Research Article

Associative and Categorical Relations in the Associative Memory Illusion

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ABSTRACT—***What kinds of associations underlie the associative memory illusion? In Experiment 1, lists composed of horizontal, or coordinate, free associates elicited false recognition of critical lures much more often than did lists composed of vertical, or subordinate, category instances. Experiment 2 replicated this result, and showed that the difference between free associates and category instances was not an artifact of differential levels of forward or backward associative strength. Associative structure plays an important role in the associative memory illusion: The illusion is strongest when the critical lure lies at the same level of categorization as the studied items.***

Memory, like perception, is subject to illusions. In memory illusions, a person either remembers an event that did not occur at all or remembers an event that did occur in a manner that seriously distorts the objective historical record (Roediger, 1996). Among the most powerful memory illusions is what has come to be called the *associative memory illusion* (AMI), originally reported by Deese (1959) and rediscovered and thoroughly documented by Roediger and McDermott (1995; see also Read, 1996; Roediger, Balota, & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001). The AMI is induced by asking a subject to study a list of words (e.g., *thread*, *pin*, *eye*, *sewing*, *sharp*, and *point*), all of which are semantic associates of an unstudied item known as the *critical lure* (e.g., *needle*). The illusion occurs when subjects who have studied the items of the inducing list incorrectly remember having studied the critical lure as well.

One prominent theory of the AMI holds that it is mediated by preexisting associative structures in memory, or what Underwood (1965) labeled implicit associative responses (Roediger, Balota, et al., 2001; Roediger, McDermott, & Robinson, 1998; Roediger, Watson, et al., 2001). Thus, within the framework of a generic spreading-activation account of memory, encoding the list items activates preexisting representations of those words in memory; this activation then spreads to semantically related items, including the critical lure. At the time of retrieval, subjects retrieve the critical lure as well as list items. A great deal of evidence generally supports this activation view of the AMI (for a review, see Roediger et al., 1998). For example, conditions that encourage semantic processing of list items at the time of encoding are more likely to produce false memories than are conditions that limit encoding to perceptual processes (see also Shobe, Park, & Kihlstrom, 2005; Thapar & Rouder, 2001; Toglia, Neuschatz, & Goodwin, 1999). The AMI is also strengthened by increasing the number of associated items in the inducing list (Robinson & Roediger, 1997), by presenting associated items in blocked rather than random fashion (Mather, Henkel, & Johnson, 1997; McDermott, 1996; Shobe et al., 2005; Tussing & Greene, 1997), and by composing lists of strong rather than weak associates of the target items (Shobe et al., 2005).

At the same time, the activation account of the AMI has encountered at least one anomaly. Even though all the lists employed to induce false memories are constructed in the same manner, they differ widely in the strength of the illusion they produce (Deese, 1959; Gallo & Roediger, 2002; Roediger & McDermott, 1995; Stadler, Roediger, & McDermott, 1999). For example, presentation of the top 15 associates of the word *window* (*door*, *glass*, *pane*, *shade*, etc.) produced false recall of that critical lure in 65% of subjects; however, presentation of the top 15 associates of the word *fruit* (*apple*, *orange*, *kiwi*, *citrus*, etc.)

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generated false recall of the corresponding critical lure in only 20% of subjects (Stadler et al., 1999). Deese (1959) attributed this variability to the strength of the backward associations between studied items and critical lures—a conclusion that has been supported by other researchers as well (McEvoy, Nelson, & Komatsu, 1999; Robinson & Roediger, 1997). In fact, a regression analysis confirmed that the most powerful predictor of the false-memory effect was the backward associative strength between studied items and critical lures, which accounted for 40% of variance in the AMI (Roediger, Watson, et al., 2001).

The importance of backward associative strength is consistent with spreading-activation or semantic priming accounts of the AMI (Roediger, Balota, et al., 2001; Roediger et al., 1998), but inspection of the lists in question suggests that the type of association involved may be important as well. The British associationism of Thomas Hobbes and John Locke was based on a rather undifferentiated notion of associations based largely on contiguity and similarity (Anderson & Bower, 1973). Similarly, word-association norms of the sort relied on by Deese and Underwood (e.g., Russell & Jenkins, 1954) recorded only the strength of association between two words, not the nature of the associative relation. However, under the influence of both artificial intelligence and Chomskian (and neo-Chomskian) linguistics, the neoassociationism of modern cognitive psychology has distinguished among different types of associative relations (Anderson & Bower, 1973). For example, G. Mandler (1979) distinguished among three types of associations linking items in memory: *coordinate* (or horizontal), linking items at the same level of categorization; *subordinate* (or vertical), linking items at different levels of categorization; and *proordinate* (or temporal), linking items in time or space (see also Kihlstrom & Wilson, 1988; J.M. Mandler, 1979).

