are in positive moods, children's false memories are more likely to be influenced by the increased automaticity with which associative activation occurs. Furthermore, according to AAT, the effect of positive moods would be obtained regardless of the emotional valence of the information that participants are trying to remember, while the effect of negative moods would be obtained for at least negative information. In contrast, FTT makes no specific predictions about the role of information valence.

Taken together, given that AAT and FTT make different predictions about the impact of mood on the developmental reversal of false memory for emotional word lists, we took the opportunity to pit one theory against the other. Assuming that the standard view of memory effects of positive and negative moods is correct, if developmental reversals are maintained or enhanced when participants are in a positive mood, but developmental reversals are reduced or eliminated in a negative mood, this outcome would provide empirical support for FTT. In contrast, if developmental reversals are reduced or eliminated for all information when participants are in a positive mood, but developmental reversals are maintained or enhanced for negative information in a negative mood, this outcome would provide empirical support for AAT. However, it should be noted that if the standard view of memory effects of positive and negative moods was not supported in the present study, then FTT's predictions regarding the effect of mood on developmental reversals cannot be tested directly. In the current experiment, we examined these predictions by assessing age-related changes in the effect of participant mood on true and false recall for negative, positive, and neutral DRM lists.

## Experiment 5

### Method

#### Participants

Ninety 7- to 8-year-old children ( $M$  age = 7.50 years,  $SD$  = 0.46) and 90 11- to 12-year-old adolescents ( $M$  age = 11.40 years,  $SD$  = 0.49) were recruited through a database of parents who had agreed to participate in studies of child development. All children were predominantly Caucasian and came from a wide range of socioeconomic backgrounds. They agreed to participate in the study, and their parents provided written consent. In addition, 90 undergraduate university students ( $M$  age = 20.37 years,  $SD$  = 1.27) were recruited through a Research Participation Pool and were paid \$15 for their participation. Half of the participants in each age group were female. The sample size was specified prior to data collection, based on typical sample sizes in the false memory literature (e.g., Howe, 2007; Storbeck & Clore, 2005; Zhang et al., 2017). All of the participants were native English speakers with normal or corrected-to-normal vision and had no history of mood disorders. They had not participated in any similar studies before. The research was reviewed and approved by the University's Human Ethics Committee, which is approved by the National Health Research Council and whose guidelines are consistent with those of the American Psychological Association.

#### Materials and Procedure

Within each age group, participants were randomly assigned to one of three mood conditions (positive, negative, or neutral;  $n$  = 30 participants of each age in each condition). Mood was induced using a video clip that had a positive, negative, or neutral valence. This technique has been shown to be the effective method of mood induction with both children and young adults (for review, see Brenner, 2000). To ensure the reliability and validity of the video clips that we used, we chose emotional video clips from classic movies and children's current television programs and then asked independent groups of 7- to 8-year-old children

(N = 12, 6 female) and 18- to 23-year-olds (N = 12; 6 female) to use a 5-point graphic scale (1 = happy smiling face; 5 = sad frowning face) to rate how happy or sad each clip made them feel. We then selected the video clips that produced the most consistent and clear-cut mood effects. The negative and positive video clips were from the movie “The Lion King.” Participants in the positive mood group watched the scene where the characters sing Hakuna Matata while participants in the negative mood group watched the scene about the death of Mufasa. Participants in the neutral mood group watched a National Geographic nature documentary about lions. Each video clip was approximately 4 min in duration.

Immediately following the mood-induction phase, we asked participants to assess their mood using a self-report measure called A Nonverbal Scale of Emotion (ANSE; Lay, Waters, & Park, 1989). The ANSE consists of nine different faces that cross sad, neutral, and happy facial expressions with calm, neutral, and excited facial expressions. Participants were shown all possible pairing of the faces (N = 36) and asked to pick one face from each pair to indicate how they were feeling. Participants received 1 point if a chosen face showed a higher level of pleasure than did the other face in the pair, and/or received 1 point if a chosen face showed a higher level of excitement than did the other face in the pair. In this way, every participant received one score for valence and one score for arousal, respectively. Nine pairs of faces showed the same level of pleasure and excitement so the range of possible scores was from 0 to 27. Higher scores indicate that participants felt more positive or excited, while lower scores indicate that participants felt more negative or calm.

Participants then listened to audio recordings of 12 emotional DRM word lists (4 lists containing words with negative valence, 4 positive, and 4 neutral) chosen from Zhang et al. (2017a; see also, Experiment 1 of the present thesis). Each list was 10-words long and the emotional valence of the words in a given list all matched and were associated with a critical lure. The emotional word lists were also matched in terms of arousal, backward associative

strength (BAS), and inter-item associative strength (connectivity). The word frequencies of both studied words and critical lures were also controlled across the emotional word lists, respectively (both  $F's < 1.11$  *ns*) (Kučera & Francis, 1967).

The presentation order of word lists was partially counterbalanced across participants; that is, half of the participants in each age group and each mood condition learned 4 negative word lists, followed by 4 neutral word lists, followed by 4 positive word lists, and the other half learned the word lists in the reverse order (see also, Howe, 2007; Howe et al., 2010; Zhang et al., 2017a). Each word on each list was presented at a 3-s rate in descending order of their BAS values. After each list had been presented, participants completed a 30s distractor task and were then asked to recall as many of the words from the list as they could remember.

## Results

### Mood manipulation check

Table 7.1 shows the mean valence and arousal scores on the ANSE and 95% CIs as a function of mood. Initially, we conducted separate 3 (mood: negative, positive, neutral)  $\times$  3 (age: adults, adolescents, children) analyses of variance (ANOVA) across valence and arousal scores. We then used a series of one-way ANOVAs to compare across mood and across age, respectively (Alpha set at .05).

Table 7.1.

*The Mean Valence and Arousal Scores and 95% CIs as a Function of Mood for Each Age Group*

	Positive Mood		Neutral Mood		Negative Mood	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
<i>Valence</i>						
Children	23.00	[21.18, 24.82]	18.20	[15.47, 20.93]	5.30	[3.86, 6.74]
Adolescents	24.43	[23.36, 25.51]	15.63	[12.37, 18.90]	4.70	[3.10, 6.30]
Adults	25.43	[24.86, 26.00]	13.93	[10.62, 17.24]	2.33	[1.47, 3.20]
<i>Arousal</i>						
Children	13.90	[12.49, 15.31]	13.47	[12.48, 14.46]	13.00	[12.10, 13.90]
Adolescents	13.30	[11.91, 14.69]	12.87	[11.27, 14.46]	12.70	[11.55, 13.85]
Adults	13.00	[11.82, 14.18]	11.97	[10.30, 13.63]	12.27	[11.23, 13.30]

For valence, there was a main effect of mood,  $F(2, 261) = 296.09, p < .001, \eta_p^2 = .694$ ; participants in the positive mood condition felt more positive ( $M = 24.29$ ) than those in the neutral mood condition ( $M = 15.92$ ), who in turn felt more positive than participants in the negative mood condition ( $M = 4.11$ ). There was no effect of age,  $F(2, 261) = 1.89, p =$

.153,  $\eta_p^2 = .014$ , power = .391, but there was a Mood  $\times$  Age interaction,  $F(4, 261) = 3.17$ ,  $p = .014$ ,  $\eta_p^2 = .046$ . Adults in the positive mood condition felt more positive than did children in the positive mood condition,  $F(2, 87) = 3.93$ ,  $p = .023$ ,  $\eta_p^2 = .083$ , and adults in the negative mood condition felt more negative than did adolescents and children in the negative mood condition,  $F(2, 87) = 5.74$ ,  $p = .005$ .  $\eta_p^2 = .117$ . There was no reliable difference in valence scores as a function of age for participants in the neutral mood condition,  $F(2, 87) = 1.99$ ,  $p = .142$ .  $\eta_p^2 = .044$ , power = .402.

For arousal, there was no effect of mood ( $p > .250$ ), age ( $p = .127$ ), nor a Mood  $\times$  Age interaction ( $p > .250$ ); as shown in Table 7.1, regardless of age or mood, all participants reported similarly moderate levels of arousal.

## Recall

Given that the critical test of FTT and AAT relies on the impact of each mood on the age-related patterns of false memory, we analysed true recall and false recall using separate 3 (age: children, adolescents, young adults)  $\times$  3 (word valence: negative, positive, neutral) mixed factor ANOVAs with repeated measures across word valence (Greenhouse-Geisser correction factor) for each mood condition. We then used planned comparisons to explore age-related differences in true and false memories as a function of word valence in each mood condition; statistical significance was accepted at a Bonferroni-adjusted alpha level of .017.

**True recall of studied words.** An age-related increase in participants' true recall of studied words was found for each mood condition (see Table 7.2). Adults recalled more studied words than did adolescents, who in turn recalled more studied words than did children (smallest  $F(2, 87) = 96.77$ ,  $p < .001$ ,  $\eta_p^2 = .690$ ). In addition, neutral studied words were recalled better than were negative studied words, which in turn were recalled better than were positive studied words (smallest  $F(2, 174) = 132.18$ ,  $p < .001$ ,  $\eta_p^2 = .603$ ).

Table 7.2.

*The Means and 95% CIs for True Recall as a Function of Age, Word Valence, and Mood Condition*

	Neutral Mood			Positive Mood			Negative Mood		
	Negative SW	Positive SW	Neutral SW	Negative SW	Positive SW	Neutral SW	Negative SW	Positive SW	Neutral SW
Children	.78 [.75, .81]	.76 [.73, .79]	.78 [.74, .81]	.77 [.74, .80]	.75 [.72, .78]	.76 [.74, .79]	.80 [.77, .83]	.75 [.72, .78]	.77 [.74, .80]
Adolescents	.91 [.88, .94]	.86 [.83, .88]	.90 [.86, .93]	.91 [.87, .94]	.86 [.83, .89]	.89 [.87, .92]	.90 [.87, .93]	.89 [.86, .92]	.89 [.85, .92]
Adults	.93 [.90, .96]	.92 [.90, .95]	.93 [.90, .97]	.93 [.89, .96]	.93 [.90, .96]	.94 [.91, .97]	.92 [.89, .95]	.91 [.88, .94]	.91 [.88, .95]

Note: SW refers to studied words.

**False recall of critical lures.** Participants in the neutral mood condition (see Figure 7.1, Top panel) exhibited the typical developmental reversal effect in false memory; there was a main effect of word valence,  $F(2, 174) = 13.96, p < .001, \eta_p^2 = .138$ , and an Age  $\times$  Word Valence interaction,  $F(4, 174) = 5.31, p < .001, \eta_p^2 = .109$ , but no effect of age,  $F(2, 87) = 4.06, p = .021, \eta_p^2 = .085$ . Consistent with prior research, children falsely recalled fewer negative critical lures than did adults,  $t(87) = -4.11, p < .001$ , but there were no age-related differences in false recall of positive or neutral critical lures ( $|t|'s \leq 1.50, p's > .05$ ).

For participants in the positive mood condition (see Figure 7.1, Middle panel), there was no effect of age,  $F(2, 87) = 2.08, p = .131, \eta_p^2 = .046$ , power = .417, and no Age  $\times$  Word Valence interaction,  $F(4, 174) = .50, p > .250, \eta_p^2 = .011$ , power = .168. There was, however, a main effect of word valence,  $F(2, 174) = 15.93, p < .001, \eta_p^2 = .155$ ; participants in the positive mood condition falsely recalled more negative critical lures ( $M = .31$ ) than neutral ( $M = .19$ ) or positive critical lures ( $M = .17$ ). Planned comparisons indicated that, regardless of word valence, there were no reliable age-related differences in false recall ( $|t|'s \leq 1.91, p's > .05$ ).

For participants in the negative mood condition (see Figure 7.1, Bottom panel), there were main effects of age,  $F(2, 87) = 6.02, p = .004, \eta_p^2 = .122$ , adolescents ( $M = .30$ ) and adults ( $M = .23$ ) made more false recall than did children ( $M = .14$ ), and word valence,  $F(2, 174) = 6.11, p = .003, \eta_p^2 = .066$ , false recall was higher for negative critical lures ( $M = .28$ ) than that for positive ( $M = .19$ ) or neutral critical lures ( $M = .19$ ), but no Age  $\times$  Word Valence interaction,  $F(4, 174) = 2.53, p = .042, \eta_p^2 = .055$ . Planned comparisons indicated that, for negative word lists, there was a developmental reversal effect: children falsely recalled fewer negative critical lures than did adolescents and adults,  $t(87) = -3.92, p < .001$ , and  $t(87) = -2.70, p < .01$ , respectively. There were no age-related differences in false recall of positive or neutral critical lures ( $|t|'s \leq 1.93, p's > .05$ ).

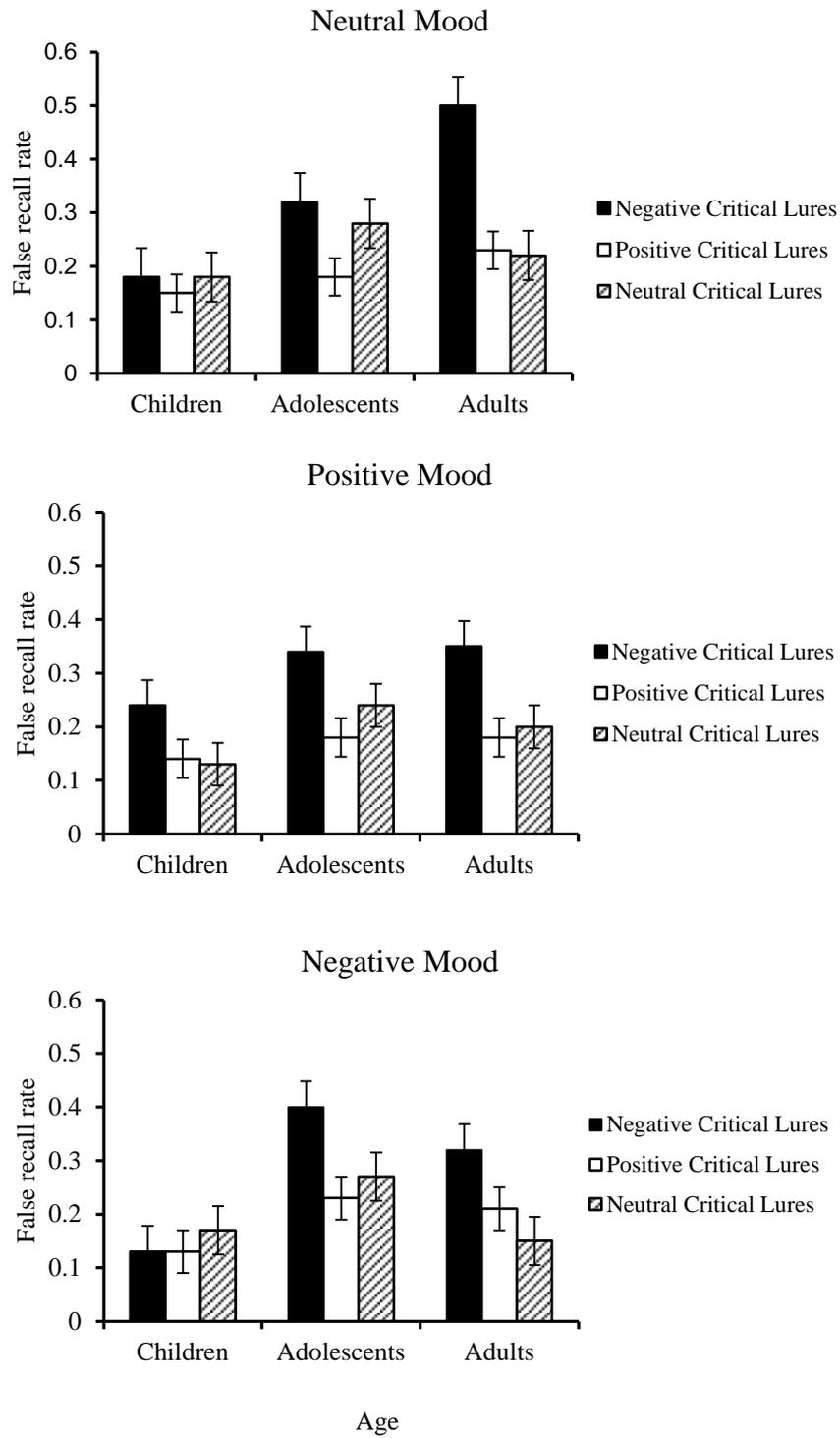


Figure 7.1. The false recall rate of critical lures as a function of word valence and age for participants in the neutral mood condition (top panel), positive mood condition (middle panel), and negative mood condition (bottom panel). Error bars show  $\pm 1SEM$ .

## Discussion

Although adults typically exhibit superior true memories in the DRM paradigm, they also exhibit more false memories. Here, we examined whether this effect is due primarily to adults' superior gist-processing ability, as proposed by Fuzzy-Trace Theory (FTT), or due to their superior automatic associative activation, as proposed by Associative-Activation Theory (AAT). Manipulating only the valence of the to-be-remembered information does not allow us to differentiate between these two theoretical explanations because both theories predict the same outcome; according to both theories, negative information tends to increase false memory compared to positive and neutral information and developmental reversals should be more pronounced for negative information than for positive and neutral information. This prediction has been supported by prior research (Brainerd et al., 2010; Brainerd, Stein, et al., 2008; Howe, 2007; Howe, Candel, et al., 2010) and again, by the current experiment, but it does not provide a lynchpin for one theory over the other.

The primary goal of the present experiment was to differentiate between the two theoretical explanations of developmental reversals in false memories. The current findings directly support AAT. According to AAT, the lower level of children's false memories relative to adults' is due to the fact that children do not activate the associative links between words and concepts as automatically as adults. In other words, if a manipulation enhances the level of automaticity with which children process information, then according to AAT, developmental reversals should be reduced. Drawing on previous research, inducing positive moods is such a manipulation because positive moods lead to a heuristic processing mode which is relatively automatic (Bolte et al., 2003; Corson, 2002; Zhang et al., 2017a). In contrast, negative moods lead to a systematic processing mode which requires more cognitive resources and effort. Consistent with AAT's predictions, we found that in a positive mood, developmental reversals were eliminated for all kinds of information, while in a negative

mood, developmental reversals still occurred for negative information. In addition, the present findings suggested that with increasing knowledge and experience, adolescents' associative links among negative concepts may be as integrated as those of adults, increasing their false recall to an adult level.

Although the current findings provide direct support for AAT's explanation for the developmental reversal effect, they do not directly refute FTT's explanation. Recall that FTT's predictions regarding the effect of negative and positive moods on developmental reversals are primarily based on the standard theoretical interpretation of negative and positive moods (e.g., Storbeck & Clore, 2005). However, the standard interpretation of the effects of positive moods was not supported in the present experiment: we found that participants in positive moods exhibited fewer, rather than more, false memories than did participants in neutral moods. In other words, positive mood, just like negative mood, appears to reduce rather than to enhance gist processing. From this perspective, according to FTT, false memories produced in a positive mood should be qualitatively similar to those produced in a negative mood. In addition, the age-related increase in false memories should be less for participants in a positive mood than for participants in a neutral mood. This pattern was exactly what we observed in the present experiment, especially for negative information.

