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Unitization and Grouping Mediate Dissociations in Memory for New Associations

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Previous research has demonstrated performance dissociations between explicit and implicit memory for newly acquired associations between unrelated words. The present article accounts for this finding in terms of two factors: unitization and grouping. Unitization involves representing previously separate items as a single unit, and grouping involves forming associations among separate representations. We propose that grouping facilitates primarily explicit remembering by providing the routes for accessing encoded word pairs via the cues available during testing; in contrast, unitization affects primarily implicit remembering by enabling the redintegration of studied items in response to partial cues. Consistent with this view, the results from two experiments show that by focusing processing on the relation between target word pairs, explicit remembering can be manipulated independently of implicit remembering. Two further experiments reveal that a materials manipulation—concreteness of words—affects both implicit and explicit remembering.

In recent articles, we distinguished between explicit remembering, as indexed by performance on standard memory tests—such as free recall, cued recall, and recognition—and implicit remembering, as indexed by performance on priming tests, such as word completion, word identification, and lexical decision (Graf & Schacter, 1985; Schacter & Graf, 1986). The importance of this distinction is underlined by a growing body of evidence that experimental manipulations and subject factors produce dissociations between explicit and implicit remembering (for reviews see Richardson-Klavehn & Bjork, 1988; Schacter, 1987; Shimamura, 1986).

The finding of performance dissociations raises a question: What is the nature of the processes/representations that differentiate explicit from implicit remembering? In previous investigations of this question, we focused on memory for information that was newly acquired on a single study trial (e.g., Graf & Schacter, 1985, 1987; Schacter & Graf, 1986, 1989; see also Schacter, Cooper, & Delaney, in press). For this purpose, pairs of unrelated words (e.g., BOOK–FOREST) were studied, and implicit memory was assessed with word completion tests for which subjects were presented word stems (e.g., FOR_____) that were paired either with the same words as in the study list (e.g., BOOK–FOR_____ [same-context test items]) or with different words (e.g., PEARL–FOR_____ [different-context test items]). The instructions were to complete the stems with the first words that came to mind. Under these conditions, a tendency to write more studied words as completions on the same- versus different-context test items shows implicit remembering of information about the newly acquired pairs; as a shorthand, we refer to this finding as *implicit memory for new associations.*

Four main findings have emerged from previous experiments. First, implicit memory for new associations was observed, but only following elaborative study tasks that required subjects to relate paired words in a meaningful manner; tasks that did not require this type of processing showed no evidence of associative priming (Graf & Schacter, 1985; Schacter & Graf, 1986). Second, we found that the size of the associative influence on completion performance was comparable across a range of elaborative study tasks that produced substantially different levels of explicit remembering (Schacter & Graf, 1986). Third, implicit memory for new associations was not affected by either pro- or retroactive interference manipulations, even though these manipulations had a significantly detrimental effect on explicit remembering (Graf & Schacter, 1987). Finally, implicit memory for new associations was consistently reduced when study and test items were presented in different modalities (auditorily at study and visually at test) than when they were in the same modality (visual); in contrast, explicit remembering showed no evidence of modality-specific associative effects (Schacter & Graf, 1989). Taken together, these results present a puzzle. On one hand, the finding that both implicit and explicit memory for new associations requires some degree of elaborative processing suggests that both are mediated by the same processes/representations. On the other hand, the finding that modality manipulations and manipulations of associative elaboration and interference have different effects on implicit and explicit memory suggests that these forms of remembering are mediated by different processes/representations.

To explain this collection of findings, we focused on two factors—unitization and grouping—that have different effects on implicit and explicit memory (cf. Schacter, 1985). Uniti-

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zation is a condition of two or more previously separate items or stimulus components that have become represented as a single unit, with each unit being a network node (e.g., LaBerge & Samuels, 1974), or by a different memory metaphor, a coordinated set of pattern analyzing processes (e.g., Kolers, 1975). Unitization is thought to occur in two ways, either as a result of perceiving structure or coherence among separate stimulus components or as a result of conceiving a structure for connecting materials that are processed concurrently (cf. Ceraso, 1985; Goldmeier, 1982; LaBerge & Samuels, 1974; Mandler, 1988). Gestalt psychology has highlighted a number of laws (e.g., proximity, good continuation) that govern how perceptual mechanisms organize the myriad of features of the visual world, for example, into a few unitized objects. Others (Miller, 1956) have emphasized that meaning can serve as the "glue" for a unitized encoding of the set of words in a phrase or sentence. We make the same assumption to explain unitization of unrelated word pairs. In previous experiments on memory for new associations, subjects were asked to process paired words in a meaningful interaction with each other; this activity required analyzing the words concurrently to yield their joint meaning, a single interpretation, thereby ensuring the unitized encoding of each pair. The advantage of this type of processing comes from the tendency of a unitized representation to become reactivated or redintegrated as a whole when only some of its components are subsequently reprocessed (e.g., Mandler, 1980; Horowitz & Prytulak, 1969). Therefore, once established, the unitized representations of paired words can facilitate subsequent processing of the same pairs, and we suggest that this facilitation is what is indexed by associative priming effects.

In addition to unitization, we postulate a second factor—grouping—that affects primarily explicit remembering. Grouping is a condition of a set of unitized representations that are connected by a network of associations; that is, grouping defines representations as members of the same collection. The network of associations is assumed to form as a result of processing to-be-remembered (TBR) targets in the same experimental situation. Many aspects of experimental situations, including the nature and appearance of targets, the study task, and relevant prior knowledge, influence processing during the study trial. These influences are thought to contribute to grouping in two ways. First, to the extent that experimental factors persist and have similar effects on the encoding of each of a set of TBR targets, there will be overlap among or associations between their unitized representations. A second and perhaps stronger and more direct influence on grouping, however, comes from processing that *follows* unitization. We suggest that most study tasks involve two steps: first, discovering or retrieving a structure for unitizing the components of a TBR target, and second, elaborating the unitized encodings according to the requirements of the experimental situation. To illustrate, in one of our previous experiments, for example, the study tasks required generating either a single word or a complete sentence for connecting paired words. We assume that for both of these tasks, subjects first conceived a meaningful connection between the two words in each pair, thereby establishing unitized representations, and then they elaborated these units by different degrees—minimal or substantial, respectively, when required to generate a single word or a complete sentence to articulate the unitizing connection between the words in each pair. To the extent that this postunitization processing is guided by a common task, theme, mood, mental set, or prior knowledge, it follows that all unitized pair representations are linked to each other, that they are part of the same group. We assume that associations among unitized representations are important because they provide the routes for accessing and retrieving target pairs on standard memory tests. Typical instructions for explicit remembering specify the to-be-recollected targets in terms of group defining features (e.g., "Remember the words that you made into sentences"), and subjects orient their responding by these specifications.

