

2015

Spurious recollection from a dual-process framework: The role of partial matching

Joyce M. Oates
American University

Lynne Reder
Carnegie Mellon University, cherdema@andrew.cmu.edu

Shaun Cook
Millersville University of Pennsylvania

Paige Faunce
Carnegie Mellon University

Follow this and additional works at: <http://repository.cmu.edu/psychology>



Part of the [Psychology Commons](#)

Published In

Cognitive Modeling in Perception and Memory: A Festschrift for Richard M. Shiffrin, Edited by J G W Raaijmakers, Robert Goldstone, Mark Steyvers, Amy Criss, Robert Nosofsky.

This Book Chapter is brought to you for free and open access by the Dietrich College of Humanities and Social Sciences at Research Showcase @ CMU. It has been accepted for inclusion in Department of Psychology by an authorized administrator of Research Showcase @ CMU. For more information, please contact research-showcase@andrew.cmu.edu.

Spurious recollection from a dual-process framework: The role of partial matching

Joyce M. Oates^a, Lynne M. Reder^b, Shaun P. Cook^c, and Paige Faunce^b

^aAmerican University

^bCarnegie Mellon University

^cMillersville University

Mailing Address:

Department of Psychology

Carnegie Mellon University

Pittsburgh, PA 15213

e-mail: reder@cmu.edu or joyce.oates@american.edu

Spurious recollection from a dual-process framework: The role of partial matching

Good models account for memory successes and failure; memory failures help constrain cognitive theories (e.g., Bui, Friedman, McDonough, & Castel, 2013; Diana, Peterson, & Reder, 2004; McTighe, Cowell, Winters, Bussey, & Saksida, 2010; Pohl, 2004), which can be useful for future models. Spurious recollection, also known as “illusory recollection” (e.g., Bixter & Daniel, 2013; Gallo, 2010; Gallo & Roediger, 2003), “phantom recall” (e.g., Brainerd, Payne, Wright, & Reyna, 2003; Brainerd, Wright, Reyna & Mojardin, 2001; Stahl & Klauer, 2009), “false recollection” (for a review see Arndt, 2012), “false memory” (e.g., Brainerd & Reyna, 2005), or “misrecollection” (e.g., Dodson, Bawa, & Krueger, 2007; Dodson, Bawa, & Slotnick, 2007), is memory failure where one claims to ‘Remember’ a spurious study episode, importantly claiming to recollect specific study details. This chapter proposes an account of spurious recollection via the Source of Activation Confusion (SAC) model (Park, Reder, & Dickison, 2005; Reder et al., 2000; Reder, Paynter, Diana, Ngiam, & Dickison, 2007; Reder & Schunn, 1996).

SAC is but one (e.g., Brainerd et al., 1999; Rotello, Macmillan, & Reeder, 2004; Reder et al., 2000; Wixted and Stretch, 2004; Yonelinas, 1994) dual-process model of recognition memory. SAC models the sources of input affecting recognition. As Wixted and Stretch noted, however, SAC has not previously provided a mechanistic account for spurious recollections¹. This chapter proposes to account for spurious recollection via partial matching, with model fits demonstrating that, not only can SAC account for spurious recollection, but it also predicts the occurrence of such responses without significant modifications to the original theory.

Historically, researchers have ignored spurious recollection findings because memory judgments based on recollection have been considered accurate. This is understandable as the

levels of spurious recollection are generally low. However, we agree with others (e.g., Higham & Vokey, 2004) who claim that spurious recollection should be investigated as a valid phenomenon. One reason stems from results obtained using the Deese (1959), Roediger and McDermott (1995) (DRM) paradigm. In this paradigm, participants study lists of words that are thematically related to a (non-presented) critical lure. During recall, the level of spurious recollection for the critical lure is often as high as the level of recall for items that appeared in the middle of the studied list. This result is quite robust (e.g., Arndt & Reder, 2003; Brainerd, Wright, Reyna, & Mojardin, 2001, Experiments 1 & 2; Gallo, 2010; Gallo & Roediger, 2003; Hicks & Marsh, 1999; Mather, Henkel & Johnson, 1997; Meade & Roediger, 2006; Verfaellie, Schacter, & Cook, 2002) and is perhaps the best-known example of spurious recollection engendering research aimed at understanding spurious recollection (e.g., Arndt & Gould, 2006; Brainerd, Forrest, Karibian, & Reyna, 2006; Brainerd, Yang, Reyna, Howe, & Mills, 2008; Brainerd, et al., 2001; Bui, Friedman, McDonough, & Castel, 2013; Gallo, 2010; Holiday, Reyna, & Brainerd, 2008; Melo, Winocur, & Moscovitch, 1999; Schacter, Verfaellie, & Pradere, 1996). There are, of course, other examples of spurious recollection such as the Misinformation Effect (e.g., Zaragoza & Mitchell, 1996) but because of length constraints, we focus on DRM here (see Ayers & Reder, 1998, for SAC's account of the Misinformation Effect.)