On the surface, two findings from the present research appear to be inconsistent with some prior research. First, it was somewhat surprising that developmental reversals were not obtained in the neutral mood condition for neutral and positive word lists considering that developmental reversals have been found when participants are in their natural (non-manipulated) mood, which is often assumed to be neutral. The difference between the present findings and prior research is likely due to differences in arousal levels, which we measured here, but is often only assumed in other research. In the present experiment, participants in the neutral mood condition were moderately aroused, but we have no idea whether the

arousal level of participants in their natural mood in prior research was also moderate or whether it was consistent across age groups. This uncertainty makes direct comparison between the present findings and prior research impossible. In addition, the difference between the present findings and prior research might also be due to arousal caused by the emotional content of the word lists. Arousal of emotional word lists was well controlled in the present experiment, however, in some prior studies, arousal has often been confounded with valence (for review, see Bookbinder & Brainerd, 2016). Prior research has indicated that once the arousal level of emotional word lists is controlled across list valence, developmental reversals for positive or neutral word lists tend to be less pronounced than for negative word lists (Brainerd et al. 2010), a finding that is consistent with the results of the present experiment.

The mechanism of the age-related changes in false memories as a function of valence of to-be-remembered information may be due to semantic density of information. Compared to positive or neutral information, negative information has greater semantic density (e.g., Kensinger & Schacter, 2008; Talmi & Moscovitch, 2004). The greater semantic density of negative information renders gist information easier to retrieve (as suggested by FTT) and also allows the associative links among negative studied words to spread more easily to negative critical lures (as suggested by AAT) (Brainerd et al., 2010; Brainerd, Stein, et al., 2008; Howe, 2007; Howe et al., 2010). Moreover, gist retrieval or associative activation is better in adults than in children, which in turn leaves more room for negative information to show the age-related increase in false memory than for positive or neutral information.

The second finding from the present research that appears to be inconsistent with some prior research is that, according to the standard theoretical interpretation of negative and positive moods, negative moods are thought to promote item-specific processing, which reduces false memories, whereas positive moods are thought to enhance gist processing,

which increase false memories (Arndt & Reder, 2003; Hege & Dodson, 2004; Storbeck & Clore, 2005, 2011). In contrast, as described earlier, our positive mood manipulation did not enhance false memories. Instead, participants who were in a positive mood exhibited fewer false memories than those who were in a neutral mood. Again, this difference is likely due to differences in arousal levels across studies. Prior research has shown that valence and arousal have different effects on false memories (Brainerd et al., 2010; Bookbinder & Brainerd, 2016; Corson & Verrier, 2007). In the present experiment, we strictly controlled arousal across moods, whereas in prior research, arousal has often been confounded with valence (e.g., Storbeck & Clore, 2005). Therefore, it is likely that the effect of positive moods on false memories in prior research was due to the combined effects of valence and arousal rather than to valence per se.

Overall, we found that children who were in a positive mood exhibited the same level of false recall irrespective of the valence of the list words, but when they were in a negative mood, the level of false recall for negative information was lower than that exhibited by adolescents and adults. These findings cannot be explained solely on the basis of age-related differences in mood strength. Although adults reported that they felt more positive than did children, and that they felt more negative than did adolescents and children, if age-related differences in mood strength played a role in the present results, we would have expected different levels of false memories between adults and children in a positive mood and different levels of false memories among adults, adolescents, and children in a negative mood. This was not the case. Additional research will be required to clearly understand any potential interaction between age and mood strength on false memories.

To the best of our knowledge, the current experiment was the first to investigate the effect of moods on developmental reversals in false memories for emotional information. Although the explanatory power of FTT for the developmental reversal effect was not

directly tested in the present experiment, our data provides the first empirical support of AAT's explanation for the effect. In future studies, this explanation could be further strengthened by conducting neuroimaging studies. For example, the anterolateral temporal lobe is thought to be involved in semantic gist memory, whereas the orbito-frontal cortex is thought to be involved in associative memory (Lewis, Critchley, Smith, & Dolan, 2005; Simons et al., 2005). In the generation of DRM false memories, both regions should be activated. In addition, individuals exhibit stronger amygdala activity during sad moods than during happy moods (Fitzgerald et al., 2011). Thus, we predict that children and adults might exhibit a similar degree of interaction among the amygdala, the orbito-frontal cortex, and the anterolateral temporal lobe in a DRM task when the activation of amygdala is relatively low (e.g., happy moods), but that there would be an age-related increase in the interaction among these areas when the activation of the amygdala is relatively strong (e.g., negative moods).

Finally, there is also an important practical implication of our findings. When children are required to deploy their memory in stressful situations like in a courtroom, they are often attempting to recall emotionally-charged information in a negative mood. How does the nature of the information and the child's mood at the time influence the accuracy of his or her recall? The current experiment is the first to address this question. We found that adults and adolescents are more likely to exhibit false memories than are children in general, and that mood has a significant effect on this age-related pattern. Counterintuitively, children who are in a negative mood may be more likely to make fewer negatively-charged errors than adolescents and adults. In contrast, children who are in a positive mood are likely to make a similar number of errors regardless of the valence of information they are attempting to recall.

## Chapter 8<sup>4</sup>

### Mood Impedes Monitoring of Mood-Congruent False Memories

In recent years, emotional false memories have attracted considerable experimental attention. Not only does this line of research offer an opportunity to better understand the theoretical interaction between emotion and memory, but it also has important practical implications for situations in which individuals are asked to remember emotionally-laden information outside the laboratory. For example, to avoid the development of emotional false memories in legal contexts, police, lawyers, and judges often specifically ask witnesses and victims to report only information that they remember actually happened and to avoid reporting information that may have come to mind, but did not take place. The key question is whether warnings of this kind, particularly at the time of memory retrieval, actually work by reducing or eliminating emotional false memories. The present experiment is the first to explore this question under controlled laboratory conditions.

Empirical investigation of emotional false memories in the laboratory is often based on the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In the typical DRM procedure, participants learn a number of neutral word lists in which all the studied words (e.g., *bed*, *rest*, *pillow*) are semantically related to a critical lure (e.g., *sleep*) that is not presented on the original list. At test, participants often falsely recall critical lures, believing that these words were presented at study, which leads to robust false recall and/or false recognition effects.

In research on emotional false memories using the DRM paradigm, the neutral word lists are replaced by emotional word lists where both studied words and critical lures are emotionally charged (e.g., *unhappy*, *sorrow*, and *depression* are list words for the critical

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<sup>4</sup> This chapter is currently under review. References to Zhang et al. (2017a) in the current chapter refer to Experiment 1 and 4 in Chapter 4 and 6, respectively.

lure, *sad*). In addition, participants learn emotional word lists while in a particular mood, which is normally induced prior to study. In this way, some to-be-remembered lists are mood congruent while others are not. Ruci et al. (2009) initially tested whether false memories would be enhanced for emotional critical lures that matched participants' mood state. Participants took part in a mood-induction procedure and were then asked to learn negative, positive, and neutral word lists. As predicted, Ruci and colleagues found a mood-congruent false memory effect. That is, participants in a negative mood falsely recalled and recognised more negative critical lures than positive and neutral critical lures, and participants in a positive mood falsely recalled and recognised more positive critical lures than negative and neutral critical lures. However, because Ruci et al. did not control arousal across mood or across the emotional word lists, it was impossible to determine whether the observed effect was due to emotional valence, arousal, or both. To address this issue, Zhang et al. (2017a) compiled emotional word lists in which arousal was strictly controlled, as was participants' mood. Zhang et al. found a negative mood-congruent false memory effect. This effect was also reported in Knott and Thorley's (2014) study where the negative mood-congruent false memory effect was maintained over a one-week period.

Theoretical explanations of the mood-congruent false memory effect have often included network theory (Bower, 1981) and spreading-activation theory (Roediger, Balota, et al., 2001) (together known as associative theories). According to these associative theories, a given mood is represented as a node in memory which collects other attributes that are related to that mood, including particular words and relevant concepts. When that mood node is activated, all of those words and concepts are activated in the associative network. The activation not only spreads to emotionally- and semantically-related information that has been presented (i.e., studied words), but also spreads to relevant information that has not been presented (i.e., critical lures). According to associative theories, mood-congruent false

memories occur because mood acts as a source of activation, which, when combined with semantic activation of the studied words, spreads to emotionally- and semantically-related critical lures, resulting in mood-congruent false memories.

Although one-process accounts which include these associative theories can explain how mood-congruent false memories occur, they cannot explain the mechanism under which mood-congruent false memories might be reduced or eliminated. Alternatively, activation-monitoring theory (AMT) and fuzzy-trace theory (FTT) — both dual-process accounts — may provide a potential explanation. According to AMT (Roediger, Watson, et al., 2001), activation alone does not determine the generation of false memories; monitoring of activated information also plays a role. Given that presented information has more perceptual details than does unpresented information, the goal of monitoring is to take advantage of these differences to distinguish between information that has been presented (true memories) and that which has not been presented (false memories). Moreover, the activation process and the monitoring process are not independent. Strong activation leads the unpresented information (e.g., critical lures) to share many of the features related to the presented information (e.g., studied words). Under these conditions, source monitoring becomes difficult and errors may arise, increasing the probability that false memories will occur. Although monitoring processes are usually discussed with respect to retrieval, according to AMT, monitoring processes can also exist at encoding. For example, research has shown that warnings about the false memory phenomenon are more effective in reducing false memories when those warnings are presented prior to study (i.e., at encoding) than when they are presented after study, but before the test (Gallo et al., 1997; McDermott & Roediger, 1998).

According to another dual-process account, FTT, there are two opponent representations (or traces) of information in memory (Reyna & Brainerd, 1995). Verbatim traces represent the specificity of information (e.g., the position, pronunciation, and length of

each studied word in the DRM paradigm) (Brainerd & Reyna, 2005). Gist traces, on the other hand, refer to the general semantic meaning of information (e.g., gist-related critical lures in the DRM paradigm). According to FTT, DRM false memories primarily reflect a process of gist extraction; a critical lure can be regarded as the gist of a word list because all of the words in the list are semantically related to the critical lure. Thus it follows that, if a manipulation, like a warning, encourages verbatim processing of information, then using this manipulation should reduce false memories.

Taken together, dual-process accounts (AMT and FTT) of how mood-congruent false memories occur predict that false memories should be reduced through enhanced monitoring and verbatim processing. Although the role of mood in the generation of mood-congruent false memories at encoding has been supported by empirical evidence (Knott & Thorley, 2014; Ruci et al., 2009; Zhang et al., 2017), to date, no empirical research has investigated whether mood could play a role in the retrieval of mood-congruent false memories through improved monitoring and verbatim processing. To our best knowledge, there is only one relevant study in the literature. Yang, Yang, Ceci, and Isen (2015) tested whether positive moods would facilitate monitoring following warnings. Participants were induced in either a positive or a neutral mood, and were asked to remember typical DRM word lists, which were neutral. Warnings were provided both before and after study. Yang and colleagues found that false recognition was lower when participants were in a positive mood relative to a neutral mood. Yang et al. concluded that, compared to neutral moods, positive moods promote monitoring that is initiated by warnings. However, because Yang et al. presented the warnings both before and after study, we cannot draw a conclusion about the effect of mood on the retrieval of critical lures, in particular. Moreover, because neutral rather than emotional (positive or negative) word lists were used in the study, we do not know whether

there would be any impact of positive or negative moods on retrieval of mood-congruent critical lures.

In Experiment 6, I drew on prior research by using warnings to encourage monitoring of memory. Moreover, in the warning instructions, I explicitly asked participants to focus on verbatim information of each studied word in order to enhance their verbatim processing. The experimental design included a no-warning condition and two warning conditions: a warning was either presented before study (the warning-before-study condition) or after study, but before test (the warning-after-study condition). I tentatively assumed that (i) compared to no warnings, either a warning at encoding or a warning at retrieval would *reduce* emotional false memories, irrespective of whether they were mood-congruent or not, (ii) the effect of a warning at encoding would be more robust than that of a warning at retrieval, and (iii) based on Yang et al.'s (2015) findings, in the warning-after-study condition, positive and negative moods, compared to neutral moods, would *promote* monitoring processes of positive and negative critical lures through warnings, respectively.

## Experiment 6

### Method

#### Participants

Two hundred and seventy 17- to 24-year-old undergraduate university students (135 female) from a moderate-sized city were recruited for this experiment via an Experimental Participation Pool. The sample size was based on prior studies of this kind (e.g., Howe, 2007; Storbeck & Clore, 2005; Zhang et al., 2017). All of the participants were native English speakers with normal or corrected-to-normal vision, and had no history of mood disorders. Participants satisfied a small portion of course assessment by completing a worksheet based on the experiment. The research was reviewed and approved by the University's Human Ethics Committee, which is approved by the National Health Research Council and whose guidelines are consistent with those of the American Psychological Association.

#### Materials and Procedure

The experimental procedure was modelled after Zhang et al. (2017a). Participants were randomly assigned to one of three warning conditions (no warning, warning-before-study, warning-after-study;  $n = 90$  in each condition). Participants in the no-warning condition (NW) were not presented with any warning instructions. Participants in the warning-before-study condition (WB) were presented with the warning instructions *before* the study phase, while participants in the warning-after-study condition (WA) were presented with the warning instructions *after* the study phase, but prior to the test phase. We modelled the warning instructions after McDermott and Roediger (1998) but added an additional instruction that, to avoid being tricked, participants should focus on the feature of each word itself rather than the semantic relation between the words. The warning instructions<sup>5</sup> were as follows:

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<sup>5</sup> For participants in the warning-after-study (WA) condition, the warning was presented using the past tense.

*In this experiment, you will learn 12 word lists, with 10 words per list. Each list consists of related words. All of the words in each list are associated to one common word, but this word will not actually be presented in the study phase. What we are trying to do in this experiment is to trick you into saying that you remember learning these common words.*

*For example, you might learn the following list of words: queen, England, crown, prince, dictator, palace, throne, monarch, royal, reign.*

*In this case, king is the common word that links all the above words. In the memory test phase, you will be asked whether or not king was presented. You should make a “New” judgment for it since king was not presented in the study phase. So to avoid being tricked by the common words, you should ignore the semantic relation between the words but focus on the features of words themselves (e.g., pronunciation). In the test phase, you should only report the words that were presented at study and avoid reporting the words that were not actually presented.*

Within each warning condition, participants were randomly assigned to one of three mood conditions (positive, negative, or neutral,  $n = 30$  in each). Participants in the positive mood-induction group listened to 8 minutes of Bach’s *Brandenburg Concerto No. 3* while participants in the negative mood-induction group listened to 8 mins of Prokofiev’s *Alexander Nevsky: Russia Under the Mongolian Yoke*. Participants in the neutral group were asked to read a collection of basic facts about New Zealand, including population size, gross national product, cultures, etc. This exercise took 8 minutes to complete based on normal reading speed. This method has been shown to effectively induce positive, negative, and neutral moods in young adults (Chepenik et al., 2007; Jiang et al., 2011; Rowe et al., 2007; Zhang et al., 2017a).

Immediately following the mood-induction phase, participants were asked to assess how happy (1) or sad (9) and how excited (1) or calm (9) they were using an adapted version of Bradley and Lang’s (1999) Self-Assessment Manikins (SAMs). These graphic scales represent different emotional dimensions on a 9-point scale: the valence SAM ranges from a happy, smiling figure (1) to an unhappy, frowning figure (9), similarly, the arousal SAM

ranges from an excited, wide-eyed figure (1) to a relaxed, calm figure (9) (see Bradley & Lang, 1999, for examples).

I used 12 emotional DRM word lists taken from Zhang et al. (2017a). Four of the word lists contained negative words, four contained positive words, and four contained neutral words. The emotional word lists did not differ in level of arousal or BAS values and every word on a particular list reflected the target emotion. Each list was 10-words long and participants were presented with the words on each list in the descending order of their BAS values.

Participants were tested in groups of up to 8. All of the tasks were presented through individual headphones. The presentation order of word lists was partially counterbalanced across participants; that is, half of the participants in each warning/mood induction condition learned 4 negative word lists, followed by 4 neutral word lists, followed by 4 positive word lists, and the other half of the participants learned the word lists in the reverse order (see also, Howe et al., 2010; Knott & Thorley, 2014; Ruci et al., 2009; Zhang et al., 2017a). Each word was presented for 2s on a computer monitor. After all of the words in the word list were presented, a message came up to inform the participant that the next word list was about to appear. Participants were asked to remember all 12 word lists. Between the study phase and the test phase, participants completed a 5-min subtraction exercise.

The recognition test words were also taken from Zhang et al. (2017a) and contained 36 studied words--from serial positions 1, 4, and 8 of each word list; 12 critical lures, and 24 unrelated words. The order of presentation of the 72 test words was completely random. Participants were asked to make an "Old" decision if they thought a word had been presented in the study phase and to make a "New" decision if they thought a word had not been presented in the study phase. After the recognition test, participants in the WB and WA

conditions were asked to write down the strategy that they used to avoid being tricked.

Finally, all of the participants were debriefed about the purpose of the experiment.

## Results

### Mood manipulation check

Recall that participants' level of emotional arousal and the valence of their mood were indexed by 9-point scales. Lower scores referred to higher arousal (excitement) and more positive valence (happiness). Two separate 3 (mood) x 3 (warning condition) analyses of variance (ANOVAs) were conducted using the valence scores and the arousal scores as dependent variables. For valence, there were main effects of mood,  $F(2, 261) = 182.18, p < .001, \eta_p^2 = .583$ , and warning condition,  $F(2, 261) = 22.78, p < .001, \eta_p^2 = .149$ , and a Mood  $\times$  Warning Condition interaction,  $F(4, 261) = 9.96, p < .001, \eta_p^2 = .132$ . As shown in Table 8.1 (*Valence*), overall, participants in positive moods felt more positive than those in neutral moods, who in turn felt more positive than participants in negative moods. However, in the positive mood group, participants in the WB condition reported higher valence scores than did participants in the NW or WA conditions. Likewise, in the neutral mood group, participants in the WB condition reported higher valence scores than did participants in the NW or WA conditions.

For arousal, there were also main effects of mood,  $F(2, 261) = 24.95, p < .001, \eta_p^2 = .160$ , and warning condition,  $F(2, 261) = 10.67, p < .001, \eta_p^2 = .076$ , and a Mood  $\times$  Warning Condition interaction,  $F(4, 261) = 10.49, p < .001, \eta_p^2 = .138$ . As shown in Table 8.1 (*Arousal*), the level of arousal was similar across three mood states. Only in the WB condition, did participants in positive moods have a higher level of arousal than participants in neutral or negative moods.

### True and false recognition analyses

The data for each dependent variable was subjected to separate 3 (warning condition: no warning, warning before study, and warning after study)  $\times$  3 (mood: negative, positive, and neutral)  $\times$  3 (list valence: negative, positive, and neutral) mixed factor ANOVAs with

repeated measures over list valence (Greenhouse-Geisser correction factor). Any significant effects were examined using the Bonferroni correction for pairwise-comparisons.