The distinction between unitization and grouping can account for previous findings on memory for new associations. The most convincing support comes from the observation that AB, AC interference manipulations affect explicit but not implicit memory for new associations (Graf & Schacter, 1987). In a retroactive interference paradigm (Graf & Schacter, 1987, Experiment 1), for example, study of the target pairs (AB) is identical in the experimental and control condition. We required subjects to study the AB list by generating a meaningful sentence for each pair and assumed that this activity was sufficient to establish unitized pair representations. By the argument that unitization results from processing two words as a single interacting unit, it follows that study of the interpolated list AC should have no influence on the unitization of AB pairs because the two lists are not composed of the same pairs. In contrast, study of the interpolated list does affect grouping of representations because a longer list of similar pairs (AB & AC) is encoded in the same experimental situation (i.e., in relation to the same cues), thereby decreasing the distinctiveness of the associations that define the group of unitized representations. Watkins and Watkins (1975) have described this negative consequence as *cue overload*; the general importance of cue distinctiveness has also been acknowledged by others (e.g., Jacoby & Craik, 1979).

The distinction between unitization and grouping can also accommodate other dissociations in memory for new associations. Consider, for example, the finding from Schacter and Graf's (1986) Experiment 1, in which subjects studied unrelated words by generating either a single linking word or a complete sentence for each pair: Completion test performance showed similar associative effects across these tasks, whereas cued recall showed a larger associative effect with the sentence than word task. To account for the completion test results, we suggest that unitization of representations was comparable across the sentence and word generating tasks because both tasks require first conceiving a meaningful connection between the two words in each pair, and this unitization occurs prior to other processing. The primary difference between tasks is that generating a complete sentence requires subjects to draw relatively more on prior knowledge than does generating a single word, thereby increasing the number and distinctiveness of associations that define each group of unitized pair representations. In a similar manner, we could use the distinction between unitization and grouping to offer post hoc interpretations for other dissociations in memory for new associations. However, previous studies were not designed to examine this view directly, and thus, extant results do not provide strong support.

To recapitulate, we use unitization and grouping to explain dissociations in memory for new associations. Unitization is assumed to result from perceiving or conceiving a TBR target pair as a coherent unit, whereas grouping is assumed to result primarily from elaborating unitized pairs in the same experimental situation. We argue that implicit memory for new associations depends primarily on unitization of target representations, which enables the subsequent redintegration of the same targets, and that explicit remembering depends primarily on grouping of representations which links each target to cues that enable retrieval on a subsequent test. Unitization may also contribute to explicit remembering, however, by facilitating the production of candidate test responses, that is, by making some items "pop into mind" more easily (because of redintegration), thereby ensuring that they are considered as test responses. By these assumptions, it follows that experimental factors that affect grouping should influence primarily explicit but not implicit memory for new associations, whereas factors that affect unitization can influence both implicit and explicit memory for new associations.

The present study was designed to investigate factors expected to have selective effects on grouping and unitizing of representations. Two experiments focused on grouping; their goal was to manipulate the number and/or the distinctiveness of group defining features that are encoded. For this purpose, word pairs were studied either in direct relation to each other (high-grouping condition) or without relating them to each other (low-grouping condition). On the basis of assumptions outlined in the preceding paragraphs, we expected this manipulation to affect explicit but not implicit memory for new associations. Two further experiments focused on unitization. The basic approach was to use concrete versus abstract word pairs. Concrete words are known to evoke more attributes, images, and associations than do abstract words (e.g., Olson, 1970; Paivio, 1968; Paivio & Madigan, 1970; Rissenberg & Glanzer, 1987). We assumed that these properties facilitate the encoding of unitized representations and that with a larger and more varied set of evoked properties, there is more opportunity for encoding two words as a distinctive, coherent unit. A difference between concrete and abstract pairs may occur either because the former are more likely to be encoded in a unitized manner or because they are encoded in a more distinctive manner. By either possibility, consistent with the assumptions that unitization can influence both implicit and explicit remembering, we expected that the concreteness manipulation would affect both forms of memory.

The general strategy of all four experiments involved study of unrelated word pairs and testing of implicit or explicit memory. The same form was used for both tests. This form showed word stems (e.g., FOR____) that were paired either with the same words as in the study list (e.g., BOOK–FOR____ [same-context test items]) or with different words (e.g., PEARL–FOR____ [different context test items]). For implicit memory, subjects were instructed to complete the stems with the first words that came to mind. For explicit memory, subjects were instructed to use the stems as aids for remembering words from the study list. Of primary interest was the level of performance on the same- versus different-context test items, that is, the size of the associative influence on performance of each test type.

Experiment 1

Previous experiments have demonstrated that different elaborative study tasks affect explicit but not implicit memory for new associations (Schacter & Graf, 1986). In Experiment 1 we examined whether this dissociation can be produced by manipulations designed to affect primarily grouping but not unitization of target representations. For this purpose, pairs of unrelated words were studied in two different conditions. Both conditions required subjects to generate meaningful sentences for presented word pairs. The difference between conditions was that for one of them, the study task required subjects to generate a different, unrelated sentence for each pair, whereas the other task required subjects to generate related sentences that formed a "story," that is, sentences that were related to a common theme, setting, or set of characters. These two tasks were assumed to have similar effects on unitization (because both require first conceiving a meaningful connection between paired words), and thus they were expected to produce similar levels of implicit memory for new associations. However, by focusing on the relations among the to-be-generated sentences, the story task was assumed to produce more grouping of target representations than the sentence generating task and thus was expected to benefit explicit memory for new associations. In short, it was expected that explicit memory for new associations would be higher after the story than sentence task but that both tasks would produce similar levels of implicit memory for new associations.