Many of the explanations for spurious recollection in DRM studies rely on a dual-process approach to memory. A common method for estimating the contribution of recollection and familiarity is to use the “Remember-Know” procedure (Gardiner, 1988; Rajaram, 1993; Tulving, 1985). This procedure requires participants to distinguish between a “Remember” judgment, recollection of study details, and a “Know” judgment, no recollection of study details. In an alternative dual-process account, Wixted & Stretch (2004) posit that a Remember judgment is

not process pure but rather is the summation of recollective and familiarity processes. Therefore, a Remember judgment for a lure item could occur due to a sufficient contribution from recollection, a combination of both recollection and familiarity, or a sufficient contribution from familiarity.

Joordens and Hockley (2000) and Reder et al. (2000) examined the mirror effect in recognition memory with the Remember/Know procedure. The data generally indicated that recollection supported hits and familiarity supported false alarms. However, Joordens and Hockley reported an increased rate of spurious recollection at delay, evidence of spurious recollection that cannot be attributed to familiarity. In addition, high-frequency lures were falsely recollected more often than low-frequency lures, similar to a result also reported by Reder et al. in Experiment 1. There is other evidence that warrants investigation of spurious recollection. Wixted and Stretch (2004) noted that there are positive correlations between Remember hits and Remember false alarms, and that both are made equally quickly. These results suggest that, when people make Remember hits and Remember false alarms, they engage similar processes or access similar kinds of information. Of interest is the mechanism driving the correlations. The results suggest that spurious recollection is relevant to the function of recognition memory.

SAC and Spurious Recollection

Although previous versions of SAC did not postulate a mechanism to explain spurious recollection, they could have, because the first SAC models used *partial-matching*. Reder and Schunn (1996) and Schunn, Reder, Nhouyvanisvong, Richards, and Stroffolino, (1997) used SAC to model feeling-of-knowing (FOK) results. In these studies, participants were exposed to arithmetic problems; then were required to quickly decide if they could retrieve the answer or if they had to calculate it. Results showed that presenting participants with studied problems in

which features (such as the operator) had been changed could yield spurious FOKs. The SAC account for these results involves a mechanism that allows for spurious FOK judgments through partial matching. Other data show that when features of a novel test probe partially match those of a studied episode, spurious recollection occurs (Reder, Paynter, Diana, Ngiam, & Dickison, 2007; Diana, Peterson, & Reder, 2004).

Similar to SAC's mechanism for spurious FOK judgments, SAC's mechanism for spurious recollection is partial matching. There are many concepts, contexts, and/or details used in partial matching that could influence the model. Some of these could be experimentally determined, such as the font or background color, while others are extra-experimental factors such as personal experience with word associations. SAC is dynamic in that new features, once discovered, can be subsequently added and modeled. Therefore, the datasets we chose to model were those with stimuli whose features could affect spurious recollection and had been experimentally manipulated (e.g., font).

In this chapter we present model fits for data from four different studies that all used a fan manipulation and varied in terms of the type of stimuli and methods used. Two of the studies (Diana, Peterson, & Reder, 2004, Experiment 1; Reder et al., 2002, Experiment 3) used words in different fonts as stimuli; the other two studies (Buchler, Light, & Reder, 2008; Reder et al., 2007) used word pairs as stimuli. Spurious recollection was more likely to lures in the high fan condition as well as when contextual details were reinstated. More details about all four studies and information on the modeling efforts are given below, but first, a description of SAC is presented.

The SAC Model

SAC is an experience-based, localist model of recognition consisting of an inter-

connected network of nodes. These nodes represent concepts (e.g., words), their features (e.g., font), episodes, and associated contexts. An episode node is created when a concept (node) becomes associated to a context. This context can be another concept node (e.g., a word paired with another word cat-hippopotamus), internal (mental/emotional) states, or the physical surroundings of the experiment.

Figure 9.1 depicts a schematic representation, according to the SAC model, of how episodic information is encoded in memory. Concept nodes have resting activation levels based on exposure history. For example, an often-experienced word (e.g., “cat”) will have a higher resting activation than an uncommonly-experienced word (e.g., “hippopotamus”). Nodes are connected by links and activation is spread via these links. During encoding, episodic traces are formed that store the study event in a particular encoding context, some general to the experiment, some more specific to a given stimulus, such as the font used at encoding. SAC relies on several retrieval assumptions to make quantifiable predictions about memory success. For details about the equations, see Reder et al. (2000).

The baseline or resting level activation of a concept (e.g., “cat”) is called node strength. The node strength can increase or decrease via a power function that is dependent on how frequently and how recently the concept was experienced. Simultaneously-experienced nodes are connected by links. The strength of any given link is dependent on the history of co-exposure. The current activation of a node increases when it receives stimulation and decays rapidly and exponentially. Stimulation can be either direct, from a target probe, or from other, linked node(s). When a test probe activates a corresponding concept node, spreading activation occurs. The activation an episode node receives depends on the strength of a link relative to the strength of other competing links. That is, the more links that a concept has (the greater the fan), the less

activation that is sent along any single link. This particular feature of SAC, allows the model to simulate the Fan Effect (e.g., Anderson, 1974; Reder & Ross, 1983).