In the *window* list just described, as in other lists yielding high rates of false memory, the associations are primarily of the coordinate sort: The target *window* lies at the same level of categorization (Rosch, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) as inducing-list items such as *door* and *pane*. By contrast, in the *fruit* list, which yields strikingly low rates of false memory, the critical lure *fruit* labels a taxonomic category, whereas the inducing-list items (e.g., *apple* and *orange*) are mostly basic-level instances of that category. The following experiments tested the hypothesis that the magnitude of the AMI depends on whether the critical lure lies at the same level of categorization as the items in the inducing list.

EXPERIMENT 1

Experiment 1 was conceived as an extension of the paradigm developed by Roediger and McDermott (1995). The stimuli included new lists composed of category instances targeting category labels as false memories, and both free recall and recognition were tested.

Method

Subjects

Forty college undergraduates were recruited for an experiment on memory and language. The subjects were run individually and were paid $8 for their participation in a single 1-hr session.

Materials

This experiment employed 12 study lists, 6 consisting of word associates and 6 of category instances. The associative study lists consisted of 12 of the first 15 associates given to the words *cold*, *sweet*, *bread*, *black*, *slow*, and *needle* in the norms collected by Russell and Jenkins (1954; see also Roediger & McDermott, 1995; Stadler et al., 1999); the remaining 3 words were reserved for use as *related lures* in a recognition test. These 6 lists were a subset of those employed by Deese (1959) and Roediger and McDermott (1995). The categorical study lists consisted of 12 of the first 15 instances of the categories *fruit*, *insect*, *flower*, *tool*, *animal*, and *furniture* (Battig & Montague, 1969); again, the remaining 3 words were reserved for use as related lures on the recognition test. Although the associative and categorical lists were derived from different published norms, the critical lures for the associative and categorical conditions were closely matched in terms of set size in their respective normative samples. Within each list, items were ordered by response frequency, with the most frequent associates or instances presented first.

Procedure

The 12 lists were recorded in two different presentation orders on a Macintosh computer using SoundEdit software; a computer controlled both presentation and test phases of the experiment via RSVP Experimental Control Software for MacOS provided courtesy of Michael J. Tarr (Brown University, Providence, RI). After the presentation of each list, the subjects completed mathematics problems for 30 s. They were then given 90 s to recall the list in writing before proceeding to the next list. Following the final study-test cycle, the subjects were surprised with a 104-item recognition test consisting of 36 studied items, 12 critical lures, 36 related lures reserved from the stimulus lists, and 20 completely new unrelated lures. The subjects made old/new recognition judgments on a 4-point confidence scale (1 = *very sure it was a new word*, 4 = *very sure it was an old item*).

Results

Recall

Table 1 presents means and standard deviations for veridical recall of studied items and false recall of critical lures. A 2×2 repeated-measures analysis of variance (ANOVA) with two levels of the list factor (free associates vs. category instances) and two levels of the target factor (old studied items vs. new critical lures) revealed significant main effects of both list type,

TABLE 1
Recall and Recognition, Experiment 1

Measure and target type	List type: Free associates	List type: Category instances
Recall (proportion)		
Studied items	.74 (.10)	.79 (.09)
Critical lures	.33 (.21)	.00 (.00)
Recognition confidence		
Studied items	3.48 (0.35)	3.60 (0.21)
Critical lures	2.77 (0.75)	1.50 (0.47)
Related lures	1.62 (0.37)	1.98 (0.44)
Proportion "old"		
Studied items	.79 (.22)	.88 (.07)
Critical lures	.60 (.30)	.10 (.15)
Related lures	.12 (.12)	.30 (.19)

Note. Standard deviations are in parentheses.

$F(1, 39) = 74.25$, $p < .001$, $\eta^2 = .65$, and target, $F(1, 39) = 537.94$, $p < .001$, $\eta^2 = .93$. More items were recalled in the associative than the categorical condition, and across conditions, correct recall of studied items exceeded false recall of critical lures. Most important, the two-way interaction was also significant, $F(1, 39) = 119.12$, $p < .001$, $\eta^2 = .75$. A planned comparison showed that false recall of critical lures was significantly greater in the associative than the categorical condition, $t(39) = 104.10$, $p < .001$, $r = .74$. In fact, there was not a single instance of false recall of critical lures from the categorical lists.