Method

Subjects and design. Subjects were 96 University of Toronto students who participated either for pay or for credits in an introductory psychology course. The design included study task (sentence vs. story construction) and test type (completion vs. cued recall) as between-subjects factors. Twenty-four subjects were assigned randomly to the four groups defined by the combination of these factors.

Materials. One hundred and thirty-six common, concrete words were selected for the construction of 32 study list pairs, 4 practice pairs, and 32 distractor pairs. The words were between 4 and 10 letters long (mean = 5.8 letters) and of medium frequency (mean = 42.3; range = 1–186 occurrences per million, Kučera & Francis, 1967). The selection of the 32 words that were used as the right-hand members or targets for the study list pairs was constrained by two additional criteria. First, the three-letter stem of each word (e.g., MAR for MARKET) was unique among all words that were used in the entire experiment. Because the stems were used as cues on the completion test, this selection criterion ensured that we had a unique cue for each target word. Second, for each target, a pocket English dictionary had to list at least 10 common words with the same stem (e.g., MARBLE, MARKET, MARGIN, MARRY), thus ensuring that each subject would easily be able to generate a completion for each stem. Each target was combined with another, unrelated word to produce the 32 pairs that were used for the study list.

Of the remaining 72 words, 8 were randomly combined to produce 4 practice pairs, and 64 were combined to produce 32 test distractor pairs. Because the stems of the targets from the latter pairs were also used as cues on the completion test, the distractor targets were selected to meet the same criteria as the targets for the study list pairs.

Tests. The same form was used for recall and completion testing. A single page showed a random arrangement of 64 test items, each consisting of a word plus a three-letter word stem (e.g., BOULDER–GRO______). The stems were from the targets of the 32 study list pairs and of the 32 distractor pairs. For the latter pairs, each test item was a stem together with an unrelated cue word. For the study list pairs, there were two types of test items: 16 items had a stem together with a cue word that had been in the same study list pair, and 16 items had a stem together with a cue word from different study list pairs. The first 16 test items were used to assess completion of targets in the *same* context (i.e., paired with the same word) as in the study list, whereas the second 16 items were used to assess completion of targets in a *different* context (i.e., paired with a different word) than in the study list. Items were arranged randomly on the test form. Two versions of the form were required for each target word to be tested in same- and different-context test items. The distractor items were included on the test primarily to disguise its memory testing function when it was used for word completion, by merging the critical items among a longer list of items (see Graf & Mandler, 1984; Schacter & Graf, 1986).

Procedure. The general procedure consisted of instruction and practice, study, and testing. Each subject was tested individually. The experiment was described as examining memory for word pairs, and the study tasks were described as methods for improving memory performance. During instruction and practice, all subjects were shown a practice word pair and required to generate and say a sentence that connected the two words from each pair (e.g., BOOK–FOREST) in a meaningful manner (e.g., "The BOOK included a picture of a FOREST"). In the sentence generating condition, subjects then practiced this task with the remaining practice pairs. In contrast, in the story condition, subjects were further instructed to make a story with the sentences that they generated for subsequent pairs, that is, to generate sentences that had the same topics, settings, or set of characters. Subjects then practiced this task with the remaining pairs.

After instruction and practice, the study list was presented, consisting of 32 randomly ordered word pairs. The study list was presented once, at a rate of about 6 s per pair. In the sentence condition, subjects generated and said aloud a meaningful sentence for each pair. In the story condition, subjects generated sentences that "make up a story."

The test phase followed immediately after study. Each subject was given a distractor task and immediately thereafter one of two memory tests: word completion or cued recall. The functions of the distractor task were to engage subjects in an unrelated activity for about 3 min before administering the critical memory tests, and more important, to induce an appropriate mental set for word completion testing. For the distractor task, subjects were presented with two pages that listed 28 common first names (e.g., JOHN ______), as well as 20 names together with the initial letter of a surname (e.g., BARBARA J______). Subjects were required to read aloud each first name and then to free-associate to the presented cues by writing the first surname that came to mind.

For the completion test, the instructions made no reference to the studied pairs. Subjects were told that before receiving the memory test, they had to "complete each word beginning on the test form with the first word that comes to mind." They were informed that they could write any word except proper names, and when a proper name was given, an alternative completion was requested. Because each word stem was presented in the context of another word, some of which were from the study list, subjects were told that the context word might sometimes help them to think of a completion. They were required to read aloud each context word and then complete the stem next to it with the first word that came to mind, as quickly as possible.

For the cued recall test, subjects were told about the composition of the test items. They were required to read aloud each context word and to use the cues to remember as many words as possible from the study list pairs. Subjects were required to write a word for each stem even if they could not recall a word from the study list.

Results

The dependent measures were the proportions of studied target words that were produced on the completion test, and the proportions of targets remembered on the cued recall test. The results are shown in Table 1. For the completion test, the level of performance was higher on the same-context test items than on the different-context test items, thereby revealing an associative influence on performance. More important, the size of this associative influence was similar with the story task (.46 and .27, respectively, for same- and different-context test items) and with the sentence task (.46 and .25, respectively, for same- and different-context test items). An analysis of variance (ANOVA) supported this summary of the results by showing a significant main effect for test items (same vs. different), $F(1, 46) = 43.2$, $MS_e = 0.023$, with no other effects approaching significance (alpha < .05 for this and all other statistical comparisons).

To establish that these results reflect memory for the studied pairs, we also required an estimate of baseline completion performance, that is, an estimate of how often subjects would write the same target words as completions without a prior presentation of the study list. For this purpose, an additional 24 subjects received the completion test without a prior presentation of the study list. The control group's performance was lower (.10) and was comparable on same (.09) and different (.10) context test items, thereby indicating that the higher level of performance in the experimental conditions is due to memory for information that was newly acquired during the study trial.