Figure 9.1 represents words that were studied in an experimental context. Idiosyncratic aspects of the encoding context such as different fonts that the words were presented in are linked to the episode node for the individual items that were studied. The more general experimental context will have numerous associative links since it represents all aspects of the situation that are shared by the various studied words in the experiment, such as lighting of the room or position of the computer.

[INSERT FIGURE 9.1 ABOUT HERE]

It is noteworthy that SAC allows for memory judgments based on activation of either concept nodes or episodic nodes. When sufficient activation accumulates to allow a node to pass a threshold (same meaning as “a criterion”), an “old” judgment can be made. Judgments made from an active (i.e., above threshold) episode node are equivalent to a recollection, whereas judgments made from an active concept node are equivalent to a familiarity-based recognition. SAC assumes that recollective judgments are attempted before familiarity ones (see Diana, Vilberg, & Reder, 2005 for neurological corroboration). This is an important point since most dual-process models assume that familiarity decisions are made more quickly than recollective ones. By default, SAC also assumes that people have direct access to the concepts, but not the associations among the concepts. This could result in errors when attempting to attribute the source of activation.

Partial matching, the proposed mechanism for spurious recollection, is based on Remember judgments (both veridical and false) from an active, veridical episode node, specifically the one with the highest level of activation. Theoretically, partial matching refers to an overlap in the features constituting a studied episode and an unstudied test probe. When an unstudied test probe is presented, the possibility exists that some features (e.g., font) will match those contributing to an existing episode. These shared features would (automatically) send activation to all episode node(s) that are associated with these features. Recollection requires that an episode node surpass threshold and typically the word (concept) needs to send activation, not just the font or other encoding features to pass threshold. However, on rare occasions, the episode corresponding to a word other than the probe can become sufficiently active from the overlapping features in the lure, thereby invoking spurious recollection.

A number of variables determine amount of activation that accumulates at an episode node. First is the number of sources associated with an episode that are activated by the test probe. Second is the strength of the association relative to the fan (i.e., number of competitors that will share this activation). As a concrete example, consider that a lure was presented at test in a distinctive font that had been used to encode some of the studied words. During the encoding phase, font associations were manipulated such that many words were presented in “high-fan” fonts, while few words were presented in “low-fan” fonts.

At test, a studied word would be presented in the font used during encoding or a font shown with a different word during the study phase. Likewise a foil (non-studied word) will be tested in a font shown with a previously studied word. The font node activated at test will send out its activation to all its associated episode nodes. If the test word had been studied but the font was swapped from study to test, it is still likely that the relevant episode will go over threshold

because the word node is also sending activation; however, when the test probe involves a foil, the word node will not send activation to a studied episode and so it is unlikely that any episode node will go over threshold, but not impossible. In this situation there is a greater chance that a spurious episode node connected to a high-fan font will go over threshold than a low-fan font. This is because with the noise in the activation distribution, there are more opportunities that one of the several attached episodes will go over threshold.

SAC Model I of Reder, Donavos, and Erickson (2002, Experiment 3)

Using the Remember-Know procedure, Reder et al. (2002) investigated whether the match of the perceptual features affects recognition memory. Words were studied in different fonts and then tested in original or swapped fonts. The fan of the fonts was manipulated so that half were presented with 12 words (high-fan) and half were presented with 1 word (low-fan). The results indicated that recognition accuracy and Remember hits were better in the low-fan condition, and this advantage was magnified if the font was original.

Figure 9.2 displays the SAC model fit of these data. In this paradigm, when a word is presented at test, the episode node receives input from the general experimental context node, the concept node representing that studied word, and the specific context representing the font of the word. A font with a low-fan will send activation to only one episode node, whereas a font with a high-fan will send activation to as many as 12 episode nodes.

[INSERT FIGURE 9.2 ABOUT HERE]

Remember judgments to lures are spurious recollections. It is important to note that in the novel condition where an unstudied word was presented in an unstudied font, the proportion of actual

spurious recollections was .10 and the proportion of predicted spurious recollections was 0.00.

The model cannot predict spurious recollections in the novel condition because we do not postulate features we do not manipulate. We fully expect that people partial match on features that we did not manipulate but we do not give ourselves the degrees of freedom of assuming unspecified features. That said, the model provides an excellent fit², with an $r^2 = .98$. The parameters for each experiment modeled in this chapter can be found at

http://memory.psy.cmu.edu/Appendix_Spurious_Recollection.pdf.

SAC Model II of Diana, Peterson, & Reder (2004, Experiment 1)

Diana et al. (2004, Experiment 1) examined recognition memory for words as a function of font-fan (high-fan=12 words, low-fan=1 word). This experiment involved a between-participants delay: one group was tested immediately, the other after a one-week delay. The results of the immediate condition replicated those of Reder et al. (2002). The false alarm data for Remember responses showed the same pattern as Reder et al. (2002, Experiment 1), and was again captured by the SAC simulation.

SAC simulates delay in two ways. First, as time passes, a node's level of activation eventually returns to baseline. After a week, the nodes would have returned to baseline. Second, the links among nodes created during encoding are weakened with time. There is a noteworthy offset between these two factors. The baseline activation level of high-fan fonts is greater as a result of the greater frequency of occurrence. However, the strength of the links between any episode node and high-fan font is initially weaker than that between an episode node and low fan font. This offset results in the same pattern of spurious recollections for immediate and delay conditions. Overall, there are more spurious recollections in the delay condition because as time

passes, SAC assumes a lower threshold for activation. The experimental results support these predictions.