For true recognition of studied words (see Table 8.2), there was no effect of warning conditions, however, there was a main effect of list valence,  $F(2, 522) = 4.96, p = .007, \eta_p^2 = .019$ , and a List Valence  $\times$  Mood interaction,  $F(4, 522) = 5.02, p = .001, \eta_p^2 = .037$ .

Pairwise comparisons showed that participants recognised more negative than positive or neutral studied words when they were in negative moods, and participants recognised more positive and negative studied words than neutral studied words when they were in positive moods.

Table 8.1.

*The Mean Valence and Arousal Scores and 95% CIs as a Function of Mood for Each Warning Condition*

Warning Condition	Positive Mood		Neutral Mood		Negative Mood	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
<i>Valence</i>						
No warning (NW)	2.43	[1.98, 2.88]	4.53	[4.08, 4.98]	7.00	[6.55, 7.45]
Warning before (WB)	4.70	[4.25, 5.15]	5.87	[5.42, 6.32]	6.63	[6.18, 7.08]
Warning after (WA)	2.60	[2.15, 3.05]	4.53	[4.08, 4.98]	6.77	[6.32, 7.22]
<i>Arousal</i>						
No warning (NW)	5.57	[4.98, 6.15]	6.07	[5.48, 6.65]	6.17	[5.58, 6.75]
Warning before (WB)	3.17	[2.58, 3.75]	4.53	[3.95, 5.12]	7.03	[6.45, 7.62]
Warning after (WA)	5.47	[4.88, 6.05]	5.87	[5.28, 6.45]	6.13	[5.55, 6.72]

Table 8.2.

*The Proportion and 95% CIs of True Recognition of Studied Words as a Function of List Valence and Mood*

	Negative mood	Positive mood	Neutral mood
Negative studied words	.77 [.72, .81]	.71 [.66, .75]	.69 [.64, .73]
Positive studied words	.71 [.66, .75]	.72 [.68, .77]	.66 [.62, .70]
Neutral studied words	.67 [.62, .71]	.66 [.62, .70]	.71 [.66, .75]

The false recognition rates are shown in Figure 8.1 as a function of warning condition, list valence, and mood. For false recognition of critical lures, there were three main findings. First, the false recognition rate was higher for negative ( $M = .58$ ) and positive critical lures ( $M = .54$ ) than it was for neutral critical lures ( $M = .47$ ),  $F(2, 522) = 15.21, p < .001, \eta_p^2 = .055$ . Second, the false recognition rate was higher in negative moods ( $M = .58$ ) than it was in neutral moods ( $M = .48$ ) or positive moods ( $M = .52$ ),  $F(2, 261) = 3.84, p = .023, \eta_p^2 = .029$ . Finally, the false recognition rate in the NW condition ( $M = .66$ ) was higher than that in the WA condition ( $M = .56$ ), which in turn was higher than that in the WB condition ( $M = .37$ ),  $F(2, 261) = 34.37, p < .001, \eta_p^2 = .208$ . In sum, warnings reduced false memory regardless of the valence of the to-be-remembered information and participants' mood. In addition, warnings provided at encoding were more effective than were warnings provided at retrieval. There were no interactions (all  $F$ 's  $\leq 1.72, ns$ ).

Recall that the primary aim of the present experiment was to determine the impact of mood on retrieval of mood-congruent critical lures when the monitoring strategies were provided after encoding, but before retrieval. Hence, four additional planned comparisons were conducted in the WA condition. For negative critical lures, the false recognition rate

was lower in neutral moods than that in negative moods,  $t(87) = 3.04, p = .003, d = 0.83$ . For positive critical lures, the false recognition rate was lower in neutral moods than that in positive moods,  $t(87) = 2.62, p = .01, d = 0.66$ . Finally, for neutral critical lures, there was no reliable difference in the false recognition rate between neutral moods and negative moods,  $t(87) = -0.99, p > .250$ , nor between neutral moods and positive moods,  $t(87) = -1.32, p = .191$ . Taken together, these findings indicate that, compared to neutral moods, negative and positive moods inhibited, rather than promoted, the monitoring processes of mood-congruent critical lures at retrieval.

For false recognition of unrelated words, false recognition rates were low and no main effects or interactions were found (all  $F$ 's  $< 2.80$  *ns*).

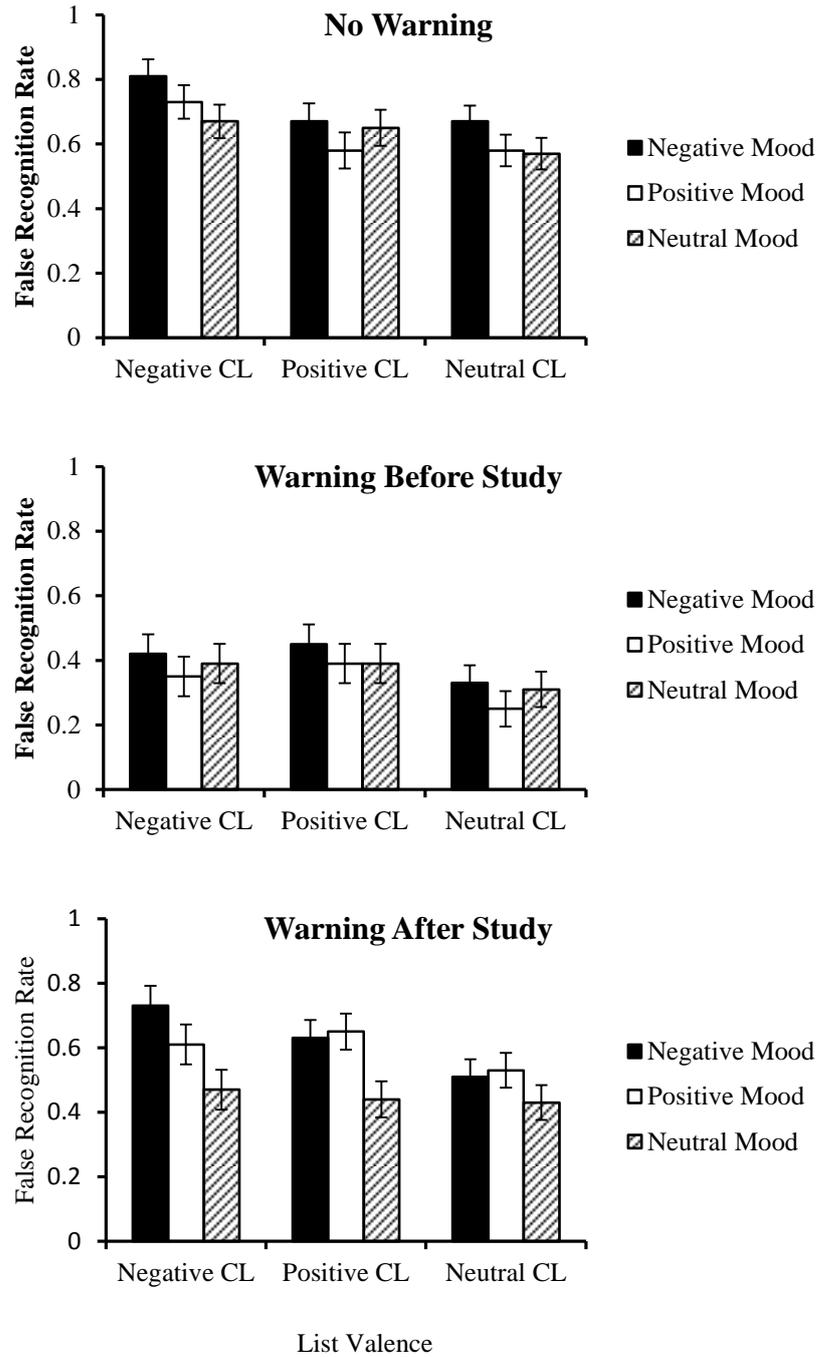


Figure 8.1. Proportions of false recognition of critical lures (CL) as a function of warning condition, list valence, and mood. Error bars show  $\pm 1SEM$ .

## Discussion

The aims of the present experiment were two-fold. First, I investigated the effect of warnings, particularly warnings at the time of retrieval, on the creation of emotional false memories. Second, I investigated the role of mood on retrieval of mood-congruent false memories when monitoring and verbatim processes were encouraged. To achieve these aims, I induced particular moods and asked participants to learn emotional DRM word lists, which differed in valence, but not in arousal. As in prior research (Gallo et al., 2001; McCabe & Smith, 2002), I provided participants with an example to illustrate the DRM false memory effect. Moreover, I also provided participants with a specific monitoring strategy — focusing on the verbatim information of each word. Consistent with prior research, warnings had no reliable effect on true recognition, but warnings provided at the time of encoding significantly reduced false recognition (see also, Del Prete, Mirandola, Konishi, Cornoldi, & Ghetti, 2014; Gallo et al., 1997; Gallo et al., 2001; McCabe & Smith, 2002; McDermott & Roediger, 1998; Starns, Lane, Alonzo, & Roussel, 2007; Watson, McDermott, & Balota, 2004). More importantly, although the effect of retrieval warnings was not as pronounced as that of encoding warnings, warnings provided at the time of retrieval also reduced false recognition, regardless of the valence of to-be-remembered information or participants' mood. This finding regarding the effect of retrieval warnings on false memories is generally consistent with prior research (e.g., Anastasi, Rhodes, & Burns, 2000; Gallo et al., 2001; McCabe & Smith, 2002), however, the effect of retrieval warnings in the present experiment was more robust compared to that in prior studies.

In contrast to our findings and those of others, some researchers have failed to report an effect of retrieval warnings on false recognition (e.g., Neuschatz, Payne, Lampinen, & Toggia, 2001). These mixed findings may be due to the type of monitoring strategies that participants are encouraged to employ at the time of retrieval (Gallo et al., 2001; Neuschatz et

al., 2001; Reyna & Kiernan, 1994). According to FTT, if participants are given a specific strategy that helps them to make verbatim responses, then false memories should be reduced (Brainerd & Reyna, 2005; Reyna & Kiernan, 1994). Consistent with FTT's prediction, in the present experiment, we provided participants with a specific strategy that required them to focus on verbatim information for each word and, under these conditions, false recognition was significantly reduced. By comparison, although Neuschatz et al. (2001) also presented participants with an example to introduce the DRM false memory effect and to further introduce the qualitative differences between true and false memories, the warnings that they used in their study (e.g., "we are trying to trick you so please try to avoid reporting items that are consistent with the theme but were not presented," p. 69) were not effective in reducing false recognition. In Neuschatz et al.'s procedure, participants had to initially deduce the theme of each list before judging whether or not a test item was consistent with that theme, leaving open the possibility that the theme that participants thought of might not have necessarily been the assigned theme or the critical lure. Under these circumstances, false recognition for the critical lure may not be reduced. In contrast, the strategy that we used in the present experiment was direct and clear; we asked participants to focus on verbatim information for each word so that participants were only required to recollect verbatim information of each encoded word to judge whether or not the word has been presented. Using this direct strategy, false recognition for the critical lures was reduced.

The finding that retrieval warnings reduced only false recognition, but had no impact on true recognition indicates that a strategy that encourages participants to access verbatim information at retrieval may help participants experience the recollection-rejection process (FTT; Brainerd & Reyna, 2005). The term *recollection rejection* refers to the process by which false-but-gist-related information is rejected from memory reports when verbatim information of studied information is accessible (Brainerd, Reyna, Wright, & Mojardin,

2003). For example, participants who are encouraged to focus on the verbatim information for each word may not make an “old” response to *anger* because they can recollect verbatim information for *mad, rage, fury*, but not verbatim information for *anger*. This same strategy may not necessarily facilitate the retrieval of list words because true recognition is not only due to verbatim processing of information, but also due to gist-related processing of information (Brainerd & Reyna, 2005; Yang et al., 2015).

The other important finding of the present experiment was that compared to neutral moods, positive moods impeded retrieval monitoring of positive critical lures, and negative moods impeded retrieval monitoring of negative critical lures. In other words, mood influenced retrieval of mood-congruent false memories through improved monitoring and verbatim processing. Although Yang et al. (2015) also found that positive moods facilitated the role of warnings on reducing false memories, direct comparisons between our experiment and Yang et al.’s is impossible because the key manipulations are totally different. For example, Yang et al. did not differentiate between encoding warnings and retrieval warnings because warnings were presented both before and after study in their experiment. In contrast, in the present experiment, independent groups of participants experienced either encoding or retrieval warnings. Moreover, it was impossible to draw conclusions about the effect of mood on mood-congruent information in Yang et al. (2015) because only neutral word lists were used. The present experiment, however, bridged this gap by manipulating both the valence of the to-be-remembered word lists and participants’ mood, making it possible to explore the effect of mood on encoding and retrieval of mood-congruent information.

Prior research has supported the role of mood on encoding of mood-congruent critical lures. That is, mood may act as a source of activation, which combines with semantic activation of studied words. The activation then spreads to emotionally- and semantically-related critical lures, thus generating mood-congruent false memories (Knott & Thorley,

2014; Ruci et al., 2009; Zhang et al., 2017a). However, no empirical study has investigated the role of mood on retrieval of mood-congruent critical lures. The present experiment was the first to find that mood may not only influence encoding of mood-congruent critical lures via *enhanced* activation (as suggested by one-process accounts), but may also influence retrieval of mood-congruent critical lures via *impeding* monitoring. This finding is consistent with the AMT account of false memories which argues that activation of studied words alone cannot ensure that false memories will occur because retrieval monitoring may also play a role (Roediger, Watson, et al., 2001). Moreover, according to AMT, activation and the monitoring process are not independent. Strong activations lead the unpresented information to share many of the features related to presented information. Under these conditions, source monitoring becomes difficult and errors may arise (Roediger, Watson, et al., 2001). The idea of monitoring in AMT was actually adapted from Johnson's source-monitoring framework (Johnson et al., 1993; Johnson & Raye, 1981). According to the source-monitoring framework, there are two types of decision-making processes: heuristic (automatic) and systematic (controlled). In the absence of additional strategies to promote monitoring, people typically make source judgments heuristically with little deliberation. However, when a monitoring strategy is encouraged, people make source judgments in a relatively controlled manner with more contemplation and deliberation (Gallo et al., 2001; Johnson et al., 1993; McCabe & Smith, 2002).

Consistent with AMT, in the present experiment, when warnings were provided at retrieval, activation of the studied words remained intact. Positive or negative moods, compared to neutral moods, may facilitate strong activations of mood-congruent information at encoding. At retrieval, strong activations in turn may lead to relatively heuristic judgements to positive or negative information under positive or negative moods, respectively. Because of the familiarity-based heuristic decision strategy, unpresented words

that are emotionally- and semantically-related to studied words (i.e., mood-congruent critical lures) tend to be regarded as having been studied.

Another explanation for the effect of mood on retrieval of mood-congruent false memories is based on Balota et al.'s (1999) idea that attentional control plays a role at retrieval when making source judgments about items with similar sources of activation. According to their account, the cognitive mechanism of avoiding DRM false memories is similar to that which occurs in the Stroop interference task. In the Stroop task, a series of squares in different colors are presented, each accompanied by a color word that is different from the color of the square. For example, a *red* square might be accompanied by the word *green*, *yellow*, or *blue* but not *red*. Participants are required to name the color of the square rather than to read out the word label (Stroop, 1935). To avoid interference by the word label, participants must focus their attention on the color, per se. According to Balota et al., when retrieval warnings are used in the DRM task, the activated semantic information is analogous to the activated word information in the square. The verbatim information that warnings emphasise, on the other hand, is analogous to the colour information in the Stroop task (Balota et al., 1999; McCabe & Smith, 2002). To avoid being tricked by the semantically-related critical lures, participants must focus their attention on the verbatim information of each studied word. The present findings demonstrate that the degree to which attentional control is effective in helping participants to avoid interference by semantic information in the DRM task may be influenced by the valence of the to-be-remembered information and rememberers' mood. Positive or negative moods may *hamper* attentional control of mood-congruent information at retrieval, and familiarity-based judgments are made to mood-congruent critical lures. As a result, false recognition for positive critical lures is higher in positive moods than in neutral moods, and false recognition for negative critical lures is higher in negative moods than in neutral moods.

Taken together, the two main findings in the present experiment may also have important practical implications in situations where people are asked to report emotional information in a particular mood. First, retrieval warnings reduced false memories, regardless of valence of to-be-remembered information and participants' mood, as long as a specific monitoring strategy was provided prior to retrieval. This finding suggests that in real-world contexts, police, lawyers, and judges should offer witnesses and victims an effective monitoring strategy to help them avoid information that has come to mind, but that did not happen. For example, questioners may initially obtain some relevant information from the scene, and then they may take advantage of this kind of true information to encourage witnesses and victims to recollect or visualise the key information. Because of the recollection-rejection process, under this condition, witnesses and victims may be able to avoid reporting false information. Second, our finding that compared to neutral moods, negative moods impeded retrieval monitoring of negative critical lures, suggested that it is necessary to consider the current mood state of witnesses or victims (i.e., negative moods) when they are attempting to recall information. In a negative mood state, it may be difficult for witnesses and victims to monitor their memories for negative information, in particular. Consequently, they may report more negative-but-unpresented information in negative moods than in neutral moods.

## Chapter 9

### Does Directed Forgetting Reduce Emotional False Memories?

In cases of child abuse, a perpetrator may tell a child victim to forget that the abuse ever happened or tell a child witness to forget what they saw. Whether these instructions influence children's memory is not known, but the answer to the question has considerable practical importance. Given that instructions of this kind are analogous to directed forgetting procedures used in laboratory studies of memory, it may be possible to use directed forgetting procedures to assess the effects of similar instructions on true and false memory in the DRM paradigm.

When directed-forgetting procedures are used within the DRM paradigm, participants initially learn List 1, followed by a directed-forgetting cue where participants are asked to forget List 1 because it will not be tested later. Then participants learn List 2. In the subsequent test, participants are required to recall the words on List 1. In the control condition, participants only learn and recall List 3. The consistent finding is that the number of List 1 words recalled by participants in the directed-forgetting condition is less than the number of List 3 words recalled by participants in the control condition. That is, directed forgetting affects episodic access to the to-be-forgotten words. As a result, true memories for these words are reduced (Basden, Basden, & Gargano, 1993; Bäuml & Kuhbandner, 2009; Conway, Harries, Noyes, Racsma'ny, & Frankish, 2000; Howe, 2005; Kimball & Bjork, 2002; Wilson & Kipp, 1998).

Does directed forgetting influence false memory in the DRM paradigm? Predictions regarding the effect of directed forgetting on DRM false memory builds on evidence that directed forgetting affects episodic access, but not semantic activation (Howe, 2005; Kimball & Bjork, 2002). Evidence has shown that directed forgetting influences memory only when a

direct memory task (i.e., free recall) is conducted (Kimball & Bjork, 2002). To complete indirect memory tasks, such as stem completion and word association, semantic activation is needed. Directed forgetting, however, does not affect the indirect memory tasks, suggesting that directed forgetting does not influence semantic activation of studied words. Based on this idea, there are two different theoretical predictions as to whether directed forgetting influences false memory in the DRM paradigm. According to the spreading-activation theory (SAT; Roediger, Balota, et al., 2001), DRM false memory is due to semantic activation of the studied words. This activation then automatically spreads to semantically-related, but non-presented critical lures, resulting in a high rate of false memory (Roediger, Balota, et al., 2001). Inasmuch as directed forgetting does not influence semantic activation, SAT predicts that directed forgetting would not affect false memory in the DRM paradigm.