The main findings from the cued recall test are also shown in Table 1. Three findings are noteworthy: First, recall was higher in the story than sentence task condition; second, recall

Table 1
Experiment 1: Mean Levels of Completion and Cued Recall Test Performance, in the Story and Sentence Condition, on Same- and Different-Context Test Items

	Condition			
	Story		Sentence	
Test type	Same	Different	Same	Different
Completion				
M	.46	.27	.46	.25
SE_m	.04	.03	.04	.02
Cued recall				
M	.86	.39	.69	.35
SE_m	.02	.03	.03	.03

was higher on same- than different-context test items; third, and most important, the size of the associative influence was larger following the story task (.86 and .39, respectively, on same- and different-context test items) than following the sentence task (.69 and .35, respectively, on same- and different-context test items). An ANOVA supported this summary of the results by showing significant main effects for study tasks (story vs. sentence), $F(1, 46) = 15.6$, $MS_e = 0.018$, and for test items (same vs. different), $F(1, 46) = 179.8$, $MS_e = 0.023$, as well as a significant interaction of these two factors, $F(1, 46) = 4.9$, $MS_e = 0.023$.

Discussion

The main findings from this experiment were that on the completion test, a similarly large associative influence was found in the story and sentence task condition, whereas on the recall test, the associative influence was larger with the story than sentence task. This pattern of results replicates and extends the findings from previous experiments that manipulated degree of elaborative processing (Schacter & Graf, 1986). More important, consistent with the view that memory for new associations is mediated by two factors—unitization and grouping—that make different contributions to performance on implicit and explicit memory tests, the present findings support the idea that grouping can be manipulated independently of unitization.

Even though the findings are consistent with expectations, an overall analysis of the combined results from the recall and completion test calls for caution. By this analysis, the interaction between study tasks and the size of the associative influence across tests was only marginally significant, $F(1, 92) = 3.15$, $p = .07$. The lack of a significant interaction may be due to a weak experimental manipulation; alternatively, it may stem from the fact that there is more overlap than we assumed between the processes that mediate associative influences on explicit and implicit memory tests. In view of the latter possibility, it is important to determine whether with a stronger manipulation explicit memory for new associations can be dissociated more clearly from implicit memory. This possibility was examined in Experiment 2.

Experiment 2

Experiment 2 differed from Experiment 1 in terms of study materials and study procedure. The study materials were meaningful sentences, each of which contained one of the word pairs from Experiment 1, with the critical words printed in capital letters (e.g., he drank a cold BEER after playing TENNIS). The study procedure had two parts. In the first part, the sentences were presented, and subjects were required to read and rate each of them in terms of how well it related the two capitalized words. Consistent with previous findings, this reading/rating task was expected to ensure the unitized encoding of target word pairs and thereby to facilitate implicit memory for new associations. The critical independent variable was manipulated in the second part of study, which involved two different conditions that were designed either to facilitate or to hinder the encoding of distinctive group defining information. The sentences were re-presented, and subjects were required to sort them, either on the basis of their meaning (topic sort task) or on the basis of their number of words (length sort task). We assumed that both of these tasks produce grouping but that more distinctive group defining associations would be encoded in the topic than length sort task. Consequently, on the assumption that grouping is relevant primarily to explicit remembering of new associations, we expected a higher level of cued recall performance after the topic versus length sort task. On the assumption that these sorting tasks do not affect unitization, both tasks were expected to have similar effects on implicit memory.

Method

Subjects and design. Subjects were 48 University of Toronto students who participated either for pay or for credits in an introductory psychology course. The design included study tasks (topic sort vs. length sort) as a within-subjects factor and test type (completion vs. cued recall) as a between-subjects factor. Twenty-four students were assigned randomly to the groups defined by each test type.

Materials. The basic materials were the same as for Experiment 1: 36 word pairs were used for the study list, 4 pairs were used for practice, and 28 pairs were used as test distractors. For each of the study list pairs, we prepared a sentence that related the two words in a meaningful manner (e.g., "He drank a cold BEER after playing TENNIS"); each sentence was printed on an index card, with the critical words appearing in capital letters. The construction of the sentences was guided by two criteria; One concerned the number of words per sentence, and the other concerned the theme or topic of each sentence. The sentences were 7, 8, 9, 10, or 11 words long. In addition, each sentence focused on one of the following topics: shopping, furniture and decoration, health and medicine, household chores, law and crime, leisure & relaxation, nature and animals, sports, weather, and work and business. The 36 critical sentences were divided into three sets of 12 sentences in such a way that each set could be further divided into four subsets of three sentences, either on the basis of word length or on the basis of topic area. For each subject, two 12-sentence sets were presented for study; the third set was not studied and was used to assess baseline completion performance. Across subjects, each set was used equally often in each condition.

Procedure. Each subject was tested individually. The general procedure was the same as in Experiment 1, except for the study tasks. The sentences were presented twice. For the first presentation, the 24 sentences were shown in random order, and subjects read each sentence aloud and rated the extent to which the two capitalized words were meaningfully related to each other. They used a 5-point scale for this task, with 5 indicating *very closely related* and 1 indicating *very loosely related.* Presentation of the sentences was paced by subjects' speed on the task (about 6 s per sentence).

For the second pass through the study list, the 12 sentences from each set were presented as a block, and subjects were required to sort one set on the basis of word length, and the other set on the basis of topic area. For length sort, subjects were instructed to "arrange these sentences into four groups in such a way that all the sentences within a group have the same number of words." To facilitate the task, index cards indicating the relevant word length for each group were placed in front of the subject. For the topic sort task, the instructions were to "arrange the sentences into four groups in such a way that all the sentences in a group have to do with the same general theme or topic area." To facilitate the task, index cards indicating the relevant topic area for each group (see *Materials* section) were displayed, and the experimenter briefly described each topic area (e.g., "*Shopping* includes sentences that concern such things as shopping for groceries or clothes"). For both tasks, the experimenter provided feedback to ensure that the sentences were sorted correctly. Across subjects, the order of administering the length and topic sort tasks and the assignment of sentence sets to tasks were completely counterbalanced.