The data from the experiment and the model predictions are displayed in Figure 9.3 with the top panel for the immediate condition and the bottom panel for the delay condition. Overall, the model fits² are excellent for both the immediate ($r^2 = .99$) and delay ($r^2 = .92$) conditions.

[INSERT FIGURE 9.3 ABOUT HERE]

SAC Model III of Reder et al. (2007)

In Reder et al. (2007), the SAC model of spurious recollection was extended to account for data in a cued recall experiment that involved injection of midazolam (a benzodiazepine that causes temporary anterograde amnesia) in one session and an injection of placebo in the other. On each day, participants studied three different lists of 45 word pairs with cued-recall of the 45 pairs after studying a list. Each test trial (recall the response to the cue) was followed by feedback with another opportunity to study the word-pair. After the study and two test rounds of the first list, participants were given an injection of placebo or drug. Following the injection, participants then completed study of two more lists of 45 word pairs. Critically, one-third of the word pairs from each list were repeated across lists, one-third were totally novel from list to list and one-third of them involved reassigning the response term to a different cue word from list 1 to list 2 to list 3.

After completing the study and test on all three lists, participants completed a final cued-recall test for all three lists. The pairs from all three lists were tested together but the list number was provided along with the cue word to avoid ambiguity from interference pairs (i.e., for those pairs where the response term for a given cue differed from list to list). Under placebo, SAC

predicts slightly higher levels of spurious recollection from word associates on the third list because it was most recently studied, meaning its words have a slightly higher baseline. Nonetheless, SAC predicts comparable levels of spurious recollection for the swapped pairs from each list. The word cue has the same activation level and fan for each of the three lists. What indicates the correct memory is the list cue. The architecture connecting the concept and episode nodes does not vary from list to list.

Table 9.1 lists the data along with the SAC predictions of correctly recalled words and spurious recollections, as a function of drug condition and list. For the placebo condition, the SAC predictions are supported.

[INSERT TABLE 9.1 ABOUT HERE]

Under midazolam, SAC makes specific predictions regarding the pattern of spurious recollections. These predictions result from the probability that an episode was formed during the study phase, which is related to the delay between the drug injection and the study phase. Whereas the first study phase occurred prior to injection, the second occurred immediately following it, with the third occurring approximately 18 minutes after injection. The formula for calculating the probability of encoding the episode accounts for these variations in timing along with the potency of midazolam following the time of injection (see Reder et al., 2007 and http://memory.psy.cmu.edu/Appendix_Spurious_Recollection.pdf).

With these constraints, SAC predicts greater spurious recollections based on items from the third list than the second when participants are tested on a swapped trial from the first list. This is because the probability that an episode was created for the second study list is lower than

that for the third. The data and SAC predictions presented in Table 9.1 support these arguments. When a swapped test probe from the second list is presented, the connections between the concept node that represents the overlapping probe word and the episode node drive the spurious recollection. Table 9.1 shows that when a swapped test probe from the third list is presented, the majority of spurious recollections are predicted from list 1 (vs. 2). The entire set of data collapsed across condition and list type were well modeled by SAC with an $r^2 = .94$.

SAC Model IV of Buchler, Reder, & Light (2008)

In an investigation of associative interference, Buchler et al. (2008, Experiment 2) used a novel 5 choice recognition test that allows one to estimate the contributions of item and associative memory. The studied stimuli were word pairs, presented in five different conditions. During the test, original, recombined and new pairs were presented. The participant could choose one of five recognition responses: old-old (original), old-old (rearranged; both words were previously seen but not previously paired together), old-new, new-old, or new-new.

Spurious recollections in this paradigm are when one incorrectly classifies an old-old (rearranged) pair as an old-old (original) pair. In such cases, the participant is claiming to recollect a spurious association between the two words of the test pair. The SAC predictions and the experimental data for test pairs in the old-old (rearranged) condition are presented in Table 9.2.

[INSERT TABLE 9.2 ABOUT HERE]

The spurious activation of the episode node in all of these conditions would result from the activation of one of the words of the test pair, as all are recombined test pairs. SAC predicts that

the greatest amount of spurious recollections should occur in the Rep5 – Rep5 condition where each of the two words of the test pair were consistently (five times) paired with the same word during the study phase. In this case, the level of activation for either word of the test pair is high. There is also a strong link between the concept node for the studied word and the episode node for the study event as this link was established and then practiced 4 additional times during the study phase. This increased level of activation is passed from the repeatedly studied word along the practiced link to the associated episode node(s) when the word is presented at test.