Alternatively, fuzzy-trace theory (FTT; Brainerd & Reyna, 2005) and activation-monitoring theory (AMT; Roediger, Watson, et al., 2001) contend that the effect of directed forgetting on false memory may be more complex than SAT predicts. On the one hand, according to FTT and AMT, the generation of false memory is not only due to semantic activation of studied words, but also due to the monitoring process in which verbatim traces (as proposed by FTT) or episodically-distinctive information (as proposed by AMT) may be used to hamper retrieval of related-but-unpresented critical lures. Because directed forgetting impairs access to verbatim traces or episodically-distinctive information (e.g., the position, pronunciation, and length of each studied word), it is likely that the monitoring process of false memory is impeded as well. According to FTT and AMT, false memories may increase with directed forgetting. On the other hand, AMT predicts that if strong activation of critical lures occurs, which leads critical lures to share many of the features related to the studied words, the monitoring process becomes difficult irrespective of whether verbatim or

distinctive information is accessible or not. As a result, directed forgetting would have no impact on false memory.

In the literature, there are only a few studies that have investigated the effect of directed forgetting on true and false memory. Kimball and Bjork (2002), for example, in a study with young adults, asked participants in the experimental group to forget List 1 because it was just a practice list and to instead remember the next list (i.e., List 2). In the recall test, however, participants had to recall the words on List 1. Participants in the control group studied and recalled only one list. Consistent with prior research, the true recall rate for the control list was significantly higher than that for the to-be-forgotten list. This finding indicated that directed forgetting impairs the access of verbatim or distinctive information of studied words. But what happened to false memory of critical lures when episodic access to the studied words was impaired by directed forgetting? In contrast to the pattern found in true memory, Kimball and Bjork found that the false recall rate for the to-be-forgotten list was significantly higher than that for the control list. In other words, false memories increased with directed forgetting. This pattern of findings is consistent with FTT and AMT.

Using the same method as Kimball and Bjork (2002), Howe (2005) recruited 5-year-olds, 7-year-olds, and 11-year-olds to investigate the developmental pattern of directed-forgetting effects on true and false memory. Consistent with adults' performance, the true recall rate for the control list was significantly higher than that for the to-be-forgotten list. This pattern was consistent across ages. For false memory, 11-year-olds recalled more critical lures than did 5-year-olds and 7-year-olds, showing a typical developmental reversal effect. However, children also exhibited significantly reduced false memory for the to-be-forgotten list (i.e., List 1) compared to the control list. That is, unlike adults, children reported fewer false memories for the list that they were asked to forget. This finding suggests that there may be an age-related difference in the effect of directed-forgetting on false memory.

In addition to age, mood may also influence the directed-forgetting effects on true and false memory because positive moods may promote reactivation of to-be-forgotten words (i.e., List 1) during the encoding of List 2, compared to negative moods (Bolte et al., 2003). Such reactivation may eliminate forgetting the words on List 1. In one study, for example, Bäuml and Kuhbandner (2009) used emotional pictures to induce positive, negative, or neutral moods. Following the presentation of a word list (i.e., List 1), participants were instructed to either forget or remember that list for a later test. They were then instructed to remember List 2. All of the words on Lists 1 and 2 were neutral. At test, participants were asked to recall List 1. As predicted, the true recall rate in the forgetting condition was significantly lower than that in the remembering condition when participants were in negative moods. However, there was no significant difference in true recall between the two conditions when participants were in positive moods. In other words, positive moods inhibited the effect of directed forgetting on reducing true memories. Whether mood would affect directed-forgetting effects on false memories has not yet been investigated. Based on prior research and the relevant theories described above, specific predictions may depend on the emotional valence of to-be-forgotten information and participant's age.

Although positive moods promote reactivation of to-be-forgotten words, compared to negative moods, as found in Bäuml and Kuhbandner (2009), the words used in that study were neutral. What would happen if the words were negatively charged? Evidence has shown that positive moods lead to a heuristic processing mode, which is characterised by a broad activation of not only positive but also negative information, whereas negative moods lead to a systematic processing mode, which is characterised by relatively restricted activation of negative information (Bolte et al., 2003; Schwarz, 2001; Zhang et al., 2017). In this sense, negative moods may promote reactivation of negative words on List 1 that is required to forget during the encoding of List 2, just as positive moods. Reactivation eliminates

forgetting the negative words on List 1. Therefore, when the words on Lists 1 and 2 are negatively charged, not only positive, but also negative moods may inhibit the effect of directed forgetting on reducing true memories. Given the reactivation of to-be-forgotten negative words in positive and negative moods, the access of verbatim traces or episodically-distinctive information may be intact. Correspondingly, the monitoring process of false memory may not be damaged. According to FTT and AMT, directed forgetting may not increase false memory when the to-be-forgotten words are negative. According to AMT, it is also possible that mood provides another source of activation of emotional information, which may lead to strong activation of critical lures. This strong activation may lead critical lures to share many of the features related to the studied words. Under this condition, the monitoring process becomes difficult. As a result, directed forgetting has no impact on false memory.

There is consensus that adults typically exhibit higher true memory than do children because adults have a better developed knowledge base than do children so that adults are better at encoding and retrieving verbatim information (as suggested by FTT) or activating studied information (as suggested by AAT), compared to children. As described earlier, positive and negative moods may help reactivate the negative to-be-forgotten words, it is possible, however, that an ability to reactivate the negative to-be-forgotten words would be lower in children than in adults. Limited reactivation in children may not sufficiently eliminate forgetting the negative List 1 words. Therefore, unlike adults, directed forgetting may reduce children's true memory for the negative to-be-forgotten words in positive and negative moods. Considering that directed forgetting inhibits children's episodic access to studied words, and it is difficult for children to use verbatim or distinctive information of studied words to monitor their memory, it is possible that directed forgetting may increase children's false memory. Alternatively, according to AMT, due to the additional activation of mood, strong activation of critical lures may happen in children, just like it happens in adults.

If this activation occurs, no matter whether the verbatim or distinctive information is accessible or not, the monitoring process itself becomes difficult. As a result, like adults, directed forgetting may have no impact on children's false memory.

The aims of Experiment 7 were two-fold. First, I wanted to investigate whether directed forgetting would influence children's true and false memory for negative information when they were in a certain mood state (e.g., negative). Second, I wanted to explore age-related differences in directed-forgetting effects on true and false memory for negative information in a certain mood state. I tentatively predicted that directed forgetting would reduce children's, but not adults', true memory for negative information in positive and negative moods. As for false memory, there were two possibilities: 1) directed forgetting would enhance children's, but not adults', false memory for negative information in positive and negative moods, or 2) directed forgetting would not influence either children's or adults' false memory for negative information in positive and negative moods.

## Experiment 7

### Method

#### Participants

Sixty 6- to 8-year-old children ( $M$  age = 7.08 years,  $SD$  = 0.46) were recruited through a database of parents who had agreed to participate in studies of child development. All children were predominantly Caucasian and came from a wide range of socioeconomic backgrounds. They agreed to participate in this study, and their parents provided written consent. In addition, 60 undergraduate university students ( $M$  age = 19.45 years,  $SD$  = 1.03) were recruited through a Research Participation Pool. They satisfied a small portion of course assessment by completing a worksheet based on the experiment. Half of the participants in each age group were female. All of the participants were native English speakers with normal or corrected-to-normal vision and had no history of mood disorders. They had not participated in any similar studies before.

#### Materials and Procedure

Participants were randomly assigned to one of the two mood conditions ( $n = 30$  participants of each age in each condition). Moods were induced using a video clip that had a positive or negative valence. The positive and negative video clips were the same as those used in Experiment 5 (i.e., the Hakuna Matata scene from *The Lion King* to induce positive mood and the scene about the death of Mufasa to induce negative mood). Immediately following the mood-induction phase, participants were asked to assess their mood using the same self-report measure called A Nonverbal Scale of Emotion (ANSE; Lay et al., 1989) that was used in Experiment 5.

Participants then listened to audio recordings of word lists. Three 10-word lists were chosen from the emotional word lists compiled in Experiment 1 and all of the lists were negatively charged. Each word was presented for 2 s on a computer monitor. Participants

were told that they should remember each word carefully for the later memory test. All of the participants experienced the directed-forgetting and the control manipulations. Participants who experienced the directed-forgetting cues were initially asked to remember List 1 (i.e., the *anger* list); after learning the words on List 1, they were told to forget them because these words would not be tested later. After 30s, words on List 2 (i.e., the *sick* list) were shown. Immediately following the presentation of List 2, participants were required to recall the words on List 1. In the control condition, participants were only asked to remember List 3 (i.e., the *lie* list), followed by a 30s distractor task, and then they were asked to recall as many of the words from the list as they could remember. The order of the directed-forgetting and the control manipulations were partially counterbalanced across participants; that is, half of the participants of each age group learned List 1 and List 2, followed by List 3, and the other half of the participants learned List 3, followed by List 1 and List 2.

## Results

### Mood manipulation check

Recall that higher scores on the ANSE indicated that participants felt more positive or excited, while lower scores indicated that participants felt more negative or calm. I conducted separate 2 (mood: negative vs positive)  $\times$  2 (age: children vs adults) analyses of variance (ANOVA) across valence and arousal scores.

For valence, there were main effects of mood,  $F(1, 116) = 1026.29, p < .001, \eta_p^2 = .898$ , and age,  $F(1, 116) = 7.20, p = .008, \eta_p^2 = .058$ , and a Mood  $\times$  Age interaction,  $F(1, 116) = 16.41, p < .001, \eta_p^2 = .124$ . Pairwise comparisons showed that regardless of age, participants in the negative mood condition felt more negative than those in the positive mood condition,  $p$ 's  $< .001$ . However, adults in the negative mood condition felt more negative than did children ( $M = 1.43$  and  $5.70$ , respectively,  $p < .001$ ). There was no reliable difference in valence scores between adults and children when they were in the positive mood condition ( $M = 24.3$  and  $23.43$ , respectively,  $p > .250$ ).

For arousal, there were main effects of mood,  $F(1, 116) = 4.44, p = .037, \eta_p^2 = .037$ , age,  $F(1, 116) = 9.58, p = .002, \eta_p^2 = .076$ , and Mood  $\times$  Age interaction,  $F(1, 116) = 13.45, p < .001, \eta_p^2 = .104$ . Pairwise comparisons showed that the level of arousal did not differ between the negative ( $M = 12.53$ ) and positive mood condition ( $M = 11.53$ ) in adults,  $p > .250$ , but when children in the positive mood condition ( $M = 15.87$ ), their level of emotional arousal was higher than that when they were in the negative mood condition ( $M = 12.17$ ). Moreover, children in the positive mood felt more excited than did adults in the positive mood ( $15.87$  vs  $11.53, p < .001$ ), but no reliable difference was found in arousal scores between children and adults when they were in the negative mood ( $12.17$  vs  $12.53, p > .250$ ).

## Recall

True and false recall were analysed using separate 2 (age: children vs young adults)  $\times$  2 (mood: negative vs positive)  $\times$  2 (Interlist cue: forget vs control) mixed factor ANOVAs with repeated measures across interlist cue. Any significant effects were examined using the Bonferroni correction for pairwise-comparisons.

**True recall of studied words.** Figure 9.1 shows the true recall rates of studied words as a function of age, mood, and interlist cue. There were main effects of interlist cue,  $F(1, 116) = 40.89, p < .001, \eta_p^2 = .261$ , and age,  $F(1, 116) = 254.59, p < .001, \eta_p^2 = .687$ ; adults ( $M = .51$ ) had better memories for studied words than did children ( $M = .16$ ). In addition to these main effects, there was also an Interlist Cue  $\times$  Age interaction,  $F(1, 116) = 17.06, p < .001, \eta_p^2 = .128$ . Regardless of interlist cue, adults had higher true recall rates for studied words than did children (both  $p$ 's  $< .001$ ). Compared to the control group, however, the directed-forgetting cues were more effective in reducing children's true memories (.08 vs .24,  $p < .001$ ). In contrast, the directed-forgetting cues did not significantly reduce adults' true memories (.50 vs .53,  $p = .112$ ). There was also an Interlist Cue  $\times$  Mood interaction,  $F(1, 116) = 7.07, p = .009, \eta_p^2 = .057$ ; regardless of their mood state, participants had a lower true recall rate of studied words when they experienced the directed-forgetting instructions than when they were in a control group. However, mood also had an effect on the directed-forgetting cues; negative moods ( $M = .32$ ) inhibited the effect of the directed-forgetting cues on reducing the true recall for studied words, compared to positive moods ( $M = .26$ ). No significant difference in true recall between negative and positive moods was found in the control condition.

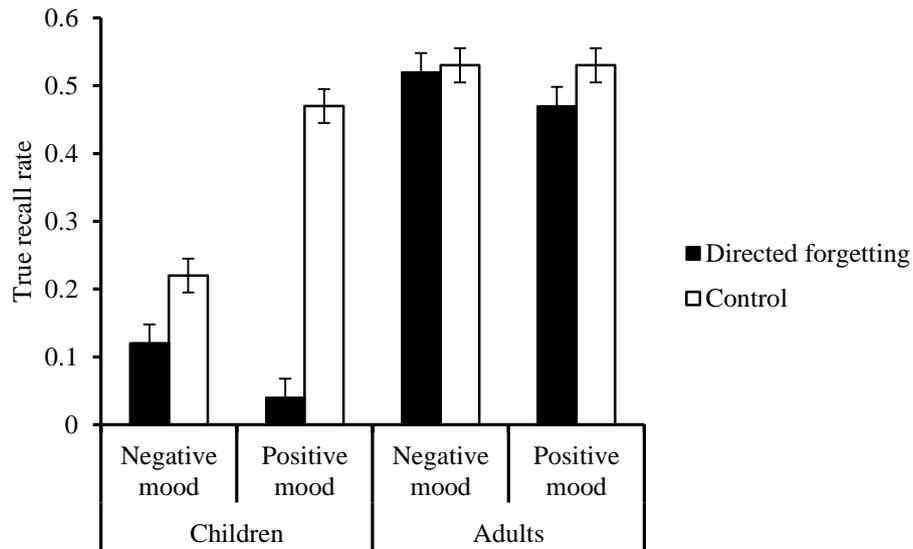


Figure 9.1. Proportion of true recall (+/-1SE) as a function of mood, age, and interlist cue.

**False recall of critical lures.** The false recall rate of the critical lures is shown in Figure 9.2 as a function of age, mood, and interlist cue. There was only a main effect of age,  $F(1, 116) = 57.76, p < .001, \eta_p^2 = .332$ , adults showed higher false recall rates than did children (.52 vs .07). There was no reliable effect of the directed-forgetting cues on false recall for critical lures, regardless of age or mood ( $F$ 's  $\leq 1.39$  ns).

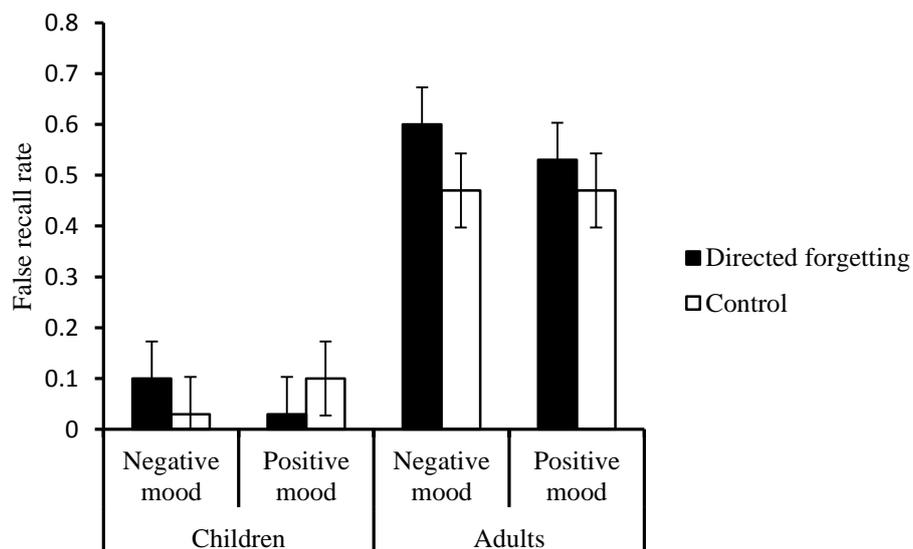


Figure 9.2. Proportion of false recall (+/-1SE) as a function of mood, age, and interlist cue.

## Discussion

The goal of the present experiment was to investigate the effect of directed forgetting on children's and adults' true and false memory for negative information in either positive or negative moods. Although the words used in the present experiment were negatively charged, which was different from those used in prior research (Basden et al., 1993; Bäuml & Kuhbandner, 2009; Conway et al., 2000; Howe, 2005; Kimball & Bjork, 2002; Wilson & Kipp, 1998), the present findings are consistent with prior research, showing that directed forgetting reduced the true recall rate for the words on the to-be-forgotten list (i.e., List 1) compared to the true recall rate for the words on the control list (.29 vs .38). More importantly, there was an age-related difference in the effect of directed forgetting on true memory for negative information, regardless of mood. That is, directed forgetting reduced children's, but not adults', true memory for negative words. This age-related difference may be due to the fact that adults' knowledge base is better developed than children's. A better developed knowledge base may help adults encode and retrieve verbatim information or activate studied information much better than children. Consistent with this idea, we found that adults generated a higher true recall rate for studied words than did children. Moreover, when children and adults were induced in either positive or negative moods, mood may help reactivate the to-be-forgotten words. Compared to adults, however, children may exhibit limited ability to reactivate the to-be-forgotten words. Limited reactivation of the to-be-forgotten words may make it difficult for children to inhibit the effect of directed forgetting on reducing true memory. As a result, directed forgetting impaired children's, but not adults', true memory for negative words. Given that negative moods promote verbatim memory, which increases true memories, another reason for why directed forgetting only reduced children's, but not adults' true memory may be that adults in the negative mood felt more negative than did children in the negative mood.

The effect of directed forgetting on true memory may be qualified by not only age, but also by mood because negative moods inhibited the effect of the directed-forgetting cues by reducing the true recall for the negative studied words, compared to positive moods (.32 vs .26). As described earlier, positive moods lead to a heuristic processing mode, which is characterised by a broad activation of not only positive but also negative information, whereas negative moods lead to a systematic processing mode, which is characterised by a relatively restricted activation of negative information (Bolte et al., 2003; Schwarz, 2001; Zhang et al., 2017). Although both positive and negative moods may promote reactivation of negative to-be-forgotten words, the magnitude of reactivation of negative to-be-forgotten words may be larger in negative than in positive moods because a mood-congruent memory effect may occur in negative moods when processing negative information. In other words, because the valence of the mood and the to-be-processed information was the same, reactivation of negative to-be-forgotten words may be more robust in negative moods than in positive moods. Given that reactivation of negative to-be-forgotten words may inhibit directed-forgetting effects on reducing true memory, the true recall rate in negative moods was higher than that in positive moods.