Memory was assessed with the same tests as in Experiment 1. However, in contrast to Experiment 1, there was a 1-hr delay between study and testing to prevent potential ceiling effects on recall in the topic sort condition. Subjects were not monitored during the delay.

Results

The main findings from the completion and cued recall test are shown in Table 2. For the completion test, the means show that the level of performance was higher on same-context test items than on different-context items, and more important, that the size of this associative influence was comparable in the topic sort condition (.28 and .18, respectively, for same- and different-context test items) and length sort condition (.26 and .17, respectively, for same- and different-context test items). An ANOVA showed a significant main effect for test items (same vs. different), $F(1, 23) = 6.0$, $MS_e = 0.035$, with no other effects approaching significance.

Overall performance in the experimental conditions was lower in Experiment 2 than in Experiment 1. The difference in results probably reflects the longer study/test delay in Experiment 2 and is consistent with previous findings that performance on similar completion tests decreases rapidly across delays (e.g., Graf, Squire, & Mandler, 1984; Schacter & Graf, 1986). Baseline performance was low (.08) and was identical on same- and different-context test items, thereby indicating that performance in the experimental conditions reflects memory for information that was newly acquired during the study trial.

The main findings from the cued recall test are also shown in Table 2. Overall performance was higher on same- than different-context items, and more important, the size of this associative influence was larger following the topic sort task (.72 and .29, respectively, for same- and different-context test items) than the length sort task (.44 and .28, respectively, for same- and different-context test items). These observations were supported by an ANOVA that showed significant main effects for test items (same vs. different), $F(1, 23) = 45.0$, $MS_e = 0.046$, and study tasks (theme vs. length sort), $F(1, 23) = 17.3$, $MS_e = 0.028$, as well as a significant interaction between these factors, $F(1, 23) = 21.6$, $MS_e = 0.020$.

We also expected that the study task manipulation would interact with the size of associative effects and test types. This expectation was confirmed by an additional ANOVA of the combined results from the recall and completion tests that revealed a significant interaction among Task × Test × Item Type, $F(1, 44) = 13.0$, $MS_e = 0.016$.

Table 2
Experiment 2: Mean Levels of Completion and Cued Recall Test Performance, in the Topic and Length Sort Condition, on Same- and Different-Context Test Items

	Condition			
	Topic		Length	
Test type	Same	Different	Same	Different
Completion				
M	.28	.18	.26	.17
SE_m	.05	.04	.04	.03
Cued Recall				
M	.72	.29	.44	.28
SE_m	.05	.03	.03	.04

Discussion

In combination with the results from Experiment 1, the findings of Experiment 2 establish that explicit and implicit memory for new associations can be manipulated independently of each other by means of elaborative tasks that focus processing on the relations among the TBR study list pairs. These findings were expected by the view that explicit remembering depends on encoding information that defines unitized pair representations as members of the same group and that such group defining information is critical for intentional memory retrieval. We argue that with the story (Experiment 1) and topic sort task (Experiment 2), more distinctive group defining associations were encoded than with the other study tasks. The importance of distinctiveness for explicit remembering has been acknowledged by many investigators (e.g., Jacoby & Craik, 1979; Watkins & Watkins, 1975). The finding that implicit memory for new associations was not affected differentially in either experiment was also expected by the assumptions that this form of memory is mediated primarily by the unitization of representations, which was not manipulated.

Experiment 3

The two remaining experiments focused on unitization. Specifically, Experiment 3 examined the idea that the encoding of unitized representations is related to the ease or facility with which paired words can be perceived or conceived of as a single unit. For this purpose, we used a study list composed of concrete and abstract word pairs. Concrete words are known to evoke more attributes, images, and associations than do abstract words (e.g., Paivio, 1971; Rissenberg & Glanzer, 1987). We assumed that these properties facilitate the encoding of unitized representations and that with a larger and more varied set of evoked properties, there is more opportunity for encoding two words as a distinctive, coherent unit. The basic procedure was similar to that of Experiment 1. During the study trial, subjects were presented word pairs (e.g., BOOK–FOREST) and were required to generate and say aloud a meaningful sentence for each pair. Immediately after study, subjects were tested for word completion followed by cued recall. Recall was assessed within subjects for two reasons: first, because previous studies have shown comparable patterns of performance in within- and between-subjects conditions and, second, because we were primarily interested in the effects of concreteness on completion performance. On the assumptions that unitization can affect both implicit and explicit memory for new associations, we expected that concreteness of study pairs would affect both completion and recall performance.

Method

Subjects and design. Subjects were 48 University of Toronto students who participated either for pay or for credits in introductory psychology courses. The design included cue type (concrete vs. abstract) as a within-subjects factor.

Materials. One hundred and twenty-four words were required to construct 24 study list pairs, 6 practice and filler pairs, and 32 completion test distractor pairs. These words were between 4 and 10 letters long (mean = 5.9 letters) and of medium frequency (mean = 60.2; range 3–193 occurrences per million, Kučera & Francis, 1967). The 24 words that were used as targets for the study list pairs were selected according to the criteria described in Experiment 1. The 24 words that were used as the left-hand members or cues were selected from the Paivio, Yuille, and Madigan (1968) norms on the basis of concreteness: 12 words had high concreteness ratings (mean = 6.8, range = 6.6–7.0), and 12 words had low concreteness ratings (mean = 2.4, range = 1.5–3.6). The target words were also concrete, as judged by the experimenters, because many words did not appear in the norms. The cues and targets were randomly combined to form 12 "concrete" pairs and 12 "abstract" pairs. These pairs were used in the study list. Across subjects, the pairing of cues and targets was counterbalanced in such a way that all targets appeared equally often with concrete and abstract cues.

Of the remaining 76 words, 12 were randomly combined to produce 6 practice and filler pairs, and 64 were used to produce 32 completion test distractor pairs. Because the stems of the targets from the latter pairs were also used as cues on the completion test, the distractor pair targets were selected according to the same criteria as the study pair targets (see Experiment 1).