Recognition Confidence

Table 1 also presents the mean confidence ratings assigned to various types of items on the recognition test. As expected, false recognition of new, unrelated lures was very low (mean confidence rating = 1.35, $SD = 0.30$), with only 4% of unrelated lures receiving confidence ratings higher than 2. A 2 × 3 repeated-measures ANOVA with two levels of the list factor (associative vs. categorical) and three levels of the target factor (old studied vs. critical lure vs. related lure) yielded significant main effects for list type, $F(1, 39) = 53.96$, $p < .001$, $\eta^2 = .58$, and target, $F(2, 39) = 278.52$, $p < .001$, $\eta^2 = .94$, as well as a significant interaction between the two factors, $F(2, 39) = 114.36$, $p < .001$, $\eta^2 = .85$. Planned comparisons showed that studied items received higher recognition ratings than critical lures for both associative lists, $t(39) = 22.95$, $p < .001$, $r = .52$, and categorical lists, $t(39) = 657.76$, $p < .001$, $r = .95$. For the associative lists, the critical lures received higher ratings than the related lures, $t(39) = 115.95$, $p < .001$, $r = .70$. However, this pattern was reversed for the categorical lists, $t(39) = 40.72$, $p < .001$, $r = .47$. The critical lures for associative lists received higher confidence ratings than the critical lures for categorical lists, $t(39) = 133.50$, $p < .001$, $r = .71$, whereas the related lures for categorical lists received higher confidence ratings than the related lures for associative lists, $t(39) = 38.77$, $p < .001$, $r = .40$.

Recognition Judgments

For the purposes of analyzing recognition judgments, all items receiving confidence ratings of 1 or 2 were classified as "new," and all items receiving ratings of 3 or 4 were classified as "old." The 2 × 3 ANOVA on the recognition judgments again yielded significant main effects for list type, $F(1, 39) = 16.94$, $p < .001$, $\eta^2 = .30$, and target, $F(2, 39) = 270.05$, $p < .001$, $\eta^2 = .93$, and a significant two-way interaction, $F(2, 78) = 101.07$, $p < .005$, $\eta^2 = .72$. Planned comparisons confirmed the pattern of results revealed in the confidence ratings. Old studied items were more likely than critical lures to be called "old," both for associative lists, $t(39) = 12.03$, $p < .001$, $r = .34$, and for categorical lists, $t(39) = 842.33$, $p < .001$, $r = .96$. For the associative lists, critical lures were more likely than related lures to be called "old," $t(39) = 134.07$, $p < .001$, $r = .72$; this pattern was reversed for categorical lists, $t(39) = 45.16$, $p < .001$, $r = .50$. Critical lures from associative lists were more likely to be called "old" than were critical lures from categorical lists, $t(39) = 124.15$, $p < .001$, $r = .73$, whereas related lures from categorical lists were more likely to be called "old" than were related lures from associative lists, $t(39) = 39.57$, $p < .001$, $r = .49$.

EXPERIMENT 2

The findings of Experiment 1 are consistent with the hypothesis that the AMI is mediated by horizontal (coordinate) associations rather than vertical (subordinate) ones. Given the important role of backward associations in producing the AMI (Roediger, Watson, et al., 2001), however, it is possible that the effect revealed by this experiment is an artifact of differences in the backward-association values of horizontal (coordinate) and vertical (subordinate) links. That is to say, the backward associative strengths between horizontal associates such as *thread*, *pin*, and *eye* and the critical lure *needle* may simply be higher than the corresponding strengths between vertical associates such as *apple*, *orange*, and *kiwi* and the critical lure *fruit*. If so, then the allegedly qualitative difference between types of associative links, horizontal (coordinate) and vertical (subordinate), dissolves into a merely quantitative difference in backward associative strength.

A secondary analysis of the University of South Florida (USF) Free Association Norms (Nelson, McEvoy, & Schrieber, 1998) made this possibility appear remote (full details are available on the World Wide Web at http://socrates.berkeley.edu/~kihlstrm/AMI-PSK-Supplement.htm). Taking from the norms the responses to the 12 critical lures employed in Experiment 1, two of us classified these responses as either horizontal (coordinate) word associations or vertical (subordinate) category instances (93.6% agreement, with disagreements resolved through discussion and arm twisting). When we compared the two types of responses for each of the 12 lists, taken separately, we found that in only one case (the *insect* list) was there a significant difference in backward associative strength between them (independent-groups *t* tests, $p < .05$). Even this difference was anomalous, as it was based on a comparison of only 3 horizontal (coordinate) associates against 20 vertical (subordinate) associates. When the 12 lists were combined, there was no overall difference in backward, mediated, or overlapping strength between associates and instances, all *t*s < 1.