Given that directed forgetting inhibited children's episodic access to studied words, and it is difficult for children to use verbatim or distinctive information of studied words to monitor their memory, would directed forgetting increase children's false memory in this condition? The answer is "no"; although directed forgetting reduced children's true memory, it did not influence either children's or adults' false memory for negative information. This finding may be due to an additional activation of mood. In other words, mood may act as a source of activation, this activation combining with semantic activation lead to strong activation of critical lures. The strong activation may ultimately lead critical lures to share many of the features related to the studied words. Under this condition, irrespective of

whether the verbatim or distinctive information is accessible or not, the monitoring process itself becomes difficult. As a result, directed forgetting did not influence false memory, regardless of age. These findings support SAT, according to which, directed forgetting did not affect DRM false memory because it did not influence semantic activation. The findings also supported AMT, which emphasises the role of strong activation of critical lures in eliminating the effect of directed forgetting on false memory.

In sum, the present experiment supported the hypothesis that directed forgetting reduced children's, but not adults', true memory for negative information in positive and negative moods. Moreover, negative moods inhibited the role of directed forgetting in reducing true memory for negative information, compared to positive moods. As for false memory, directed forgetting had no effect on children' and adults' false memory for negative information regardless of mood. The present findings indicate that when victims or witnesses, either children or adults, are in a negative mood state (i.e., sad), no matter what a perpetrator says to them in terms of asking them to either forget the abuse happened or forget what they witnessed, a perpetrator's instructions would neither reduce victims' or witnesses' true memory for negative information that happened, nor increase victims' or witnesses' false memory for negative information that never happened.

## Chapter 10

### Concluding comments and future studies

The overarching goal of the present thesis was to use the DRM paradigm investigating the effects of emotion, including emotional content and emotional state, on true and false memories in both children and adults, and to explore the methods that might be used to reduce emotional false memories in laboratory settings. In this final chapter, I will review the main findings of each experiment contained in the thesis, discuss their theoretical implications, and propose new avenues for future research.

#### Overview

When I initially embarked on this research, there was no single study where researchers had used DRM word lists in which 1) all the list words shared the same emotional valence as the corresponding critical lure, and 2) arousal and BAS were equated across the different emotionally-laden list words and critical lures. Given this, my first step was to construct emotional word lists, which did not differ in level of arousal and BAS values and where every word on a particular list reflected the target emotion. Sixty 18- to 35-year-old undergraduate university students (30 female) were presented with a total of 233 words, which were selected from prior research (Brainerd et al., 2010; Budson et al., 2006; Howe & Malone, 2011; Joormann et al., 2009; Roediger, Watson, et al., 2001; Ruci et al., 2009; Thijssen et al., 2013). Words were shown one after the other, in a random order. Participants were asked to type the response to each target word, and to assess the emotional valence and arousal of the word using adapted versions of a 9-point SAM scale (1: happy or excited to 9: sad or calm). The goals of Experiment 1 were met: neither BAS nor arousal values differed as a function of type of word lists; however, there was a significant difference in valence; negative lists had higher valence values than did neutral lists, which in turn had higher

valence values than did positive lists. These findings suggest that every word on the compiled lists had the assigned emotional content (positive, negative, neutral), and the lists were matched in terms of arousal and BAS. This set of standard word lists provided a good preparation for the following experiments.

Having compiled emotional word lists where every list word shared the same emotional valence with the corresponding critical lures, in Experiment 2, I compared the level of false recognition created by these pure emotional lists with that created by hybrid emotional lists used by other researchers. The hybrid lists, “love,” “nice,” “anger,” and “sick,” were chosen from the CEL, which is a pool of 32 emotional word lists (Brainerd et al., 2010; Brainerd, Stein, et al., 2008). I used the first 10 words in these lists to make the list length the same as that of the pure emotional lists. The critical lures for the hybrid and the pure emotional lists were the same. Sixty 17- to 23-year-old undergraduate university students (30 female) participated in Experiment 2, in which each participant randomly learned either pure or hybrid emotional lists. In the test phase, participants were asked to judge if a word had been presented in the study phase by pressing 1 (yes) or 2 (no). Irrespective of list valence, pure emotional lists generated more true recognition but less false recognition, compared to the hybrid emotional lists. Consistent with prior research, false recognition was generally higher for the negative lists than for the positive lists.

In contrast to the consistent findings regarding the effect of emotional content on false recognition, the findings on false recall have been mixed. The mixed findings may be due to the confounding effects of valence and arousal rather than to valence per se. Therefore, in Experiment 3, I tested the effect of emotional content on false recall, while controlling the arousal of the emotional lists. Thirty 17- to 26-year-old undergraduate university students (21 female) learned 2 negative, 2 neutral, and 2 positive lists. The presentation order of word lists was partially counterbalanced across participants. After each list had been presented,

participants completed a 30s distractor task and were then asked to recall as many of the words from the list as they could remember in 1 min. Although true recall was higher for the negative and neutral lists than for the positive lists, false recall was higher for the negative lists than for the positive and neutral lists. In other words, the valence effect of emotional content was not only found for false recognition, but also for false recall, especially when arousal of emotional content was controlled. These findings suggest that the valence effect of emotional content on false memories may not be restricted to a specific memory test (recognition or recall).

Emotional content is only one aspect of emotion. Considering that in many contexts in which false memories really matter (e.g., in the courtroom or the clinic), the memories themselves are not only emotionally charged, but they are retrieved in a distinctive emotional state or mood, in Experiment 4, I explored whether false memories would be influenced by both the emotional content of the word lists and participant's mood. Ninety-three 17- to 33-year-old undergraduate university students (66 female) were randomly assigned to one of the three mood conditions (positive, negative, or neutral;  $n = 31$  participants in each condition). Mood was induced using music combined with self-imagery. Immediately following the mood-induction phase, participants used the 9-point SAM scales to assess how happy (1) or sad (9) and how excited (1) or calm (9) they were. Each participant then learned the 12 emotional word lists which were created in Experiment 1. The 72-word recognition test was conducted after a 5-min subtraction exercise. Negative mood-congruent true- and false-recognition effects were found; participants in the negative mood condition had lower false recognition rates for positive and neutral critical lures than that for negative critical lures. This pattern of results was also found for participants' true recognition of the words on the lists. These findings suggest that mood may affect the way we process emotional information no matter whether information has been presented or not.

In Experiment 5, I explored age-related differences in the effect of mood on false memories for emotional information. Importantly, given that FTT and AAT, two important theories proposed to account for the DRM false memory effect, make different predictions about the effect of mood on false memories and on developmental reversals in false memories, I took the opportunity to pit one theory against the other. Ninety 7- to 8-year-old children, 90 11- to 12-year-old adolescents, and 90 undergraduate university students participated in the experiment. Within each age group, participants were randomly assigned to one of three mood conditions (positive, negative, or neutral;  $n = 30$  participants of each age in each condition). Mood was induced using a video clip that had a positive, negative, or neutral valence. Immediately following the mood-induction phase, participants assessed their mood using A Non-verbal Scale of Emotion (ANSE). Participants then listened to audio recordings of the 12 emotional DRM word lists compiled in Experiment 1. After each list had been presented, participants completed a 30s distractor task and were then asked to recall as many of the words from the list as they could remember. Consistent with prior research, false recall was greater for negative information than for positive and neutral information. This finding alone does not allow us to choose one theory over the other because both theories predict this pattern of results. A second finding from this experiment, however, directly supported AAT, showing that the age-related increase in false memories was eliminated in positive moods, whereas this increase was maintained in negative moods for negative information.

The goal of the last two experiments in the present thesis was to determine whether adults' and children's emotional false memories could be reduced, or even eliminated. Drawing on prior research, I used warning instructions that provided *adults* with a specific strategy to help reduce their emotional false memories in Experiment 6. Two hundred and seventy 17- to 24-year-old undergraduate university students (135 female) were randomly

assigned to one of three warning conditions (no warning, warning-before-study, warning-after-study;  $n = 90$  in each condition). Participants in the no-warning condition (NW) were not presented with any warning instructions. Participants in the warning-before-study condition (WB) were presented with the warning instructions *before* the study phase, while participants in the warning-after-study condition (WA) were presented with the warning instructions *after* the study phase, but prior to the test phase. Within each warning condition, participants were randomly assigned to one of three mood conditions (positive, negative, or neutral,  $n = 30$  in each). The mood-induction method was the same as that in Experiment 4 (music combined with self-imagery). Immediately following the mood-induction phase, participants used the 9-point SAM scales to assess how happy (1) or sad (9) and how excited (1) or calm (9) they were. Participants then learned the 12 emotional word lists that were compiled in Experiment 1. After learning all 12 word lists and finishing a 5-min subtraction exercise, participants were asked to complete a 72-word recognition test.

There were three main findings in Experiment 6. First, consistent with prior research, warnings had no reliable effect on true recognition, but warnings provided at the time of encoding (i.e., before the study phase) significantly reduced false recognition. Second, although the effect of retrieval warnings was not as pronounced as that of encoding warnings, warnings provided at the time of retrieval also reduced false recognition, regardless of the valence of to-be-remembered information or participants' mood. Third, compared to neutral moods, positive moods *impeded* retrieval monitoring of positive critical lures, and negative moods *impeded* retrieval monitoring of negative critical lures. In other words, mood influenced retrieval of mood-congruent false memories through improved monitoring and verbatim processing. The findings suggest that explicit warnings, either encoding or retrieval warnings, can reduce adults' emotional false memories. Moreover, mood may influence mood-congruent false memories both at encoding and at retrieval. At encoding, mood may

serve as a source of activation, combined with semantic activation to help *activate* emotionally-and-semantically-related critical lures, while at retrieval, mood may help *impede monitoring* mood-congruent critical lures.

Considering that the warning instruction is difficult for children to understand, in Experiment 7, I used directed-forgetting cues instead of warning instructions to investigate whether children's emotional false memories could be reduced. Sixty 6- to 8-year-old children and 60 undergraduate university students participated in the experiment. Participants were randomly assigned to one of the two mood conditions ( $n = 30$  participants of each age in each condition). The mood-induction method and mood-assessment method were the same as those in Experiment 5. Each participant experienced both the directed-forgetting and the control manipulations. In the directed-forgetting cue manipulation, participants were initially asked to remember List 1 (the *anger* list), after learning the words on List 1, they were then told to forget them because these words would not be tested later. After 30s, words on List 2 (the *sick* list) were shown. Immediately following the presentation of List 2, participants were surprisingly required to recall the words on List 1 as many as possible. In control manipulation, participants were only asked to remember List 3 (the *lie* list), followed by a 30s distractor task, and then were asked to recall as many of the words from the list as they could remember.

In Experiment 7, the directed-forgetting cues significantly reduced true recall for the words on the to-be-forgotten list (i.e., List 1) compared to true recall for those on the control list (.29 vs .38). Moreover, directed forgetting reduced children's, but not adults', true memory for negative words, showing an age-related difference in the effect of directed forgetting on true memory. The effect of directed forgetting on true memory was qualified by not only age, but also mood because negative moods inhibited the effect of the directed-forgetting cues on reducing the true recall for the negative studied words, compared to

positive moods (.32 vs .26). Although directed forgetting reduced children's true memory, directed forgetting had no effect on children' and adults' false memory for negative information, regardless of mood. These findings support the activation-monitoring theory (AMT) proposed to account for the DRM false memory effect.

### **Theoretical Implications**

In general, two major theories have been proposed to account for the DRM false memory effect and the way it changes as a function of the age of the participant. Associative theorists, including those who support the *Implicit Associative Response (IAR)*, *Spreading Activation Theory (SAT)*, *Associative Activation Theory (AAT)*, and *Activation-Monitoring Theory (AMT)*, believe that DRM false memories are due to associative (e.g., semantic) activation processes in the mental lexicon. The fundamental assumption of these theories is that related concepts are organised together in the mental lexicon so that when one concept is activated, this activation also further activates other, related concepts. Because of their close links, some of these related concepts that have not been presented (e.g., critical lures), will be erroneously activated merely by association, resulting in false memories (for a review, see Gallo, 2010). In addition to the associative-activation process, AMT also emphasises the role of the monitoring process on false memory. The goal of monitoring is to distinguish between events that actually happened from those that did not so as to reduce false memories. When strong activation happens, which leads the unrepresented information to share many of the features related to presented information, monitoring becomes difficult and errors may arise, increasing false memories (Johnson et al., 1993; Roediger, Watson, et al., 2001). Associative theories, especially AAT, posit that it is changes in the content and structure of children's knowledge base (e.g., reorganisation of knowledge, increase of associations) that contribute to the age-related increase in DRM false memories. This, combined with increasing experience in using concepts, causes increases in the level of automaticity with which

children access or activate associative information. In other words, with increased knowledge and experience, the difference in false memories between children and adults is mainly due to the different degree of automaticity with which they access or activate associative information in the knowledge base. As children develop knowledge through learning and practice, they develop a better memory network in which the associative links among related concepts become better organised and integrated. As this happens, related concepts are easier to access (Howe, 2005, 2006).

Fuzzy-trace theory (FTT), on the other hand, proposes that there are two representations of information (or traces) in memory. Verbatim traces represent the specificity of information (e.g., the position, pronunciation, and word length of each studied word in the DRM paradigm). Gist traces refer to the general semantic meaning of information (e.g., gist-related critical lures in the DRM paradigm). According to FTT, verbatim and gist traces are stored in parallel, which means people can store the gist of information irrespective of whether they already retain surface details of the information. Verbatim and gist traces, however, are retrieved separately, which means that whether verbatim or gist traces are finally accessed depends on the retrieval cues provided. Moreover, according to FTT, the generation of DRM false memories is mainly due to gist extraction because a critical lure can be regarded as the gist of a word list and all of the words in the list are semantically related to the critical lure (for a review, see Brainerd & Reyna, 2005). As described earlier, FTT was the first theory to predict the counterintuitive developmental reversals in DRM false memories. According to FTT, the age-related increase in DRM false memories is due to the ability to access and extract the gist of DRM word lists developing with age. In essence, young children's immature gist memory protects them from false memory errors in the DRM paradigm.

One key question is whether there is a theory, either associative theories or FTT, that can account for all of the empirical findings in the present thesis? The simple answer is “no.” In some cases, associative theories (i.e., *IAR*, *SAT*, *AAT*, and *AMT*) provide a more suitable explanation for the findings, in some cases, fuzzy-trace theory is better, and in other cases both associative theories and FTT account for the findings. Table 10.1 summarises the main findings of the present experiments and whether they provide empirical support for each theory or both. Evidence supporting associative theories over FTT includes: (1) there was a positive correlation between true and false recognition; (2) the age-related increase in false memories was eliminated in positive moods, whereas this increase was maintained in negative moods for negative information; (3) mood impeded monitoring of mood-congruent critical lures at retrieval, and negative moods inhibited the effect of directed-forgetting cues on reducing the true recall for the negative information; and (4) directed forgetting reduced only children’s true memory, but it did not influence either children’s or adults’ false memory.

In contrast, evidence supporting FTT over associative theories includes: (1) pure emotional lists generated more true recognition but less false recognition, compared to hybrid emotional lists; and (2) retrieval warnings had no impact on true recognition, but reduced false recognition. As for the effect of emotional content on false memory, both associative theories and FTT make the same prediction that false memories would be higher for negative information than for positive or neutral information. This prediction was supported throughout the experiments. Moreover, the finding that explicit warnings reduced false memories, regardless of valence of information and participant’ mood, also supports both FTT and associative theories, especially *AMT*.

Mixed support for one set of theories over another may lead to the conclusion that the underlying mechanisms of the DRM false memory and its development are so complicated

that no single theory could account for all of the phenomena. On the other hand, the findings suggest that associative theories and FTT are not mutually exclusive; FTT may benefit from associative theories to explain how the gist information is mentally generated, while associative theories may benefit from FTT to explain why the same factor may have different impacts on true and false memories.

Table 10.1.

*Empirical Findings of the Current Experiments that Supports Associative Theories, FTT or Both*

Experiments	Main findings	Associative theories VS FTT
Expt.1 (Chapter 4)	<ul style="list-style-type: none"> <li>• Every word on the compiled lists had the assigned emotional content</li> <li>• The lists were matched in terms of arousal and BAS</li> </ul>	—
Expt.2 (Chapter 5)	<ul style="list-style-type: none"> <li>• Irrespective of list valence, pure emotional lists generated more true recognition but less false recognition, compared to hybrid emotional lists</li> <li>• False recognition was generally higher for the negative lists than for the positive lists</li> </ul>	<ul style="list-style-type: none"> <li>• Support FTT</li> <li>• Support associative theories and FTT</li> </ul>
Expt.3 (Chapter 5)	<ul style="list-style-type: none"> <li>• Consistent with false recognition, false recall was higher for the negative lists than for the positive and neutral lists</li> </ul>	<ul style="list-style-type: none"> <li>• Support associative theories and FTT</li> </ul>
Expt.4 (Chapter 6)	<ul style="list-style-type: none"> <li>• Participants in the negative mood condition had lower false recognition rates for positive and neutral critical lures than those for negative critical lures</li> <li>• Across mood conditions, true recognition rates for negative, positive, and neutral list words were</li> </ul>	<ul style="list-style-type: none"> <li>• Support associative theories and FTT</li> <li>• Support associative theories, in particular.</li> </ul>

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	positively correlated with false recognition of negative, positive, and neutral lures, respectively	
Expt.5 (Chapter 7)	<ul style="list-style-type: none"> <li>• False recall was greater for negative information than for positive and neutral information</li> <li>• Age-related increase in false memories were reduced or eliminated in positive moods, whereas this increase was maintained in negative moods for negative information</li> </ul>	<ul style="list-style-type: none"> <li>• Support associative theories and FTT</li> <li>• Support associative theories (e.g., AAT), in particular</li> </ul>
Expt.6 (Chapter 8)	<ul style="list-style-type: none"> <li>• Explicit warnings, either at encoding or retrieval, reduced adults' emotional false memories</li> <li>• Retrieval warnings reduced only false recognition, but had no impact on true recognition</li> <li>• Mood impeded monitoring of mood-congruent critical lures at retrieval</li> </ul>	<ul style="list-style-type: none"> <li>• Support associative theories (e.g., AMT) and FTT</li> <li>• Support FTT</li> <li>• Support associative theories</li> </ul>
Expt.7 (Chapter 9)	<ul style="list-style-type: none"> <li>• Directed forgetting reduced children's, but not adults', true memory for negative words</li> <li>• Negative moods inhibited the effect of directed-forgetting cues on reducing true recall for the negative studied words, compared to positive moods</li> <li>• Although directed forgetting reduced children's true memory, it did not influence both children' and adults' false memory.</li> </ul>	<ul style="list-style-type: none"> <li>• Support associative theories</li> <li>• Support associative theories</li> <li>• Support associative theories (e.g., SAT and AMT)</li> </ul>

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## Future Studies

Although prior research and the current experiments have primarily focused on the negative consequences of emotional false memories (e.g., false accusations of sexual abuse resulting in imprisonment of innocent people), future research is needed to investigate the potentially positive and adaptive functions of emotional false memories. As Bernstein and Loftus (2009) expressed: “In essence, all memory is false to some degree. Memory is inherently a reconstructive process, whereby we piece together the past to form a coherent narrative that becomes our autobiography. In the process of reconstructing the past, we color and shape our life’s experiences based on what we know about the world ” (p. 373). In brief, memories are prone to errors because of their constructive nature. If perceptual illusions are by-products of the constructive nature of the perception system given that the amount of sensory information varies over time, then false memories may be the by-product of the constructive nature of the memory system, the adaptive significance of which is to help an organism survive in various environments. For example, an animal with false memories about the presence of a predator at a cave when only paw prints of its existence were present will be more cautious on return to the cave than one who correctly remembers that there was no predator. Thanks to false memories, the animal’s behaviour may be changed correspondingly, such as approaching the cave at a different time, preparing a route for escaping, etc. These behaviours may increase the possibility that the animal with false memories will survive (Howe, 2011; Howe, Garner, Charlesworth, & Knott, 2011).