Tests. The completion test was constructed as in the preceding experiments. It consisted of a single page with a random arrangement of 56 test items, with each item composed of a word plus a word stem (e.g., BOULDER–GRO______). The word stems were the targets of the 24 study list pairs and of the 32 distractor pairs. For the latter, each test item showed a stem together with a cue word from a distractor pair. For the critical pairs, there were two types of test items: 12 items (6 with concrete and 6 with abstract cues) had a stem together with a cue that had been in the same critical pair, and 12 items (using the remaining 6 concrete and 6 abstract cues) had a stem together with a cue from a different critical pair. The first 12 of these test items were used to examine completion of targets tested in the *same* context (same-context test items) as in the study list, and the second 12 items were used to examine completion of targets in a *different* context (different-context test items) than in the study list. All test items were arranged randomly on the test form. Four versions of the form were required to test each studied target with concrete and abstract cue words and in same- and different-context conditions.

The recall test was different from that used in the preceding experiment. It consisted of a single page that listed the cues from the studied pairs in random order. This type of test, which is generally called a paired-associate test, does not provide a direct index of memory for new associations; nevertheless, we used it for the present experiment because it was convenient primarily for validating the experimental manipulation.

Procedure. The general procedure was the same as in Experiment 1. Each subject was tested individually. During study, subjects were presented with word pairs and required to generate and say aloud a sentence that related the two words from each pair (e.g., BOOK–FOREST) in a meaningful manner (e.g., "the BOOK included a picture of a FOREST"). The study list consisted of 29 pairs: the 24 critical pairs (12 with concrete cues and 12 with abstract cues) and 5 filler pairs, three of which were at the beginning of the study list and two were at its end. Across subjects, the pairing of concrete and abstract cues with target words was counterbalanced in such a way that all targets appeared equally often with concrete and abstract cues. The study list was presented once, at a rate of about 6 s per pair, with the sentence generating instructions described in Experiment 1.

The test phase followed immediately after the study phase. Each subject was first given a distractor task and then two memory tests: word completion followed by paired-associate recall. The distractor and completion test were given as described in Experiment 1. For the paired-associate recall test, which was given immediately after the completion test, the cues were the left-hand words from the study list pairs, and subjects were instructed to use these cues as aids for recollecting as many of the studied pairs as possible. The test was terminated when a subject had not remembered any further study list words for about 1 min.

Results

The main dependent measures were the proportions of studied targets produced on the completion test and the proportions of targets remembered on the paired-associate recall test. The mean proportions are shown in Table 3. For the completion test, overall performance was higher on same-context test items than on different-context items, and more important, the size of this associative influence was larger for pairs that were studied with concrete cue words (.40 and .22, respectively, for same- and different-context items) than for pairs that were studied with abstract cue words (.26 and .22, respectively, for same- and different-context items). An ANOVA showed a significant main effect for test items (same vs. different), $F(1, 47) = 15.8$, $MS_e = 0.039$, and for pair type (concrete vs. abstract), $F(1, 47) = 6.7$, $MS_e = 0.033$, as well as a significant interaction between these two factors, $F(1, 47) = 12.7$, $MS_e = 0.017$. Baseline performance, obtained from a separate group of 32 subjects, was similar for same (.11) and different (.10) context test items, and for items with concrete (.10) and abstract (.11) cue words, thereby indicating that the findings from the experimental conditions reflect memory for newly acquired information.

Overall performance on the paired-associate recall test was higher for targets that had been studied with concrete cues (.64) than for targets with abstract cues (.39); this is consistent with the results from previous studies (e.g., Paivio, 1971; Rissenberg & Glanzer, 1987). Because recall was assessed after word completion, we also computed separate scores for recall

Table 3
Experiment 3: Mean Levels of Completion Test Performance, With Concrete and Abstract Word Pairs, on Same- and Different-Context Test Items

	Materials			
	Concrete		Abstract	
Test type	Same	Different	Same	Different
Completion				
M	.40	.22	.26	.22
SE_m	.04	.02	.03	.03

of target words that had been produced as completions and of targets that had not been produced as completions. This conditional analysis showed higher recall for concrete than abstract pairs for targets that were produced as completions (.91 and .69, respectively, for concrete and abstract pairs), as well as for targets that were not produced as completions (.37 and .24, respectively, for concrete and abstract pairs). The difference between these sets of scores could be due either to an item difference (i.e., some words are easier to complete and recall) or to the facilitative effects of completion testing on subsequent recall (i.e., completion testing provides another study opportunity). Recall performance on the latter, non-completed words reveals the direct effects of cue type (concrete vs. abstract) on paired-associate recall.

Discussion

The critical finding from this experiment is that concreteness of study list words affected implicit memory for new associations. Although this finding supports the idea that concreteness facilitates the encoding of unitized representations, an alternative interpretation must also be considered. It is possible that subjects in Experiment 3 generated qualitatively different sentences for pairs with concrete versus abstract words and that this difference may have influenced the size of the associative effects on completion test performance. For example, subjects may have generated more meaningful sentences for pairs with concrete than abstract words. Previous research has indicated that an associative influence on completion test performance occurs only for paired words that are meaningfully related during study and does not occur for paired words that are embedded in an anomalous sentence, such as "The thankful VIRTUE sat at the DESK" (Graf & Schacter, 1985; Schacter & Graf, 1986). In view of this outcome, it is possible that the different findings from concrete and abstract pairs reflect a difference in the meaningfulness of the sentences that were generated during the study trial. Experiment 4 examined this possibility.

Experiment 4

In Experiment 4 we used the same general method as in Experiment 3 except that the study list consisted of sentences instead of word pairs, and explicit memory was assessed with a cued recall test as in Experiments 1 and 2. For each study list pair from Experiment 3 (e.g., BOOK–FOREST), we prepared a sentence that related the two words in a meaningful manner (e.g., "The BOOK included a picture of a FOREST"). During the study part, subjects read each sentence as it was presented on an index card, and they rated it in terms of meaningfulness. Memory was assessed with a word completion and cued recall test as in Experiments 1 and 2, thereby enabling a direct comparison between implicit and explicit memory for new associations. On the assumptions that concreteness facilitates the encoding of unitized representations and that unitization can affect both explicit and implicit remembering, we expected a larger associative effect with concrete than abstract pairs on both tests, word completion and cued recall.