Because there were only minor differences between the two types of associations, it seemed unlikely that the effect observed in Experiment 1 was an artifact of list-wise differences in backward associative strength. As a further check, we conducted a new experiment with lists of coordinate or subordinate associates of the same critical lures, matched for the strength of both forward and backward associations.

Method

Materials

For this experiment, we selected the three critical lures from Experiment 1 (*animal*, *flower*, and *fruit*) for which the responses in the USF norms contained substantial numbers of both coordinate (e.g., *zoo*, *petals*, *vegetable*) and subordinate (e.g., *raccoon*, *tulip*, *banana*) associations. We then created new lists of coordinate and subordinate associates to these three targets that were precisely matched (all *t*s < 1) in both forward and backward associative strength. The *animal* and *fruit* lists were each 15 items long; because of limitations in the USF norms, the *flower* lists were only 11 items long. The experimental protocol was filled out with three lists (*anger*, *cold*, and *music*) from the standard lists employed by Roediger and McDermott (1995).

Subjects and Procedure

The procedure for this experiment was the same as for Experiment 1, except that we eliminated the recall tests and the related lures. Thirty-eight college undergraduates were randomly assigned to receive either coordinate or subordinate versions of the *animal*, *flower*, and *fruit* lists, along with the standard *anger*, *cold*, and *music* filler lists. There were 19 subjects in each group. All subjects received credit toward the research-participation component of their psychology course.

Results

As in Experiment 1, false recognition of new, unrelated lures was very low (mean confidence rating = 1.37, $SD = 0.36$), with only 5% of these items receiving confidence ratings higher than 2. Considering only the standard lists (free associates targeting *anger*, *cold*, and *music*), we obtained a solid AMI: Across the two groups, the critical lures received an average confidence rating of 3.33 ($SD = 0.52$), compared with 3.63 ($SD = 0.32$) for studied items. In terms of dichotomous old/new judgments, the subjects falsely recognized 81% of critical lures and correctly recognized 89% of studied items. The two groups did not differ significantly in these respects.

Recognition Confidence

Table 2 presents the mean confidence ratings for studied items and critical lures from the new matched lists of associates and category instances. A 2 × 2 mixed-design ANOVA with two levels of list type (associative vs. categorical) as a between-groups factor and two levels of target type (old vs. critical lure) as a within-subjects factor found significant main effects of both list type, $F(1, 36) = 14.47$, $p < .001$, $\eta^2 = .29$, and target type, $F(1, 36) = 79.51$, $p < .001$, $\eta^2 = .69$. The two-way interaction was also significant, $F(1, 36) = 25.76$, $p < .001$, $\eta^2 = .42$. Planned comparisons yielded the same pattern as in Experiment 1. In the associative lists, the critical lures received relatively high confidence ratings, although not quite as high as those given to studied items, $t(18) = 2.66$, $p < .05$, $r = .72$. By contrast, in the categorical lists, the critical lures received much lower confidence ratings than those given to studied items, $t(18) = 10.11$, $p < .001$, $r = .87$. The ratings given to critical lures in the categorical lists were also much lower than the ratings given to critical lures in the associative lists, $t(36) = 4.82$, $p < .001$, $r = .74$.

Recognition Judgments

A 2 × 2 ANOVA of the proportion of items judged as "old" yielded the same pattern. There were significant main effects of both list type, $F(1, 36) = 16.98$, $p < .001$, $\eta^2 = .32$, and target type, $F(1, 36) = 73.37$, $p < .001$, $\eta^2 = .67$. Again, the two-way interaction was also significant, $F(1, 36) = 33.57$, $p < .001$, $\eta^2 = .48$. Planned comparisons showed that, for the associative lists, critical lures were falsely recognized at almost the same rate as studied items were correctly recognized, $t(18) = 1.82$, n.s. By contrast, for the category-instance lists, critical lures were falsely recognized much less often than studied items were correctly recognized, $t(18) = 11.08$, $p < .001$, $r = .87$. They were also falsely recognized much less often than critical lures from the associative lists, $t(36) = 4.29$, $p < .001$, $r = .64$.