As can be seen in Table 9.2, the predicted amount of spurious recollection for the other conditions is small. Table 9.2 also shows that the greatest amount of spurious recollection occurred in the Fan5 – Fan5 condition. Here each word of the test pair was studied 5 times, just as in the Rep5 – Rep5 condition. Therefore, the levels of activation should be equivalent. Unlike in the Rep5 – Rep5 condition, however, the words in the Fan5 – Fan5 condition were studied with 5 different partners. Therefore the links between the concept and episode nodes would not have been practiced. There are three possible reasons that, although SAC predicted the most spurious recollections in the Rep5 – Rep5 condition, there were actually more spurious recollections in the Fan5 – Fan5 condition. One, it is possible that the increase in fan translates into five times as many chances for an episode node to be become over threshold. In the SAC modeling effort, it is possible that the variability in the model contributed to spurious recollection in this case. Two, in the model, the threshold parameters could have been too high to allow activation of one of the five episode nodes associated with each studied word. Three, there could be influences of extra-experimental association that cannot be accounted for by SAC. These three possibilities are not mutually exclusive. Nonetheless, the SAC model of the entire set

of data is impressive, as it fit 75 separate data points with an $r^2 = .95$ using only four free parameters.

Discussion

These model fits show how SAC provides a mechanistic account of spurious recollection under various conditions. Partial matching ability has always existed in SAC, even though it has not been previously detailed. This chapter presents an explanation for spurious recollection based on the existing model without postulating any substantive changes. SAC, like all models, is not completely accurate and is not a comprehensive memory model. We are not the first to propose a mechanism that accounts for spurious recollection. Other theories, which include a recollective component, have also been proposed (e.g., Gallo and Roediger, 2003). The notion that features between true and false memories can match under certain circumstance is not new (e.g., Reyna & Titcomb, 1996; Schacter, Koutstaal, & Norman, 1997) and is related to the current explanation of spurious recollection. Wixted and Stretch's (2004) model assumes that two processes operate in recognition memory, and bases its predictions on one output. The ideas in this signal-detection model are not wholly incompatible with those being proposed here. Further, although Brainerd et al. (2003) propose separate mechanisms for veridical and spurious recollection, SAC assumes the same memory mechanism for both.

Since all of the experiments modeled here include a manipulation of a contextual feature (e.g., font), it could be argued that SAC has the ability to model spurious recollection only in situations where partial matching occurs. The question of whether SAC could model spurious recollection data from other paradigms such as DRM is valid. Others (e.g. Arndt & Reder, 2003; Reder & Anderson, 1980; Reder & Ross, 1983) propose an answer to this. The suggestion is that during the study of thematically related lists of words, a theme node can be created. This node

would exist in SAC as an episode node and when the critical lure was presented during the test phase, it is possible that activation of the theme node would cause a participant to spuriously recollect the lure from the study phase. This explanation of spurious recollection and the DRM paradigm is similar to those proposed by others (e.g., Roediger, Watson, McDermott, & Gallo, 2001).

Recollection-To-Reject

An interesting strategy that one could use in making Remember and Know judgments is recollection-to-reject (e.g., Brainerd et al., 2001, 2003; Odegard & Lampinen, 2005). When presented with a test probe, the participant could initiate a search of all studied items to verify whether the test probe was among them. Once the search was completed and the test probe was not found, the participant could then reject the probe because it was not recollected.

Although a recollection-to-reject strategy would guard against spurious recollection, it has disadvantages. For one, it requires an exhaustive memory search for the distractor, placing high demand on cognitive processing. Two, due to the passing of time the loss of item to context associations would result in rather poor recognition. Therefore, it does not seem like an optimal strategy for veridical recognition. Further, it is unclear whether such a strategy explains a significant amount of variability in recognition performance. Our modeling efforts investigated the use of a recollection-to-reject strategy and found that it did not account for any more variance than did partial matching alone.

In conclusion, the mechanistic account and modeling results reported here advance our understanding of spurious recollection across a number of manipulations. A key component of all the model fits presented is that they predict performance in situations where a contextual feature was experimentally manipulated and do not make unverifiable predictions based on

contextual features that were not systematically manipulated. This partial matching account is important because it makes no substantive changes to a memory model (SAC) that can explain other memory phenomena. As all modeling enterprises should endeavor, the SAC account of spurious recollection provides a foundation for future research by constraining current theories and allowing for the generation of testable predictions. Although there are undoubtedly instances of spurious recollection and other false memory phenomena that cannot be completely explained by partial matching, the hope is that this account will further our understanding of such memory effects and lead to fruitful discussions.

References

- Arndt, J. (2012). False recollection: Empirical findings and their theoretical implications. *Psychology of Learning and Motivation, 56*, 81-124.
- Arndt, J., & Gould, C. (2006). An examination of two-process theories of false recognition. *Memory, 14*(7), 814-833.
- Arndt, J. & Reder, L.M. (2003). The effect of distinctive visual information on false recognition. *Journal of Memory and Language, 48*, 1-15.
- Ayers, M.S. & Reder, L.M. (1998). A Theoretical review of the misinformation effect: Predictions from an activation-based memory model. *Psychonomic Bulletin & Review, 5*(1), 1-21.
- Bixter, M.T., & Daniel, F. (2013). Working memory differences in illusory recollection of critical lures. *Memory & Cognition*. [ePub ahead of print]
- Brainerd, C.J., Forrest, T.J., Karibian, D., & Reyna, V.F. (2006). Development of the false-memory illusion. *Developmental Psychology, 42*(5), 962-979.
- Brainerd, C.J., Payne, D.G., Wright, R., & Reyna, V.F. (2003). Phantom recall. *Journal of Memory and Language, 48*(3), 445-467.
- Brainerd, C. J., Reyna, V. F., & Mojardin, A. H. (1999). Conjoint Recognition. *Psychological Review, 106*(1), 160-179.
- Brainerd, C. J., & Reyna, V. F. (2005). *The Science of False Memory*. New York: Oxford University Press.
- Brainerd, C. J., Wright, R., Reyna, V. F., & Mojardin, A.H. (2001). Conjoint recognition and phantom recollection. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 341-361.