In recent years, the adaptive and positive functions of false memories have been investigated in laboratory settings. Howe and Derbish (2010), for example, manipulated survival-related information and processing in experiments where all participants were asked to learn neutral (e.g., *mountain*), negative (e.g., *sad*), and survival-related word lists (e.g., *death*). After the study phase, half of the participants were randomly assigned to the

pleasantness rating condition, where they rated each word in terms of pleasantness on a 1 (least pleasant) to 7 (most pleasant) scale. The other half of the participants were required to rate each word for how relevant it would be for their survival in the scenario provided on a 1 (least relevant) to 7 (most relevant) scale. Across four experiments, Howe and Derbish found a consistent pattern: survival-related information and survival-related processing led to more true and false memories. The findings indicate that not only true memories, but also false memories may have been shaped by evolution with adaptation in mind.

In another study, Howe, Garner, Dewhurst, and Ball (2010) investigated whether false memories would help solve a complex cognitive task, such as the compound remote associate task (CRAT). In this task, three words, for instance, *apple*, *family*, *house*, are presented. Participants are asked to think of a word that could link all of the three words, such as *tree* in this case. Solutions to the CRAT problems involve spreading activation in the well-organised associative network, where activation will continue until the correct concept is activated (Bowden, Jung-Beeman, Fleck, & Kounios, 2005). According to associative theories in false memories, activation may also spread to unrepresented-but-related concepts, resulting in false memories. Therefore, Howe and colleagues predicted that false recall of a critical lure would prime or help solve the CRAT problems, if the critical lure is the same as the linking word in the CRAT.

To test their prediction, Howe et al. asked participants to learn 4 out of 8 DRM word lists. After learning each list, participants completed a 30s distractor task and recalled as many words as they could remember from the list. Once this learning-distractor-recall process had been repeated for each of the 4 lists, participants were asked to solve all 8 CRAT problems, the solutions to which were the same as the critical lures for the DRM word lists. In this way, half of the CRAT problems were primed by the critical lures generated in the DRM procedure, while another half were not. Consistent with the prediction, Howe et al.

found that CRAT problems that were primed by the DRM word lists were solved more often and faster than problems that were not primed. This pattern, however, happened only when the critical lures of the corresponding DRM lists were falsely recalled. When the critical lures were not falsely recalled, there was no reliable difference in CRAT problem solution rates and times between problems with DRM priming and problems with no DRM priming. The findings were later replicated in adults as well as in 11-year-old children (Howe et al., 2011), and suggest that false memories are not simply the negative consequences that we are familiar with in the forensic and clinical literatures, but rather have a beneficial effect on human cognition.

In the future, researchers need to draw on these prior studies to further explore whether emotional false memories, as false memories more generally, have a possible positive effect on cognition and emotion. Based on the consistent findings that negative information generated more false memories than did positive or neutral information, it is possible that CRAT problems that are primed by the DRM lists with negative valence will be solved more often and faster than problems that are primed by the DRM lists with positive or neutral valence because the greater semantic density of negative lists allows the associative links among negative studied words to spread more easily to negative critical lures (Howe, 2007; Howe, Candel, et al., 2010), which are the solutions to the CRAT problems. In addition, mood, as a source of activation, may aid the encoding and retrieval of mood-congruent information. Therefore, it is necessary to consider the nature of information as the solutions to the CRAT problems in terms of whether it is mood-congruent or mood-incongruent.

We now know a considerable amount about spontaneous false memories generated by the DRM paradigm, and the developmental reversal effect in DRM false memories. Only a few studies, however, have attempted to investigate spontaneous false memories using other

paradigms (e.g., spontaneous false memories evoked by other material, such as stories, pictures, videos, etc.), or explored developmental trends in different types of spontaneous false memories (Bookbinder & Brainerd, 2017; Dewhurst, Pursglove, & Lewis, 2007; Howe & Wilkinson, 2011; Otgaar, Howe, Peters, Sauerland, & Raymaekers, 2013; Otgaar, Verschuere, Meijer, & van Oorsouw, 2012). Using different materials to investigate spontaneous false memories is important because it provides an opportunity to understand the generalisability of spontaneous DRM false memories. Moreover, it helps us better understand the mechanisms behind the development of spontaneous false memories. In other words, if it is true that developmental reversals in spontaneous false memories are due to gist extraction (as suggested by FTT) or associative activation (as suggested by AAT), then a similar developmental trend should be observed across studies using different materials, or the developmental pattern should vary in predictable ways based on the tenets of AAT and FTT. In one study, for example, Dewhurst et al. (2007) designed several stories in which a DRM word list was included in each of the stories. Dewhurst et al. believed that would presenting stories with DRM word lists would make the themes or gist of the lists more obvious than presenting DRM word lists alone. According to AAT and FTT, children would benefit from this manipulation more than adults, whose associative networks are more established. Thus, Dewhurst and colleagues predicted that the developmental reversal effect would be reduced or even eliminated with the use of story contexts. In line with their prediction, younger children (5-year-olds) indeed yielded *more rather than less* spontaneous false memories than did older children (8- and 11-year-olds).

In another study, Otgaar et al. (2013) induced children's and adults' spontaneous false memories using DRM word lists and videos. Just like stories, Otgaar et al. believed that the themes of the video stimuli would be more obvious than those of DRM word lists, thus developmental reversals would be reduced when videos were used as false memory stimuli.

Moreover, Otgaar and colleagues considered the emotional valence of to-be-remembered information. They predicted that false memories would be more produced for the negative than for the neutral information, regardless of the type of false memory stimuli. Finally, Otgaar et al. were interested in the relation between two types of spontaneous false memories generated by the DRM word lists and generated by videos, respectively.

In their study, children (6-8-year-olds), adolescents (10-12-year-olds), and young adults were provided with negative and neutral DRM lists, as well as neutral, negative and positive videos in which certain key elements (themes) were removed, but were later presented during the recognition task. The order of the presentation of the DRM word lists and videos was counterbalanced. Otgaar et al. found that, when using the DRM paradigm, the developmental reversal effect was found in spontaneous false memories. When using the video false memory paradigm, however, the developmental reversal effect was eliminated; children exhibited more false recognition than did adults. As for false memory differences as a function of varying emotional stimuli, false memories generated by different paradigms showed different patterns. For DRM word lists, negative lists produced *more* false recognition than did neutral lists, whereas for videos, negative videos yielded *less* false recognition than did positive or neutral videos. Otgaar et al. argued that the new finding — negative videos reduced false recognition compared to positive or neutral videos — might be due to distinctiveness; the negative video about the street fight might be much more distinctive than the positive or the neutral video, increasing item-specific processing. According to FTT, unrepresented information is better discriminated from presented information by item-specific processing, thereby reducing false memories.

Finally, Otgaar and colleagues computed Pearson's correlations to examine the possible relation between spontaneous false memories generated by the DRM word lists and those generated by the videos. For each age group, spontaneous false memories elicited by

the DRM word lists were positively correlated with spontaneous false memories elicited by the videos. This finding suggests that, in spite of opposing developmental patterns, different types of spontaneous false memories may share similar mechanisms. Taken together, extant data on different types of spontaneous false memories generated by various material are limited. Much work is needed to replicate and extend the existing studies, and to further investigate how emotional content and moods influence spontaneous false memories that are produced by different false memory stimuli.

Although I have primarily focused on spontaneous false memories that arise because of internal processes, such as gist extraction or associative activation, a great deal of evidence has shown that false memories can also be elicited by explicit suggestions (i.e., misinformation). Research of this kind usually uses the misinformation paradigm where participants initially experience an event, then receive postevent misinformation, and finally complete a memory test (Loftus & Hoffman, 1989; also see relevant studies reviewed in Chapter 1). Explanations for the misinformation effect range from retroactive interference, which stipulates that people make memory errors for the original information because of interference from the newly postevent information (e.g., Loftus, 1979), to memory trace impairment, in which postevent misinformation impairs access to the memory trace of the original event itself (e.g., Brainerd & Reyna, 2005). The most widely supported explanation for misinformation false memories, however, is based on a source monitoring framework (Johnson et al., 1993). According to this framework, the misinformation effect is due to source monitoring errors; people wrongfully attribute the misinformation that is provided externally to their own memory of the original information that is generated internally. It is this misattribution that results in the creation of false memories in the misinformation paradigm (e.g., Loftus, 2003; MacLeod & Saunders, 2008; Okado & Stark, 2005; Otgaar & Candel, 2011; Otgaar et al., 2013; Stark, Okado, & Loftus, 2010; Zhu, Chen, Loftus, Lin, &

Dong, 2013). Because the ability to monitor the source of a memory develops significantly from early childhood to young adulthood (Lindsay, Johnson, & Kwon, 1991), adults are less likely to make memory errors than children in the misinformation paradigm, showing *an age-related decrease* in misinformation false memories. This developmental pattern has been extensively supported in the literature (for reviews, see Brainerd & Reyna, 2005; Ceci & Bruck, 1993).

Although the difference between DRM and misinformation false memories is obvious — one is elicited by internal processes, while the other is elicited by external suggestion, there have been some studies examining the relation between the two types of false memories given that both of them may involve one cognitive process — source monitoring (e.g., Ost et al., 2013; Otgaar & Candel, 2011; Otgaar et al., 2012; Wilkinson & Hyman, 1998; Zhu et al., 2013). Mixed findings, however, have been found in this line of research; a significant positive correlation between DRM and misinformation false memories has been found in some studies (e.g., Otgaar et al., 2012; Zhu et al., 2013), whereas this relation has not been replicated in other studies (e.g., Ost et al., 2013; Otgaar & Candel, 2011; Wilkinson & Hyman, 1998). One possible explanation for the mixed results is the different manipulations conducted in different studies. For example, the misinformation task was presented prior to the DRM task in Zhu et al. (2013), but the misinformation task was interrupted by the DRM task which was regarded as an filler task in Ost et al. (2013). Another possibility is the emotional nature of the to-be-remembered information used in the misinformation and DRM tasks. Three sub-points are worth considering here and in future studies. First, in no single study has the emotional valence and arousal of the material (e.g., events) used in the misinformation task been carefully assessed. For example, the event reported in Zhu et al. (2013) involved a man stealing things from a car. On the surface, this event should be treated as negative. Without a standardised assessment procedure, however, it is impossible to know

how negative the event is or the degree of emotional activation elicited by the event (i.e., emotional arousal). Moreover, we have no idea whether the emotional content of the to-be-remembered information, either its emotional valence or emotional arousal, would influence false memories in the misinformation paradigm. Despite many studies investigating the effect of emotional content on false memories by means of the DRM paradigm, only a few studies have used the misinformation paradigm (Porter, Bellhouse, McDougall, Ten Brinke, & Wilson, 2010; Porter, Spencer, & Birt, 2003; Van Damme & Smets, 2014). A consistent finding of these studies is that susceptibility to false memories due to misinformation was greater for negative than for positive or neutral events, which is consistent with DRM findings. More importantly, this effect depends on the nature of misinformation in terms of whether it is centrally-related or peripherally-related to the original information. Evidence has shown that when the misinformation was peripherally-related, negative events generated more false memories than did positive or neutral events. In contrast, when the misinformation was centrally-related, there was no valence effect on misinformation false memories (e.g., Van Damme & Smets, 2014). Finally, speaking of the valence of emotional content, it is necessary to keep the valence of DRM word lists and that of events the same, especially when comparing false memories elicited by these two types of material. Unfortunately, in no single published study have researchers considered this point, leaving considerable room for future studies. In sum, much work remains to be done in terms of comparing DRM and misinformation false memories, and investigating the effect of emotional content on false memories elicited by the DRM and misinformation paradigms.

In addition to the emotional nature of the to-be-remembered information, the effect of the emotional state of rememberers on DRM and misinformation false memories warrants further investigation for at least three reasons. First, prior research regarding how negative and positive moods influence false memories in the DRM paradigm has shown contradictory

findings. Some researchers have found that, compared to neutral moods, negative moods reduce false memories, while positive moods increase false memories (e.g., Storbeck & Clore, 2005; 2010). Other researchers have not reported this pattern, but rather found that positive moods yielded fewer, rather than more, false memories than did neutral moods (e.g., Zhang et al., 2017b). Zhang et al. argued that the mixed findings are likely due to differences in arousal levels across studies; when controlling the arousal level of positive, negative and neutral moods, positive moods would not increase false memories, but instead reduce false memories in the DRM paradigm. Future studies are needed to replicate Zhang et al.'s study and further test their assumption.

Likewise, how negative and positive moods influence false memories in the misinformation paradigm is not clear because of contradictory theories and findings included in the literature. Some researchers have found that people in positive moods are more vulnerable to incorporating misinformation into their memory, thus establishing more misinformation false memories than people in negative moods. This finding may occur because of the heuristic processing mode of positive moods, which may help to notice a broad range of stimuli, thus allowing people to confuse information that was presented with similar information that was not presented (e.g., Forgas, Laham, & Vargas, 2005; Levine & Bluck, 2004). Other researchers, on the other hand, have argued that negative moods signal the need to focus on problems, narrowing people's attention to problem-related information (i.e., central information) at the expense of peripheral details. Thus, negative moods would increase false memories for peripheral information in the misinformation paradigm (e.g., Berntsen, 2002; Van Damme & Smets, 2014; Waring & Kensinger, 2009).

It is possible to reconcile these different accounts and findings in future studies by considering the nature of to-be-processed information in terms of whether it is centrally-related or peripherally-related. In addition, it is of interest to consider both the emotional

nature of to-be-processed information as well as rememberers' mood in a single study. As described earlier, misinformation false memories are due to source monitoring errors. And moods have been found to impede monitoring of mood-congruent information (see Chapter 8). Therefore, it is likely that more source monitoring errors would be made for mood-congruent information than for mood-incongruent information in a corresponding mood state. In other words, misinformation false memories would be higher for positive than for negative or neutral information in positive moods, and misinformation false memories would be higher for negative than for positive or neutral information in negative moods. This specific hypothesis remains to be tested.

Second, moods have been found to influence developmental reversals in DRM false memories. More specifically, developmental reversals were eliminated for all information in positive moods, but developmental reversals were maintained for negative information in negative moods (Zhang et al., 2017b). This finding supported AAT with regards to the mechanism underlying developmental reversals in DRM false memories, as described in Chapter 7. Importantly, this finding reflected that positive moods facilitate a relatively automatic processing mode (i.e., heuristic), whereas negative moods promote a systematic processing mode. It is very likely that a relatively automatic processing mode would impair monitoring of memory, which would influence adults much more than children as adults have better monitoring abilities than do children. Thus, source monitoring errors would increase more in adults than in children. As a result, adults would show similar, or even greater misinformation false memories than would children in positive moods. That is, an age-related decline in misinformation false memories would be reduced, or even eliminated, in positive moods. In contrast, a systematic processing mode which needs much cognitive effort would not impair monitoring of memory. Given that monitoring ability is still greater in adults than

in children, an age-related decline in misinformation false memories would be maintained in negative moods.

Finally, it is important to note that in my thesis and most of the studies reviewed so far, mood is generally distinguished in terms of its valence, either positive or negative, which may neglect potential effects of discrete emotions on false memories in the DRM and misinformation paradigms. Recently, some investigators have examined the effect of discrete emotions on false memories in the DRM paradigm (Bland et al., 2016). Instead of using general negative or positive moods, Bland and colleagues induced a specific mood, either fear or anger, and provided participants with fear-related, anger-related, and neutral word lists. A mood-congruent false memory effect was found; false memories were more likely to be elicited for fear-related lists in the fear mood state, and false memories were more likely to be elicited for anger-related lists in the anger mood state.

This is a good start, but much work is needed in the future. For example, research is sparse on how the goals and motivations associated with specific moods affect false memories in the misinformation paradigm, but it is possible to make specific predictions in this respect by drawing on relevant research. When considering the goals and motivations associated with specific moods, specific moods can be divided into pregoal and postgoal moods (Kaplan, Van Damme, Levine, & Loftus, 2016; Montagrin, Brosch, & Sander, 2013). Pregoal moods include desire, hope, anger, fear, and disgust, which are characterised by high motivational intensity. When experiencing pregoal moods, people's attention narrows to information that is central to their goals at the expense of peripheral details (Kaplan, Van Damme, & Levine, 2012; Kaplan et al., 2016). Thus, it is predicted that greater vulnerability to misinformation concerning those details would occur in pregoal moods. In contrast, postgoal moods include happiness and sadness, which are characterised by low motivational intensity because their occurrence reflects the fact that the goal has already been reached or

not. When experiencing postgoal moods, people's attention broadens to all kinds of information no matter whether it is central or peripheral to their goal, allowing peripheral details to be processed (Kaplan et al., 2012; Kaplan et al., 2016). Thus, it is likely that lower vulnerability to misinformation concerning those details would occur in postgoal moods.

### **Final Summary**

In the present thesis, I initially compiled emotional DRM word lists, which did not differ in level of arousal and BAS values while every word on a particular list shared the same valence with the corresponding critical lure. Using these normed emotional DRM word lists, I investigated the effect of emotional content and emotional state on false memories, the age-related changes in emotional false memories, and whether adults' and children's emotional false memories could be reduced by warnings or directed forgetting, respectively. Generally, I found that negative lists elicited more false memories than did positive or neutral lists. This pattern could be strengthened by participant' negative moods, showing a negative mood-congruent false memory effect. Furthermore, the age-related differences in false memories occurred as a function of emotional content and participant' mood; positive moods eliminated the typical age-related increase in false memories for all kinds of information, while negative moods maintained the increase for negative information. Warnings and directed forgetting generally reflected the opposite effects on emotional true and false memories; warnings reduced emotional false memories, but had no effect on emotional true memories. In contrast, directed forgetting reduced emotional true memories, but had no effect on emotional false memories.