Method

Subjects were 72 University of British Columbia students who participated for credits in introductory psychology courses. The design included pair type (concrete and abstract) as a within-subjects factor and test type (completion and cued recall) as a between-subjects factor. Thirty-six subjects were randomly assigned to each test condition.

The materials were the same as in Experiment 3 except that for each study list pair, we produced a sentence that related the two words in a meaningful manner (e.g., "He was in a good MOOD after the long TRIP"). Each sentence was printed on an index card, with the critical words appearing in capital letters.

The completion test form from Experiment 3 was used to assess both implicit and explicit memory. When this form was used to assess implicit remembering, it was given with the same instructions as in the preceding experiments: Subjects were required to read aloud each context word and then to complete the stem next to it with the first word that came to mind. When the form was used to assess explicit remembering, it was given as described in Experiment 1: Subjects were informed about the composition of the test items and instructed to recollect the capitalized words from the study list with the help of the test cues.

The general procedure was the same as for Experiment 3 except that instead of generating sentences for the study list pairs, subjects were required to read and rate sentences that were presented on index cards. A 5-point scale, with 1= *very loosely related*, and 5= *very closely related*, was displayed in front of the subject. As each sentence was presented, the subject read it aloud and then rated how loosely or closely it related the two capitalized words. The presentation of sentences was paced by subjects' speed on the rating task (about 6 s per sentence). After study, the name completion distractor task was given, followed by the word completion or cued recall test.

Results

The main findings are shown in Table 4. For the completion test, the means show higher performance on same- versus different-context test items, and more important, the size of the associative influence on performance was larger for concrete word pairs (.47 and .24, respectively, for same- and different-context test items) than for abstract word pairs (.29 and .20, respectively, for same- and different-context test items). An ANOVA showed a significant main effect for test items, $F(1, 35) = 25.9$, $MS_e = 0.033$, and for pair type, $F(1, 35) = 16.3$, $MS_e = 0.026$, as well as a significant interaction

Table 4
Experiment 4: Mean Levels of Completion and Cued Recall Test Performance, With Concrete and Abstract Word Pairs, on Same- and Different-Context Test Items

	Materials			
	Concrete		Abstract	
Test type	Same	Different	Same	Different
Completion				
M	.47	.24	.29	.20
SE_m	.04	.03	.03	.02
Cued Recall				
M	.58	.28	.42	.26
SE_m	.04	.04	.04	.03

between these two factors, $F(1, 35) = 7.4$, $MS_e = 0.025$. A control group of 24 additional subjects showed that base rate performance was lower (.09) and comparable across test items and pair types, thereby indicating that performance in the experimental conditions reflects memory for newly acquired information.

The means from the cued recall test were higher on same- versus different-context test items, and the size of this associative influence was larger for concrete word pairs (.58 and .28, respectively, for same- and different-context test items) than for abstract word pairs (.42 and .26, respectively, for same- and different-context test items). An ANOVA showed a significant main effect for test items, $F(1, 35) = 51.0$, $MS_e = 0.037$, and for pair type, $F(1, 35) = 8.7$, $MS_e = 0.03$, as well as a significant interaction between these two factors, $F(1, 35) = 7.3$, $MS_e = 0.025$.

An ANOVA of the combined results from the completion and recall test showed a significant main effect for test type, $F(1, 70) = 5.9$, $MS_e = 0.089$, reflecting the higher overall recall versus completion test performance. More important, no interactions involving test type approached significance.

Discussion

These findings strengthen and extend the results from Experiment 3. The finding of similar associative effects with study tasks that required subjects to generate sentences (Experiment 3) or to read experimenter-produced sentences (Experiment 4) weakens the argument that the larger associative effects for concrete than abstract pairs reflect a difference in the meaningfulness of the study sentences. Moreover, a statistical analysis showed that during the study phase of Experiment 4, subjects gave similar meaningfulness ratings for sentences with concrete (3.78) and abstract (3.62) word pairs, $t(35) = 1.5$. In view of these ratings, it appears that concreteness has a direct influence on implicit memory for new associations by facilitating the encoding of unitized pair representations.

The finding of similar patterns of completion and recall performance has two possible interpretations; first, that concreteness influences unitization of target representations which contributes to both explicit and implicit remembering, or second, that concreteness influences both unitization and grouping of representations. The results from the present study do not allow us to choose between these possibilities.

General Discussion

In the present experiments we examined the idea that memory for newly acquired associations is mediated by two factors—unitization and grouping. Two relevant patterns of results were observed. First, Experiments 1 and 2 showed that study task manipulations can selectively influence the size of associative effects on cued recall tests while having no effect on word completion performance; cued recall of new associations was higher after the story than sentence generating task in Experiment 1 and after the topic versus length sort task in Experiment 2, even though all tasks had similar effects on completion test performance. Second, Experiments 3 and 4 showed that a materials manipulation—concreteness—had a similar influence on completion and cued recall test performance; both test types showed larger associative effects when subjects studied concrete versus abstract word pairs, either by generating a sentence for each pair (Experiment 3) or by rating such sentences in terms of meaningfulness (Experiment 4). This collection of findings is consistent with the proposal that implicit memory for new associations is mediated primarily by the unitization of target representations, whereas explicit memory for new associations is affected by both grouping and unitization of representations.

Consider, first, the completion test results. The elaborative study tasks used in the present experiments, as well as in our previous experiments (e.g., Graf & Schacter, 1985, 1987; Schacter & Graf, 1986, 1989), required subjects to connect paired words in a meaningful manner. We argue that this activity involves interpreting each word pair as a single, coherent unit, and thereby establishes a unitized representation. The finding of similar completion test effects across different conditions (Experiments 1 and 2) was expected because the study tasks did not manipulate unitization. To explain the additional finding of larger associative completion effects with concrete than abstract pairs (Experiment 3 and 4), we emphasize that the former evoke more attributes and images than do the latter and that a larger and more varied set of attributes presents more opportunities for encoding two words in a unitized manner.