- Brainerd, C.J., Yang, Y., Reyna, V.F., Howe, M.L., & Mills, B.A. (2008) Semantic processing in “associative” false memory. *Psychonomic Bulletin & Review*, *15*(6), 1035-1053.
- Buchler, N.E.G., Faunce, P.A., Light, L.L., Gottfredson, N., & Reder, L.M. (2010). Effects of repetition on associative recognition in young and older Adults: Item and associative strengthening. *Psychology and Aging*. *22*(1), 104-121.
- Buchler, N.E.G, Light, L.L., & Reder, L.M. (2008). Memory for items and associations: Distinct representations and processes in associative recognition. *Journal of Memory and Language*, *59*, 183-199.
- Bui, D. C., Friedman, M. C., McDonough, I. M., & Castel, A. D. (2013). False memory and importance: Can we prioritize encoding without consequence? *Memory & Cognition*, 1-9.
- Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, *58*, 17-22.
- Diana, R., Reder, L.M., Arndt, J., & Park, H. (2006). Models of recognition: A review of arguments in favor of a dual process account. *Psychonomic Bulletin & Review*, *13*, 1-21.
- Diana, R., Peterson, M.J., & Reder, L.M. (2004). The role of spurious feature familiarity in recognition memory. *Psychonomic Bulletin & Review*, *11*(1), 150-156.
- Dodson, C.S., Bawa, S., & Krueger, L.E. (2007). Aging, metamemory, and high-confidence errors: a misrecollection account. *Psychology and Aging*, *22*(1), 122-133.
- Dodson, C.S., Bawa, S., & Slotnick, S.D. (2007). Aging, Source Memory, and Misrecollections. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *33*, 169-181.
- Gallo, D.A. (2010). False memories and fantastic beliefs: 15 years of the DRM illusion. *Memory & Cognition*, *38*(7), 833-848.

- Gallo, D. A., & Roediger, H. L. (2003). The effects of association and aging on illusory recollection. *Memory & Cognition*, *31*, 1036-1044.
- Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition*, *16*, 309-313.
- Geraci, L., & McCabe, D.P. (2006). Examining the basis for illusory recollection: The role of Remember/know instructions. *Psychonomic Bulletin & Review*, *13*(3), 466-473.
- Hicks, J.L., & Marsh, R.L. (1999) Remember-Know judgments can depend on how memory is tested. *Psychonomic Bulletin & Review*, *6*(1), 117-122.
- Higham, P. A. & Vokey, J. R. (2004). Illusory recollection and dual-process models of recognition memory. *The Quarterly Journal of Experimental Psychology*, *57A*(4), 714-744.
- Holliday, R.E., Reyna, V.F., & Brainerd, C.J. (2008). Recall of details never experienced: Effects of age, repetition, and semantic cues. *Cognitive Development*, *23*(1), 67-78.
- Joordens, S., & Hockley, W.E. (2000). Recollection and familiarity through the looking glass: When old does not mirror new. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(6), 1534-1555.
- Mather, M., Henkel, L.A., & Johnson, M.K. (1997). Evaluating characteristics of false memories: Remember/Know judgments and memory characteristics questionnaire compared. *Memory & Cognition*, *25*(6), 826-837.
- McTighe, S. M., Cowell, R. A., Winters, B. D., Bussey, T. J., & Saksida, L. M. (2010). Paradoxical false memory for objects after brain damage. *Science*, *330*(6009), 1408-1410.
- Meade, M.L., Roediger III, H.L. (2006). The effect of forced recall on illusory recollection in younger and older adults. *The American Journal of Psychology*, *119*(3), 433-462.

- Melo, B., Winocur, G., & Moscovitch, M. (1999). False recall and false recognition: An examination of the effects of selective and combined lesions to the medial temporal lobe/diencephalon and frontal lobe structures. *Cognitive Neuropsychology*, *16*(3-5), 343-359.
- Odegard, T.N. & Lampinen, J.M. (2005). Recollection rejection: Gist cuing of verbatim memory. *Memory & Cognition*, *33*(8), 1422-1430.
- Park, H., Arndt, J., & Reder, L. M. (2006). A contextual interference account of distinctiveness effects in recognition. *Memory & Cognition*, *34*(4), 743-751.
- Park, H., Reder, L.M., & Dickison, D. (2005). The effects of word frequency and similarity on recognition judgments: The role of recollection. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *31*(3), 568-578.
- Pohl, R. (Ed). (2004). *Cognitive illusions: A handbook on fallacies and biases in thinking, judgement and memory*. New York, NY: Psychology Press.
- Pratte, M. S. & Rouder, J. N. (2011). Hierarchical single- and dual-process models of recognition memory. *Journal of Mathematical Psychology*, *55*, 36-46.
- Rajaram, S. (1993). Remembering and knowing: Two means of access to the personal past. *Memory & Cognition*, *21*, 89-102.
- Reder, L.M. & Anderson, J.R. (1980). A partial resolution of the paradox of interference: The role of integrating knowledge. *Cognitive Psychology*, *12*, 447-472.
- Reder, L.M., Donavos, D.K., & Erickson, M.A. (2002). Perceptual match effects in direct tests of memory: The role of contextual fan. *Memory & Cognition*, *30*(2), 312-323.
- Reder, L.M., Nhouyvansivong, A., Schunn, C.D., Ayers, M.S., Angstadt, P., & Hiraki, K. (2000). A mechanistic account of the mirror effect for word frequency: A computational