Both associative theories and FTT account for some of the findings, but no single one can explain all of the phenomena. In fact, I believe that associative theories and FTT are not mutually exclusive; FTT could be further supplemented by associative theories to explain how the gist information is mentally generated in mind, while associative theories could be

supplemented by FTT to explain why the same factor can have different impacts on true and false memories. In the future, additional work is needed in order to understand the interaction between emotion and false memories. Three research directions would add to this understanding: (1) investigating the positive and adaptive roles of emotional false memories on cognition and emotion; (2) examining the effect of emotion on spontaneous false memories that are produced by different paradigms; and (3) exploring susceptibility to false memories due to misinformation as a function of the nature of misinformation (e.g., emotional valence or centrally-or-peripherally-related to the original information) and participants' mood. In sum, research regarding the interaction between emotion and false memories is still in its infancy, leaving much room for future studies to keep exploring this research field.

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## Appendix A1

### Study factors that influence the magnitude of false memories in the DRM paradigm

Author(s)	Factor	Participants	Main manipulation(s)	Main finding(s)
McEvoy, Nelson, & Komatsu (1999)	Expt. 1: BAS variations	University students	2 experimental list groups: <ul style="list-style-type: none"> <li>• 24 lists with high BAS</li> <li>• 24 lists with relatively low BAS</li> </ul>	<ul style="list-style-type: none"> <li>• False recall and corrected false recognition rates were significantly higher when BAS from the presented words to the critical lure was high than when BAS was low.</li> </ul>
Gallo & Roediger (2002)	Expt. 1: BAS variations	University students	28 word lists: <ul style="list-style-type: none"> <li>• 1 list from Stadler et al. (1999)</li> <li>• 7 lists from Deese (1959)</li> <li>• 12 lists from the Russell and Jenkins norms</li> <li>• The authors believed that these 20 lists would yield relatively low level of false recall</li> <li>• The remaining 8 lists were chosen from Stadler et al.'s (1999) norms</li> </ul>	<ul style="list-style-type: none"> <li>• As expected, the 20 lists yielded very low levels of false recall: the mean false recall rate was only .10, whereas true recall did not differ across lists.</li> <li>• Positive correlation between the current norms and previous ones (.90)</li> <li>• Positive correlation between false recall and BAS (.49)</li> <li>• Like false recall, lists with low BAS tended to yield lower false recognition.</li> </ul>
Brainerd & Wright	BAS variations	University students	<ul style="list-style-type: none"> <li>• 16 lists; every four lists were</li> </ul>	<ul style="list-style-type: none"> <li>• The false recognition rate for</li> </ul>

(2005)			<p>possessed with high/low BAS and high/low FAS</p> <ul style="list-style-type: none"> <li>• S's listened to an audio recording of all 16 lists, and then they had 2 min to read instructions of the conjoint-recognition</li> </ul>	<p>critical lures increased when either BAS or FAS increased.</p> <ul style="list-style-type: none"> <li>• The effects of BAS and FAS on false recognition were comparable but were independent of each other.</li> </ul>
Howe, Wimmer, Gagnon, & Plumpton (2009)	Expt. 1: BAS variations	<p>5- to 11-year-old children</p> <p>University students</p>	<p>Presented with:</p> <ul style="list-style-type: none"> <li>• 4 high BAS/high FAS lists</li> <li>• 4 high BAS/low FAS lists</li> <li>• 4 low BAS/high FAS lists</li> </ul>	<ul style="list-style-type: none"> <li>• Although FAS was important, especially for DRM lists, the age-related changes were driven mainly by BAS.</li> <li>• False recall was positively related to BAS, regardless of whether those lists were DRM or category, whereas true recall was negatively related to BAS.</li> </ul>
Knott, Dewhurst, & Howe (2012)	Expt. 1 & 2: BAS variations	University students	<p>Expt. 1:</p> <p>Two sets of lists; 16 typical DRM and 16 category:</p> <ul style="list-style-type: none"> <li>• 4 high BAS/high connectivity</li> <li>• 4 high BAS/low connectivity</li> <li>• 4 low BAS/high connectivity</li> <li>• 4 low BAS/low connectivity</li> </ul> <p>BAS and connectivity were within-subjects factors</p>	<ul style="list-style-type: none"> <li>• Lists with high BAS but low connectivity produced the highest level of false recall and recognition, regardless of list type.</li> <li>• Connectivity was more important than BAS for true recall and recognition.</li> </ul>

			<p>Expt. 2: Lists were the same as those in Expt. 1; BAS and connectivity were between-subjects factors</p> <p>Stem completion task; 28 stems, with four of the stems corresponding to the critical lures that were related to the studied lists</p>	<ul style="list-style-type: none"> <li>• An indirect priming effect was found for DRM lists regardless of BAS or connectivity: stems were more likely to be completed by critical lures related to the studied lists than those associated with unstudied lists.</li> <li>• Only when category lists had high BAS, did an indirect priming effect occur.</li> </ul>
Robinson & Roediger (1997)	List length	Adults	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• 4 lists of each list length: 0, 3, 6, 9, 12, or 15 words, respectively</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• List length kept constant but the number of associated words was varied</li> </ul>	<ul style="list-style-type: none"> <li>• True recall decreased and false recall increased, with increasing list length.</li> <li>• Although list length was controlled across lists, with increasing the number of associations, true recall decreased but false recall increased.</li> </ul>
Sugrue & Hayne (2006)	List length	<p>9- and 10-year-old children</p> <p>University students</p>	<ul style="list-style-type: none"> <li>• Varied list length: 7 or 14 words</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of long lists on false recall was more significant for adults than for children: a 127% increase in adults' false recall vs 48% increase in children's false recall</li> </ul>

				<ul style="list-style-type: none"> <li>Adults had higher false recognition rates than did children but only in the long-list condition, not in the short-list condition.</li> </ul>
Sugrue, Strange, & Hayne (2009)	List length	10-year-old children University students	<ul style="list-style-type: none"> <li>Varied list length: 7 or 14 words</li> <li>S's reported any words that they had thought about but had not reported</li> </ul>	<ul style="list-style-type: none"> <li>Regardless of age, S's recalled more critical lures in the long-list condition than in the short-list condition.</li> <li>Long lists were more likely to activate critical lures than were short lists.</li> </ul>
Howe, Wimmer, Gagnon, & Plumpton (2009)	Expt. 2: List length	5- and 11-year-old children University students	<ul style="list-style-type: none"> <li>Removal of the strongest BAS word or several of the weakest BAS words in a list to vary list length while keeping BAS constant</li> </ul>	<ul style="list-style-type: none"> <li>Intact lists elicited more false recall than did either the strong-item-removed lists or the weak-items-removed lists.</li> <li>List length was not the decisive factor that results in false recall, compared to BAS.</li> </ul>
Seamon, Luo, & Gallo (1998)	Presentation rate	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>Between-subjects design</li> <li>2s, 250ms, or 20ms per word with a concurrent memory load ("remember a 7-digit sequence") or no concurrent load</li> </ul>	<ul style="list-style-type: none"> <li>S's recognised critical lures (.18) even when they had difficulty recognising studied words (.12)</li> <li>The memory load task reduced both true and false memory, while presentation rate only</li> </ul>

			<p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• Within-subjects design</li> <li>• 2s or 20ms per word; with or without a memory load</li> </ul>	<p>affected true memory</p> <ul style="list-style-type: none"> <li>• False recognition also occurred when list words were presented at a rate of 20ms.</li> <li>• For the 2-s exposure condition, true recognition exceeded false recognition, whereas for the 20ms exposure condition, the reverse was true.</li> <li>• There was no effect of memory load on true or false memory.</li> </ul>
McDermott & Watson (2001)	Presentation rate	University students	<ul style="list-style-type: none"> <li>• Five presentation rates: 20, 250, 1000, 3000, or 5000ms per word</li> <li>• Two types of list: semantic vs phonological</li> </ul>	<ul style="list-style-type: none"> <li>• For semantically-related lists, false recall increased when the presentation rate was short (20 or 250ms per word). In contrast, false recall declined when longer presentation rate was manipulated (1000, 3000, or 5000ms).</li> <li>• For phonologically-related lists, the pattern was different; false recall was high at the fastest duration and decreased when duration lengthened.</li> </ul>
Gallo & Roediger (2002)	Expt.2: presentation	University students	<ul style="list-style-type: none"> <li>• Three presentation rates: 0.5, 1, or 3s per word</li> </ul>	<ul style="list-style-type: none"> <li>• False recall and recognition decreased while true recall</li> </ul>

	rate			increased with slower presentation rates.
Seamon et al. (2002)	Presentation rate	University students	<ul style="list-style-type: none"> <li>• Two presentation rates: 2s or 5s per word</li> <li>• Half of the S's rehearsed silently while the other half rehearsed overtly by reporting any word coming to mind</li> </ul>	<ul style="list-style-type: none"> <li>• Increasing the presentation rate enhanced true recall, but did not influence false recall or false recognition.</li> <li>• S's in the 5s-presentation condition rehearsed more studied words and critical lures than did those in the 2s-presentation condition.</li> </ul>
Smith & Hunt (1998)	Presentation modality	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Ten 5-word lists were presented either visually or aurally.</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• Six 12-word lists were presented either aurally or visually</li> </ul> <p>Expt. 3:</p> <ul style="list-style-type: none"> <li>• Lists and procedure were the same as those in Expt. 2, but in Expt. 3, half of S's made pleasantness ratings for each studied word</li> </ul>	<ul style="list-style-type: none"> <li>• True recall was not affected by presentation modality, but false recall was reduced following visual presentation of the lists relative to aural presentation.</li> <li>• Consistent with Expt.1, false recognition was higher following aural than visual presentation.</li> <li>• Regardless of instructional conditions, false recall was higher following aural compared to</li> </ul>

				<p>visual presentation.</p> <ul style="list-style-type: none"> <li>• Regardless of presentation modality, false recall was lower in the pleasantness rating condition.</li> </ul>
Kellogg (2001)	Expt.1: presentation modality	University students	<ul style="list-style-type: none"> <li>• List words were presented either visually or aurally</li> <li>• S's wrote or spoke the words they just read or heard</li> </ul>	<ul style="list-style-type: none"> <li>• False written recall was lower following visual compared to aural presentation.</li> <li>• This modality effect was eliminated when spoken recall was conducted.</li> </ul>
Gallo, McDermott, Percer, & Roediger (2001)	Presentation modality	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Between-subjects design</li> <li>• List words were presented either visually or aurally</li> <li>• S's did either a free recall test or math problems before a final recognition test.</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• Study and test modality were manipulated within-subjects</li> </ul>	<ul style="list-style-type: none"> <li>• Auditory presentation resulted in more false recall and false recognition than did visual presentation.</li> <li>• The modality effects on the recognition test were not as large as those found in previous studies.</li> <li>• The effect of study modality on false recognition was found: false recognition was greater following auditory than visual study.</li> <li>• The modality effect was not</li> </ul>

			<p>Expt. 3:</p> <ul style="list-style-type: none"> <li>• Study and test modality were manipulated between-subjects.</li> </ul>	<p>found when critical lures were aurally tested.</p> <ul style="list-style-type: none"> <li>• More false recognition resulted from auditory study than visual study.</li> <li>• S's made more false recognition when the study modality was consistent with the test modality.</li> </ul>
Cleary & Greene (2002)	Presentation modality	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Lists were presented aurally, visually, or S's read out the list words loudly</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• Same presentation conditions as in Expt 1, except that all of the list words were presented twice</li> </ul>	<ul style="list-style-type: none"> <li>• False recall and recognition were higher following auditory study than visual study.</li> <li>• The level of false recall and recognition was similar in read-aloud group with that in standard visual presentation group.</li> <li>• False recall and recognition were higher for S's in the auditory condition than for S's in the visual and read-aloud conditions.</li> </ul>
Toglia, Neuschatz, & Goodwin (1999)	Expt. 1: level of processing	University students	<p>2 encoding conditions:</p> <ul style="list-style-type: none"> <li>• Semantic encoding: S's rated each word for pleasantness</li> <li>• Non-semantic encoding: S's made</li> </ul>	<ul style="list-style-type: none"> <li>• About half the S's recalled at least one critical lure. Most of the errors were semantic.</li> </ul>

			yes/no decision on whether each word contained the letter “a”	<ul style="list-style-type: none"> <li>S’s in the semantic encoding condition had higher true and false recall than did those in the non-semantic encoding condition.</li> </ul>
Rhodes & Anastasi (2000)	Level of processing	University students	<p>Expt. 1:</p> <p>2 encoding conditions:</p> <ul style="list-style-type: none"> <li>Shallow-level-of-processing: count and write down the number of vowels in each word</li> <li>Deep-level-of-processing: visualize each word and make a concrete/abstract rating</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>The shallow-level task was the same as Expt1, but the deep-level-of-processing was changed to a category sorting task.</li> </ul>	<ul style="list-style-type: none"> <li>S’s in the deep-level-of-processing condition recalled more studied words and critical lures than did those in the shallow-level-of-processing condition.</li> <li>Consistent with Expt. 1, S’s in the deep-level-of-processing condition again recalled more studied words and critical lures than those in the shallow-level-of-processing condition.</li> </ul>
Thapar & McDermott (2001)	Level of processing	University students	<p>Expt. 1: recall test</p> <p>Expt. 2: recognition test</p> <p>3 encoding conditions:</p> <ul style="list-style-type: none"> <li>Write the number corresponding to the pleasantness rating of the word</li> </ul>	<ul style="list-style-type: none"> <li>The pattern was the same in Expts 1 and 2; deep processing (semantically processed lists) led to more true and false recall and recognition than did shallow</li> </ul>

			<ul style="list-style-type: none"> <li>• Write the number corresponding to the number of vowels in the word</li> <li>• Write the name of the colour in which the word appeared</li> </ul>	processing (superficially processed lists).
Perez- Mata, Read, & Diges (2002)	Divided attention	University students	<p>Expt.1:</p> <ul style="list-style-type: none"> <li>• List type: abstract vs concrete</li> <li>• Attention condition: full vs divided</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• S's saw each list alone, or while monitoring an auditory shadowing task</li> </ul>	<ul style="list-style-type: none"> <li>• Abstract lists yielded more false recall than concrete lists.</li> <li>• S's in the divided attention condition had higher false recall rates than did those in the full attention condition.</li> <li>• Divided attention led to less true recall than full attention.</li> <li>• False recall was higher with divided attention compared to full attention.</li> </ul>
Seamon et al. (2003)	Divided attention	University students	<ul style="list-style-type: none"> <li>• Expt. 1: 6 study-test trials, free recall test</li> <li>• Expt. 2: 5 study-test trials, recognition test</li> </ul> <p>In both experiments, four encoding conditions:</p>	<ul style="list-style-type: none"> <li>• Compared with true recall, false recall was significantly affected by encoding condition.</li> <li>• Conditions that focused attention on the studied words, such as by either writing each word or each word's second letter, reduced false recall, whereas the write</li> </ul>

			<ul style="list-style-type: none"> <li>• hear word</li> <li>• write word</li> <li>• write second letter</li> <li>• write number</li> </ul>	<p>number condition did not reduce false recall.</p> <ul style="list-style-type: none"> <li>• Encoding strategies and attention influenced false recognition and false recall similarly</li> </ul>
Dodd & MacLeod (2004)	Divided attention	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• S's instructed to ignore the word on the screen but to indicate its print colour</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• S's instructed to respond vocally to the word name but to ignore its display colour</li> </ul>	<ul style="list-style-type: none"> <li>• False memories occurred even when S's processed word lists unintentionally.</li> <li>• There was a dramatic increase in true recognition; however, false recognition to critical lures remained robust.</li> </ul>
Knott & Dewhurst (2007)	Divided attention	University students	<ul style="list-style-type: none"> <li>• List type: DRM vs categorised lists</li> <li>• Full vs divided attention (the random number generation task)</li> <li>• Divided attention was manipulated at study in Expt. 1, at test in Expt. 2</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of divided attention at encoding was the same for DRM and categorised lists.</li> <li>• Divided attention reduced false <i>remember</i> responses compared to full attention, regardless of list type.</li> <li>• Divided attention at retrieval increased false <i>remember</i> responses to critical lures but had</li> </ul>

				no effect on true <i>remember</i> responses.
Payne et al. (2002)	Stress	University students	<ul style="list-style-type: none"> <li>• 2 groups: stress vs non-stress</li> <li>• The Trier social stress test was used to elicit moderate psychological stress</li> </ul>	<ul style="list-style-type: none"> <li>• Stressed S's had significantly more false memories than did non-stressed S's, whereas their true memories were comparable.</li> <li>• True recognition for non-stressed S's exceeded their false recognition (78% vs 61%).</li> <li>• For the stress group, true recognition did not differ from false recognition (81% vs 77%).</li> </ul>
Wenzel et al. (2004)	Expt. 1: Stress	University students	<ul style="list-style-type: none"> <li>• 3 groups of S's: spider fearful, blood fearful, or non-fearful</li> <li>• 4 word lists: spider, blood, river, and music</li> </ul>	<ul style="list-style-type: none"> <li>• Fearful S's did not recall more threat-relevant studied words or threat-relevant critical lures compared to non-fearful S's.</li> </ul>
Smeets, Jelicic, & Merckelbach (2006)	Stress	University students	<ul style="list-style-type: none"> <li>• Stress vs control group</li> </ul>	<ul style="list-style-type: none"> <li>• The magnitude of false memories did not differ between the two groups.</li> </ul>
Smeets et al. (2008)	Stress	University students	<ul style="list-style-type: none"> <li>• 4 groups: encoding stress, consolidation stress, retrieval stress or no-stress control group</li> <li>• List valence: emotional vs neutral</li> </ul>	<ul style="list-style-type: none"> <li>• S's in the consolidation stress group had greater true memories, whereas those in the retrieval stress group had lower true memories compared to the other groups, especially for emotional</li> </ul>

				<p>lists.</p> <ul style="list-style-type: none"> <li>• Neither emotional nor neutral false recall was affected by any stress exposure.</li> </ul>
Quas et al. (2016)	Stress	<p>7- to 8-year-old children</p> <p>12-14-year-old adolescents</p>	<ul style="list-style-type: none"> <li>• Two versions of the Trier Social Stress Test-Modified (TSST-M): high or low stress</li> <li>• List valence: neutral, negative, or positive</li> </ul>	<ul style="list-style-type: none"> <li>• Adolescents in high-stress group had better true memories than did adolescents in the low-stress group, whereas children's accuracy did not differ as a function of stress conditions.</li> <li>• Increases in S's cortisol responses were only related to greater true memories but not false memories for positive emotional words.</li> </ul>