TABLE 2
Recall and Recognition, Experiment 2

	List type	
Measure and target type	Free associates	Category instances
Recognition confidence		
Studied items	3.45 (0.24)	3.66 (0.28)
Critical lures	2.91 (0.28)	1.68 (0.75)
Proportion "old"		
Studied items	.83 (.09)	.90 (.11)
Critical lures	.69 (.34)	.16 (.28)

Note. Standard deviations are in parentheses.

GENERAL DISCUSSION

If the AMI is defined by the false recollection of critical lures, it is clear from this study that the illusion is induced by lists of coordinate (horizontal) associations, but not by lists of subordinate (vertical) associations. Lists of basic-level category instances rarely elicit either false recall or false recognition of superordinate category labels (see also Buchanan, Brown, Zabeza, & Maitson, 1999; Pansky & Koriat, 2004). However, these lists do elicit false recall and recognition of other basic-level category instances (see also Nessler, Mecklinger, & Penney, 2001; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000; Smith, Ward, Tindell, Sifonis, & Wilkenfeld, 2000). Moreover, superordinate category labels are elicited as false recollections when the lists of study items are composed of free associations to these words, rather than of instances of the categories they represent.

The difference between associative and categorical lists was not an artifact of differences in backward associative strength between studied items and critical lures, because in Experiment 2 the matched pairs of lists were precisely equated in terms of both forward and backward associative strength. Nor was the difference between the two kinds of lists produced by a drift of memory (true and false) toward the basic level of categorization (Pansky & Koriat, 2004): Subjects falsely recognized superordinates at high levels as long as the studied items were associates rather than instances of these critical lures. Nor did subjects simply edit superordinates out of their responses to the categorical lists because items at this level did not occur in these lists: Except for *vegetable* on the *fruit* list employed in Experiment 2, superordinates did not occur in the lists of associates either, although all three of the associative lists produced false recall of superordinates at high levels.

The results of these experiments both extend and qualify the dominant activation theory of the AMI, according to which false recollection is stimulated by the activation or priming of semantically associated items stored in semantic memory (Roediger et al., 1998; Underwood, 1965). The extension of the activation theory comes from the finding that false recognition extends to other associates of the critical lure, as well as to the critical lure itself. For example, in Experiment 1, subjects who studied the *needle* list falsely recognized the critical lure *needle*, but also tended to falsely recognize other associates (*sharp*, *hurt*, and *knitting*) that were not actually on the studied list. Similarly, even though subjects who studied the *fruit* list did not falsely recognize the word *fruit*, they did falsely recognize other, unstudied category instances (*kiwi*, *berry*, and *cherry*; Seamon et al., 2000; Smith et al., 2000). False recollection extends to a great deal of semantically associated knowledge, as long as the associations are coordinate rather than subordinate in nature.

The qualification of the activation theory of the AMI is that in addition to associative strength and the direction of association, associative structure is important. Presentation of subordinate-level category instances does not induce false memory for a highly associated word that lies at a different level of categorization. Similarly, we would not expect false recollection of the word *needle*, a common consequence of presentation of words such as *thread*, *pin*, and *eye*, to ensue from presentation of a list composed of subordinate instances such as *hypodermic needle*, *knitting needle*, and *sewing needle*. Along these lines, it is interesting that Palermo and Jenkins (1963) long ago observed that subordinate-level cues rarely elicited superordinate responses on word-association tasks, at least among linguistically mature subjects.

Although associative processes have been implicated in the AMI since its initial discovery by Deese (1959), more recent research has begun to examine the factors contributing to variability in the effect. One such factor, originally suggested by Deese himself, is certainly backward associative strength (McEvoy et al., 1999; Roediger, Watson, et al., 2001). Forward associative strength is also a factor (e.g., Brainerd & Wright, 2005; Gallo & Roediger, 2002; Shobe et al., 2005). Yet a third factor is the density of associative relations among list items (McEvoy et al., 1999). To this list of quantitative variables we now add another, more qualitative, factor, the type of association, or the level of the associative link. The effects of this factor cannot be accounted for by associative strength or direction. Lists of strongly related items elicit false recollections at the same level of categorization as that represented by the studied items. This suggests that the associative links mediating the AMI proceed along horizontal lines, to related items at the same level of categorization, rather than along vertical lines, to superordinate or subordinate levels.

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