- model of Remember/know judgments in a continuous recognition paradigm. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 26(2), 294-320.
- Reder, L.M., Oates, J.M., Dickison, D., Anderson, J.R., Gyulai, F., Quinlan, J.J., ... Jefferson, B. (2007). Retrograde facilitation under midazolam: The role of general and specific interference. *Psychonomic Bulletin & Review*, 14(2), 261-269.
- Reder, L.M., Paynter, C., Diana, R.A., Ngiam, J., & Dickison, D. (2007). Experience is a double-edged sword: A computational model of the encoding/retrieval tradeoff with familiarity. In Ross, B. & Benjamin, A.S. (Eds.), *The Psychology of Learning and Motivation*, Academic Press, 271-312.
- Reder, L.M. & Ross, B.H. (1983). Integrated knowledge in different tasks: The role of retrieval strategy on fan effects. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 9, 55-72.
- Reder, L.M. & Schunn, C.D. (1996). Metacognition does not imply awareness: Strategy choice is governed by implicit learning and memory. In Reder, L.M., (Ed.) *Implicit Memory and Metacognition*. Mahwah, N.J.: L. Erlbaum, 45-77.
- Reyna, V.F., & Titcomb, A.L. (1996). Constraints on the suggestibility of eyewitness testimony: A fuzzy-trace theory analysis. In D.G. Payne & F.G. Conrad (Eds.), *Intersections in basic and applied memory research* (pp. 27–55). Mahwah, NJ: Lawrence Erlbaum Associates Inc.
- Roediger, H. L., III & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 21, 803-814.

- Roediger, H. L., III, Watson, J.M., McDermott, K.B., & Gallo, D.A. (2001). Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review*, *8*(3), 385-407.
- Rotello, C.M., Macmillan, N.A., & Reeder, J.A. (2004). Sum-difference theory of Remembering and knowing: A two-dimensional signal-detection model. *Psychological Review*, *111*(3), 588-616.
- Schacter, D.L, Koutstaal, W., & Norman, K.A. (1997). False memories and aging. *Trends in Cognitive Sciences*, *1*(6), 229-236.
- Schacter, D.L, Verfaellie, M., & Pradere, D. (1996). The Neuropsychology of Memory Illusions: False Recall and Recognition in Amnesic Patients. *Journal of Memory and Language*, *35*(2), 319-334.
- Schunn, C.D., Reder, L.M., Nhouyvanisvong, A., Richards, D.R., & Stroffolino, P.J. (1997). To calculate or not calculate: A source activation confusion (SAC) model of problem-familiarity's role in strategy selection. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *23*, 1-27.
- Stahl, C., & Klauer, K.C. (2009). Measuring phantom recollection in the simplified conjoint recognition paradigm. *Journal of Memory and Language*, *60*(1), 180-193.
- Tulving, E. (1985). Memory and consciousness. *Canadian Psychology*, *26*, 1-12.
- Verfaellie, M., Schacter, D.L., & Cook, S.P. (2002). The effect of retrieval instructions on false recognition: exploring the nature of the gist memory impairment in amnesia. *Neuropsychologia*, *40*(13), 2360-2368.
- Wixted, J.T., & Stretch, V. (2004). In defense of the signal detection interpretation of Remember/Know judgments. *Psychonomic Bulletin & Review*, *11*(4), 616-641.

- Yonelinas, A.P. (1994). Receiver-operating characteristics in recognition memory: Evidence for a dual-process model. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20(6), 1341-1354.
- Yonelinas, A.P. (2002). The Nature of Recollection and Familiarity: A Review of 30 Years of Research. *Journal of Memory and Language*, 46(3), 441-517.
- Zaragoza, M. S., & Mitchell, J. (1996). Repeated exposure to suggestion and the creation of false memories. *Psychological Science*, 7(5), 294-300.

Author Notes

This work was supported by the National Institutes of Health grant 5R01MH052808. We thank Daniel Dickison for help with programming and Ya (Katie) Zhang for comments on the chapter.

Footnote

1 While one can argue that all states deliver all responses (hence new items will give some spurious recollections) but just vary in the probability of those responses (Pratte & Rouder, 2011), in this paper we will show that we can explain spurious recollections without invoking Rouder's position.