## Appendix A2

### Test factors that influence the magnitude of false memories in the DRM paradigm

Author(s)	Factor	Participants	Main Manipulation(s)	Main Finding(s)
McDermott (1996)	Expt. 1: Retention interval	University students	<ul style="list-style-type: none"> <li>• An immediate free recall test after learning each list</li> <li>• Two days later, final recall test</li> </ul>	<ul style="list-style-type: none"> <li>• The false recall rate remained and even exceeded the true recall rate after 2 days.</li> </ul>
Toglia, Neuschatz, & Goodwin (1999)	Expt. 2: Retention interval	University students	<ul style="list-style-type: none"> <li>• 3 retention interval conditions: immediate, after one week, or after three weeks</li> </ul>	<ul style="list-style-type: none"> <li>• S's in the immediate testing condition recalled more studied words than those in the longer retention interval conditions.</li> <li>• Retention interval had no effect on false recall of critical lures.</li> </ul>
Lampinen & Schwartz (2000)	Retention interval	University students	Expt. 1: <ul style="list-style-type: none"> <li>• Immediate vs after 48 hours</li> </ul>	<ul style="list-style-type: none"> <li>• Uncorrected true recognition declined more significantly than uncorrected false recognition.</li> <li>• Corrected true and false recognition decreased by equivalent amounts across 48 hours.</li> </ul>

			<p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• A further R/K judgment for all words S's recognised</li> </ul>	<ul style="list-style-type: none"> <li>• For uncorrected data, there was a reliable decline for false R after 48 hours. But this pattern was not significant for corrected data.</li> </ul>
Thapar & McDermott (2001)	Retention interval	University students	<ul style="list-style-type: none"> <li>• 3 retention interval conditions: immediate, 2-day delay, and 7-day delay</li> <li>• Expt. 1: recall test Expt. 2: recognition test</li> </ul>	<ul style="list-style-type: none"> <li>• Regardless of test type, false memories decreased across retention interval.</li> <li>• The decline in false memories was not as significant as that for true memories.</li> </ul>
Seamon et al. (2002)	Retention interval	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• 3 conditions: no delay, a 2-week delay, or a 2-month delay</li> </ul> <p>Expt. 2: 2-day delay.</p>	<ul style="list-style-type: none"> <li>• True recall decreased faster than did false recall.</li> <li>• False recall after a 2-week delay was as strong as it was after an immediate test.</li> <li>• True and false recognition decreased over retention interval.</li> <li>• False recognition was only marginally more persistent than true recognition.</li> </ul>
Howe et al. (2010)	Expts 3-5: Retention	Expt. 3: Young adults	<ul style="list-style-type: none"> <li>• Recognition test: immediate vs 1-week later</li> </ul>	<ul style="list-style-type: none"> <li>• True and false recall was greater for neutral lists than</li> </ul>

	interval	<p>Expt. 4: 5- and 8-year-olds</p> <p>Expt. 5: 7- and 11-year-olds</p>	<ul style="list-style-type: none"> <li>List valence: negative vs neutral</li> </ul>	<p>for negative lists.</p> <ul style="list-style-type: none"> <li>For neutral lists, true recognition decreased but false recognition did not change significantly across the retention interval.</li> <li>For negative lists, false recognition increased and true recognition decreased across the retention interval.</li> <li>For both younger and older children, the pattern was the same: their true memories declined with time but their false memories remained stable for neutral information, and even increased for negative information over a 1-week delay.</li> </ul>
Knott & Thorley (2014)	Retention interval	University students	<ul style="list-style-type: none"> <li>Mood condition: negative vs neutral</li> <li>List valence: negative vs neutral</li> <li>Recognition test: immediate vs 1-week later</li> </ul>	<ul style="list-style-type: none"> <li>Regardless of immediate or one-week later test, S's in negative mood were more likely to remember negative critical lures than neutral critical lures.</li> </ul>

Brainerd & Reyna (1998)	Expts 1 & 2: Test instructions	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• 2 conditions: standard recognition test vs meaning recognition test: accept all words that were consistent with list themes.</li> </ul> <p>Expt. 2: 5 types of test words</p> <ul style="list-style-type: none"> <li>• Studied words</li> <li>• List-associate distractors</li> <li>• Missing-exemplar distractors</li> <li>• Critical lures</li> <li>• Additional distractors</li> </ul>	<ul style="list-style-type: none"> <li>• For the standard recognition test, false recognition rates were the same as true recognition rates, whereas for the meaning recognition test, false recognition rates were higher than true recognition rates.</li> <li>• In standard recognition, true and false recognition rates for studied words and critical lures did not differ but were higher than false recognition rates for other distractors.</li> <li>• In meaning recognition, false recognition rates for critical lures were higher than true recognition and others.</li> </ul>
McKelvie (1999)	Test instructions	University students	<ul style="list-style-type: none"> <li>• 2 conditions: free recall vs forced recall (i.e., fill all recall spaces)</li> </ul>	<ul style="list-style-type: none"> <li>• Forced instructions increased false recall for critical lures but not true recall for studied words.</li> </ul>
McKelvie (2001)	Test instructions	University students	<ul style="list-style-type: none"> <li>• 2 conditions: free retrieval vs</li> </ul>	<ul style="list-style-type: none"> <li>• False recall and recognition</li> </ul>

			<p>forced retrieval</p> <ul style="list-style-type: none"> <li>Rated each recalled word for confidence using 6-point scale</li> </ul>	<p>were higher with forced than with free retrieval instructions.</p> <ul style="list-style-type: none"> <li>Confidence was lower with forced than with free retrieval instructions for only false recall but not for false recognition.</li> </ul>
Brainerd, Wright, Reyna, & Mojardin (2001)	Expts 1 & 2: Test instructions	University students	<p>Expt. 1: three conjoint recognition conditions:</p> <ul style="list-style-type: none"> <li>V condition: S's only accepted studied words</li> <li>M condition: S's only accepted meaning-related words</li> <li>VM condition, S's accepted studied words and meaning-related words</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>Studied words were presented either forward or backward order</li> <li>Adding a recall or math task</li> </ul>	<ul style="list-style-type: none"> <li>65% of false recognitions of critical lures in the V condition were based on phantom recollection.</li> <li>Critical lures and studied words were accepted at a similar rate across three conditions, and other related lures were accepted more often in the M and VM condition compared to V condition.</li> <li>Manipulation presentation order decreased true recognition rates after recall and increased the rates after</li> </ul>

			before doing the conjoint recognition	<p>math problems.</p> <ul style="list-style-type: none"> <li>• Critical lures were more likely to be accepted in V condition than in M condition.</li> <li>• The false recognition rate for critical lures was higher than the true recognition rate for studied words in V condition.</li> </ul>
Seamon, Luo, Shulman, Toner, & Caglar (2002)	Test instructions	University students	<ul style="list-style-type: none"> <li>• 8 vs 12 word lists</li> <li>• Instructions: remember-remember vs forget-remember</li> </ul>	<ul style="list-style-type: none"> <li>• S's in remember-remember group recalled more studied words than those in forget-remember group.</li> <li>• Directed forgetting instructions had no effect on false recall of critical lures.</li> </ul>
Bauml & Kuhbandner (2003)	Test instructions	University students	<p>Expt. 1: recall the words under 3 conditions</p> <ul style="list-style-type: none"> <li>• A standard free recall condition</li> <li>• A part-list cuing condition</li> <li>• A retrieval practice condition</li> </ul>	<ul style="list-style-type: none"> <li>• Retrieval practice and part-list cuing decreased recall of critical lures.</li> <li>• Low false-recall levels corresponded to larger effects of retrieval practice and part-list cuing, while high false-recall levels were</li> </ul>

			<p>Expt 2:</p> <ul style="list-style-type: none"> <li>• The same as Expt.1 but here the critical lures were not part of the studied lists</li> </ul>	<p>accompanied by no effects of retrieval practice and part-list cuing.</p> <ul style="list-style-type: none"> <li>• Retrieval practice and part-list cuing induced the same qualitative and quantitative effects on recall.</li> <li>• Part-list cuing and retrieval practice reduced false recall of critical lures.</li> </ul>
Starns & Hicks (2004)	Test instructions	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Studied word lists in the form of paired associates</li> <li>• Retrieval practice for half of the words, from half of the lists.</li> </ul> <p>Expt. 2:</p> <ul style="list-style-type: none"> <li>• Cued-recall test</li> </ul>	<ul style="list-style-type: none"> <li>• There was a reduction in the level of false recognition for list themes that received retrieval practice.</li> <li>• Recognition rates were lower for all U-P words (words that were not individually practiced but were from, or related to practiced lists) related to the list theme.</li> <li>• Consistent with Expt.1, retrieval-induced forgetting was found for both true and</li> </ul>

				false memories in the form of cued recall.
Reysen & Nairne (2002)	Part-list cuing	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Free recall vs cued recall</li> </ul> <p>Expt. 2: 3 conditions</p> <ul style="list-style-type: none"> <li>• Free recall</li> <li>• Cued recall tests with random cues</li> <li>• Cued recall tests with the even numbered list words used as cues</li> </ul>	<ul style="list-style-type: none"> <li>• S's recalled more studied words and critical lures on free recall tests than on cued recall tests.</li> <li>• S's recalled more critical lures and studied words in the free recall condition than in either the consistent cue condition or the random cue condition.</li> </ul>
Kimball & Bjork (2002)	Expt. 2: Part-list cuing	University students	<p>3 manipulations:</p> <ul style="list-style-type: none"> <li>• Cuing (was or was not provided at test)</li> <li>• Number of cues (four or eight)</li> <li>• Cue associative strength (strongest or weakest associates)</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of part-list cuing was the same as that of directed forgetting in terms of reducing true memory rates.</li> <li>• Part-list cuing also declined false memories, which were retained as a function of directed forgetting.</li> </ul>
Kimball, Bjork,	Part-list cuing	University students	3 manipulations in Expts 1 & 2:	

Bjork, & Smith (2008)			<ul style="list-style-type: none"> <li>• Cue serial position (either the eight earliest or eight latest studied words)</li> <li>• Cue associative strength (forward strength in Expt. 1; backward strength in Expt. 2)</li> <li>• Cue recall permissibility</li> </ul>	<ul style="list-style-type: none"> <li>• Irrespective of forward association strength or backward association strength, cue associative strength did not affect false recall.</li> <li>• Presenting part-list cues reduced false recall but it only happened when cues were early-studied words and their recall was prohibited.</li> </ul>
Kawasaki-Miyaji, Inoue, & Yama (2003)	Language shifts	Japanese university students who had learned English for at least seven years	<ul style="list-style-type: none"> <li>• Lists were studied and tested in either English or Japanese</li> </ul>	<ul style="list-style-type: none"> <li>• When the study language and the test language matched, true recognition rates were higher.</li> <li>• When the test language was Japanese, false recognition rates were higher.</li> </ul>
Anastasi, Rhodes, Marquez, & Velino (2005)	Language shifts	University students	<p>Expt. 1:</p> <ul style="list-style-type: none"> <li>• Monolingual vs bilingual English speakers</li> </ul>	<ul style="list-style-type: none"> <li>• Although true memories were equivalent between monolingual English speakers and bilinguals, the former generated more false memories than did the latter.</li> </ul>

		Adults	<p>Expt. 2:</p> <ul style="list-style-type: none"> <li>Spanish word lists combined with originally English version to test native Spanish speakers.</li> </ul>	<ul style="list-style-type: none"> <li>Native Spanish speakers did not differ in their true recognition for English and Spanish words.</li> <li>Native Spanish speakers made more false memories in English than in Spanish.</li> </ul>
		Adults	<p>Expt. 3:</p> <ul style="list-style-type: none"> <li>S's who had extensive experience with Spanish but little or no exposure to English were recruited.</li> </ul>	<ul style="list-style-type: none"> <li>Spanish speakers were more likely to make true and false recognitions when studied words were presented in Spanish compared to those presented in English.</li> </ul>
		Adults	<p>Expt. 4:</p> <ul style="list-style-type: none"> <li>Native English speakers but tested in both English and Spanish with which they had little experience.</li> </ul>	<ul style="list-style-type: none"> <li>Monolingual English speakers were more likely to remember studied words and critical lures presented in English than those presented in Spanish.</li> </ul>
Cabeza & Lennartson (2005)	Language shifts	University students	<ul style="list-style-type: none"> <li>English-French bilinguals learned and were tested with words presented either in English or in French</li> </ul>	<ul style="list-style-type: none"> <li>Irrespective of within-language or across language, S's yielded robust false memories.</li> </ul>

				<ul style="list-style-type: none"> <li>• The effect of study-test language shift was greater for studied words compared to that for critical lures.</li> </ul>
Sahlin, Harding, & Seamon (2005)	Language shifts	University students	<ul style="list-style-type: none"> <li>• English-Spanish bilinguals learned and were tested with words presented either in English or in Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Bilingual S's false recognised critical lures no matter whether the words were tested in the same language or not.</li> <li>• False memories were greater for same-language than for different-language critical lures.</li> </ul>
Howe, Gagnon, & Thouas (2008)	Language shifts	6- to 12-year-olds and university students	<ul style="list-style-type: none"> <li>• All English-French bilinguals</li> <li>• Within-language (i.e., the study and test language were the same) vs between-language conditions (i.e., the study and test language were different)</li> </ul>	<ul style="list-style-type: none"> <li>• An age-related increase in true and false recall was found both in within-language conditions and between-language conditions.</li> <li>• Fewer false memories in the between-language condition than in the within-language conditions for youngest children, no difference for 8- to 12-year-olds, and more false recall in between than in within conditions for adults.</li> <li>• As for recognition, false</li> </ul>

				recognition was greater in between- than in within-conditions, regardless of age.
Marmolejo, Diliberto-Macaluso, & Altarriba (2009)	Language shifts	University students	<ul style="list-style-type: none"> <li>Spanish-English bilinguals learned and were tested with word lists in either English or in Spanish.</li> </ul>	<ul style="list-style-type: none"> <li>True and false memories were higher in English than in Spanish.</li> <li>False recall and recognition were higher across languages than within languages.</li> </ul>

## Appendix B

### The normed emotional word lists

Negative word lists															
Critical lure: anger				Critical lure: sick				Critical lure: lie				Critical lure: sad			
List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence
rage	0.617	4.517	6.367	ill	0.683	5.100	6.617	fib	0.667	5.167	6.117	unhappy	0.550	5.567	6.717
mad	0.600	4.417	6.350	illness	0.617	5.117	6.933	deceive	0.317	4.933	6.467	sorrow	0.433	5.683	7.033
enrage	0.483	4.450	6.117	flu	0.450	5.167	6.600	deception	0.317	5.000	6.400	depression	0.400	5.367	7.500
fury	0.350	4.550	5.867	nausea	0.417	5.083	6.583	cheat	0.283	4.783	6.750	cry	0.400	5.400	6.550
wrath	0.233	4.383	5.717	cough	0.350	5.333	6.167	untruthful	0.283	5.150	6.717	upset	0.367	5.333	6.917
hatred	0.233	5.033	7.050	virus	0.300	4.300	6.567	dishonest	0.267	5.050	6.883	tears	0.293	5.345	6.741
hate	0.183	4.683	7.050	fever	0.267	4.783	6.383	mislead	0.183	4.917	6.567	down	0.117	5.433	5.433
annoy	0.117	4.833	6.083	vomit	0.250	4.650	6.917	FALSE	0.133	5.117	5.800	suicide	0.100	4.667	7.900
fight	0.100	4.333	5.967	cold	0.017	5.150	5.800	betray	0.067	4.617	7.100	low	0.033	5.450	5.900
fear	0.017	4.483	6.517	hurt	0.017	5.033	6.700	trick	0.050	4.483	4.717	distress	0.033	4.300	6.767
<b>Mean</b>	0.293	4.568	6.308	<b>Mean</b>	0.337	4.972	6.527	<b>Mean</b>	0.257	4.922	6.352	<b>Mean</b>	0.273	5.254	6.746

Positive word lists															
Critical lure: beautiful				Critical lure: nice				Critical lure: love				Critical lure: happy			
List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence
stunning	0.417	4.217	3.467	pleasant	0.433	5.400	3.817	affection	0.533	4.600	3.550	glad	0.517	4.917	3.833
gorgeous	0.350	4.200	3.283	polite	0.317	5.133	4.000	adore	0.483	4.683	3.417	pleased	0.483	4.900	3.517
pretty	0.217	4.183	3.267	compliment	0.317	4.583	3.533	passion	0.383	4.000	3.683	joyful	0.433	4.433	3.433
attractive	0.167	4.217	3.333	considerate	0.167	5.467	3.750	kiss	0.350	3.767	3.267	content	0.350	5.633	3.750
elegant	0.133	4.767	3.533	genial	0.083	5.167	4.783	heart	0.233	4.667	3.917	elated	0.300	4.333	3.900
brehtaking	0.117	3.583	3.050	sweet	0.067	4.500	4.033	care	0.217	5.317	3.733	satisfied	0.250	5.050	3.550
lovely	0.100	4.750	3.367	thoughtful	0.050	5.383	4.117	devoted	0.183	4.600	3.800	laugh	0.217	3.550	3.133
exquisite	0.100	4.867	3.567	friend	0.033	4.300	3.250	friendship	0.150	4.283	3.433	enjoyment	0.217	4.317	3.633
striking	0.050	4.300	3.950	amiable	0.033	5.383	4.483	embrace	0.133	4.867	3.500	ecstatic	0.200	3.850	3.317
appealing	0.033	4.533	3.633	smile	0.000	4.533	3.233	like	0.100	4.983	4.100	enjoyable	0.183	4.317	3.433
<b>Mean</b>	0.168	4.362	3.445	<b>Mean</b>	0.150	4.985	3.900	<b>Mean</b>	0.277	4.577	3.640	<b>Mean</b>	0.315	4.530	3.550

Neutral word lists															
Critical lure: foot				Critical lure: car				Critical lure: mountain				Critical lure: music			
List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence	List word	BAS	Arousal	Valence
toe	0.567	5.433	5.133	sedan	0.650	5.367	4.833	peak	0.483	4.567	4.267	band	0.500	4.500	4.183
shoe	0.367	5.267	4.533	automobile	0.567	5.150	4.600	climber	0.350	4.817	4.367	instrument	0.433	4.567	3.967
ankle	0.250	5.250	5.117	vehicle	0.517	5.083	4.600	summit	0.317	4.417	3.917	concert	0.383	4.067	3.583
sock	0.200	5.417	4.817	garage	0.450	5.167	4.633	climb	0.267	4.467	4.200	piano	0.367	5.250	3.983
hand	0.183	5.150	4.417	drive	0.433	4.900	4.417	hill	0.167	5.033	4.750	jazz	0.367	4.867	3.817
sandals	0.167	5.117	4.300	van	0.317	5.383	4.767	steep	0.100	4.683	5.017	melody	0.350	5.333	4.050
boot	0.117	5.317	4.783	jeep	0.283	4.650	4.383	ski	0.100	4.217	3.917	rhythm	0.317	4.517	3.750
kick	0.100	4.583	4.867	highway	0.183	5.117	4.700	top	0.083	5.133	4.617	sound	0.267	4.767	4.183
knee	0.050	5.383	5.083	truck	0.083	5.350	5.017	valley	0.067	5.350	4.300	symphony	0.267	4.883	3.850
walk	0.033	5.200	4.233	bus	0.050	5.583	4.717	range	0.050	5.033	4.583	radio	0.250	4.833	4.100
<b>Mean</b>	0.203	5.212	4.728	<b>Mean</b>	0.353	5.175	4.667	<b>Mean</b>	0.198	4.772	4.393	<b>Mean</b>	0.350	4.758	3.947