The effects of concreteness on implicit remembering might reflect either a change in the probability that two words were encoded in a unitized manner or a change in the distinctiveness of encoded unitized representations. Because concrete words evoke more images and associations than do abstract words, subjects are more likely to succeed in constructing an interpretation that combines two paired words into a single unit. Alternatively, it is possible that although all pairs were encoded in a unitized manner, concrete words gave rise to more distinctive units than did abstract words, and in turn, more distinctive representations may be more likely to become reactivated or redintegrated during testing. A difference in the distinctiveness of unitized representations may reflect the use of different types of information (e.g., semantic, visual, phonemic, spatial) for connecting paired words, with concrete and abstract pairs being encoded in terms of different types of information. On the basis of our previous findings that implicit memory for new associations occurs only with study tasks that require subjects to engage in some form of semantic elaborative processing, we have assumed that unitization is achieved by encoding semantic/conceptual information.

The results from a recent, unpublished experiment, however, suggest that visual imagery may also provide an effective dimension for unitization. In this experiment, 16 subjects studied pairs of unrelated words (all concrete) either in a condition that required reading and rating sentences for meaningfulness, as in Experiment 4, or in a condition that required forming an interactive image of the paired words. For the latter task, subjects were asked to "picture" the objects named by the paired words in interaction with each other.

Immediately after study, completion and paired associate recall test performance were assessed as in Experiment 3. Overall completion test performance showed a larger associative effect following the imagery task (.46 and .25, respectively, on same- and different-context test items) than following the meaningfulness rating task (.29 and .20, respectively, on same- and different-context test items), and as expected from previous research, paired associate recall was higher after the imagery task (.65) than the meaningfulness rating task (.37). The pattern of completion test performance suggests that visual imagery provides an effective dimension for unitization (cf. Begg, 1978). It is possible that imagery (which is closely related to concreteness, Paivio et al., 1968) mediated the present finding of larger associative effects with concrete than abstract word pairs.

The possibility that pair representations can be unitized along different stimulus dimensions was also raised by the recent finding that implicit memory for new associations was larger when study and test were in the same modality (visual) than when they were in different modalities (visual at study and auditory at test) (Schacter & Graf, 1989). Modality-specific priming is surprising in view of previous evidence indicating that implicit memory for new associations occurs only with study tasks that require some form of semantic, elaborative processing (e.g., Graf & Schacter, 1985; Schacter & Graf, 1986), which is generally assumed to be independent of study modality. To accommodate this finding, we suggest that semantic/elaborative processing provides the "glue" (the structure) that unitizes sensory/perceptual and other features of paired words that are processed concurrently during the study trial. Because written and spoken words differ in at least some of the features that are processed during study, the content of unitized representations is (at least in part) modality specific. By the assumption that redintegration of unitized representations is triggered by reprocessing study trial information during testing, encoding modality-specific information is important because it is made available by the test cues. In this way, modality-specific information provides the access key to previously unitized pair representations.

Interpretation of the cued recall test results from the present study is straightforward. The finding that cued recall of new associations was higher after the story versus sentence task (Experiment 1) and after the topic versus length sort task (Experiment 2) was expected by the following assumptions: first, that explicit remembering depends on grouping and unitization of representations, and second, that grouping is emphasized by encoding targets in relation to each other (as in the story task) and in relation to distinctive situational cues (as in the topic sort task). Concreteness may have influenced explicit remembering via its effect on unitization. We suggested in the introduction that unitization can facilitate explicit remembering by making target items "pop to mind" more easily in response to test cues (cf. Mandler, 1982). In general, this effect of unitization on target reconstruction should be particularly strong on tests, such as cued recall, that require targets to be produced in response to cues and should be weaker on tests, such as recognition, that do not require target production. These speculations about the effects of unitization on explicit memory tests may explain, in part, the previous finding that implicit and explicit remembering are more likely to be independent of each other when explicit memory is assessed with a recognition test (see Tulving, Schacter, & Stark, 1982) than with a cued recall test (see Graf & Schacter, 1985; Schacter & Graf, 1986).

The present proposal that implicit and explicit memory for new associations is mediated by unitization and grouping of representations is in some respects related to an account of priming known as the *activation view* (e.g., Graf & Mandler, 1984; Graf et al., 1984; Mandler, 1980; Mortensen, 1980; Rozin, 1976). Extant activation views differ in several important respects, but they share the basic idea that when an item is presented for study, its representation in memory is automatically activated, and this activation facilitates subsequent implicit remembering. It is important to note, however, that extant views fail to explain implicit memory for new associations because new associations have no preexisting representation that can be activated during the study trial (for other problems with activation views, see Jacoby, 1983; Schacter, 1987).

The relation between activation views and the present account emerges from a consideration of what is thought to occur as a result of activation. According to one view, it is assumed that when a familiar item is presented for study, its preexisting representation is automatically activated, thereby increasing the integration of (i.e., the internal organization among) its components and, in turn, facilitating subsequent redintegration (Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Mandler, 1980). We envisage a similar processing sequence for priming of new associations. The difference is that by our account, unitization is *not* automatic when an item is presented for study; instead, it depends on study activities that involve conceiving paired words as coherent entities, thereby establishing unitized representations (cf. Schacter & McGlynn, 1989). In other words, we share the notion that what mediates implicit remembering is the redintegration of unitized target representations, but we believe that unitization is achieved differently for familiar and unfamiliar items. It is possible that the unitized encoding of familiar items is automatic because processing is guided by preexisting representations, whereas in the absence of such a representation—for unfamiliar, new items—unitized encodings are achieved only with study tasks that involve some form of elaborative processing. In any event, our account emphasizes that specific processing activities performed at the time of study play a crucial role in subsequent implicit remembering performance, in agreement with other views (e.g., Jacoby, 1983; Roediger & Blaxton, 1987; Schacter, in press; Schacter et al., in press).

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