2 All models presented in this chapter were fit using the method of least squares that yields a value of r^2 (variance accounted for). Although r^2 is affected by the number of free parameters such that the variance accounted increases with more free parameters, we are not guilty of the "kitchen sink regression." Across models of different experiments, we keep the parameter values of most variables constant, leaving relatively few free parameters. For example, the model fits of Buchler, Reder, and Light (2008), involved 75 data points with only four free parameters.

Figure Captions

Figure 9.1. Representation of the basic SAC model. Adapted from “A contextual interference account of distinctiveness effects in recognition” by Park, Arndt, and Reder, (2006), *Memory & Cognition*, 34(4), 743-751. Copyright 2006 by Psychonomic Society, Inc.

Figure 9.2. Data and SAC model of data from Experiment 3 in Reder, Donavos, & Erickon (2002). For each condition, the bars represent Reder et al. data for hits and false alarms partitioned by R and K responses. The lines represent the SAC model simulation of these data.

Figure 9.3. Top Panel: Data presented from Diana, Peterson, & Reder (2004), Experiment 1, immediate condition. Shown are the mean proportion old responses as a function of whether the item was a target (studied word) or a lure (unstudied word) and whether the font shown at test matched the encoding font (original) or was not seen with the word before (swap) and whether the font had been studied with many words (High Fan) or few words (Low Fan). Each bar presents both the Know and the Remember portions of the hits and false alarms. The lines indicate the SAC model fit of these data. Bottom Panel: Data and SAC model fit from the same experiment, but the delay condition.

Table 9.1:

SAC predictions of spurious recall for the swapped pairs (interference pairs) of pre- and post-injection lists in Reder et al., 2007. The predictions and actual levels of spurious recall are listed according to condition: placebo or midazolam. Spurious recall occurs with swapped pairs when a participant recalls the wrong studied associate to the cue word based on the study list number given as part of the recall cue.

Condition:	Recalled Item		
	List 1 Associate	List 2 Associate	List 3 Associate
<u>Placebo</u>			
List 1 Cue	.36 (.28)	.16 (.15)	.08 (.19)
List 2 Cue	.18 (.12)	.34 (.33)	.18 (.19)
List 3 Cue	.07 (.12)	.19 (.15)	.43 (.41)
<u>Midazolam</u>			
List 1 Cue	.51 (.61)	.01 (.01)	.08 (.13)
List 2 Cue	.42 (.28)	.04 (.03)	.16 (.12)
List 3 Cue	.20 (.28)	.03 (.01)	.26 (.28)

Correct responses are shown in bold. Model predictions are listed in parentheses.

Table 9.2:

SAC predictions and actual mean proportion of responses to each of the four word-pair types in the word-pair recognition test as a function of the number of associates (fan) for word1 and word2 and whether the pair was repeated.

Word Pair:	Response				
	Old-Old (original)	Old-Old (rearranged)	Old-New	New-Old	New-New
<u>Intact Pair</u>					
Fan 1-1	.45 (.07)	.11 (.05)	.06 (.03)	.10 (.03)	.28 (.07)
Fan 1-5	.40 (.07)	.19 (.05)	.04 (.02)	.29 (.06)	.07 (.05)
Fan 5-1	.40 (.07)	.19 (.07)	.31 (.06)	.02 (.01)	.08 (.05)
Fan 5-5	.53 (.08)	.37 (.07)	.04 (.03)	.05 (.02)	.01 (.01)
Rep x5	.84 (.07)	.06 (.03)	.04 (.02)	.03 (.02)	.03 (.02)
<u>Rearranged Pair</u>					
Fan 1-1	<i>.06</i> (.03)	.20 (.05)	.19 (.04)	.20 (.04)	.35 (.07)
Fan 1-5	<i>.13</i> (.04)	.35 (.08)	.04 (.02)	.42 (.07)	.07 (.05)
Fan 5-1	<i>.13</i> (.05)	.32 (.07)	.45 (.06)	.02 (.01)	.07 (.03)
Fan 5-5	<i>.26</i> (.08)	.61 (.08)	.05 (.03)	.06 (.03)	.01 (.01)
Rep x5	<i>.12</i> (.04)	.53 (.08)	.14 (.04)	.14 (.04)	.08 (.04)
<u>Item Pair</u>					
Fan1-New	.02 (.03)	.08 (.03)	.29 (.07)	.08 (.02)	.53 (.08)
New-Fan1	.04 (.03)	.07 (.03)	.06 (.03)	.31 (.07)	.52 (.08)
Fan5-New	.04 (.03)	.17 (.06)	.69 (.08)	.02 (.02)	.08 (.05)
New-Fan5	.07 (.04)	.10 (.04)	.02 (.01)	.72 (.08)	.09 (.05)
<u>Novel Pair</u>					
New-New	.01 (.01)	.05 (.02)	.10 (.03)	.10 (.02)	.74 (.07)

*Correct responses are shown in bold. Model predictions are listed in parentheses. Spurious recollection data and predictions are italicized. From "Distinct representations and processes in associative recognition," by N. E. G. Buchler, L. L. Light, & L. M. Reder, 2008, *Journal of Memory and Language*, 59, 183–199. Copyright 2008 by Elsevier. Reprinted with permission.*