Journal of Experimental Psychology: Human Learning and Memory
1976, Vol. 2, No. 2, 172–181

Imagery and the Retention of Free-Recall Learning

Lynn Hasher, Barbara Riebman, and Frances Wren
Temple University

Three studies investigated the effects of imagery on long-term retention in a free-recall task. In the first experiment, the retention of lists of pictures versus lists of words learned under either imagery, verbal, or standard free-recall learning instructions was compared. In the second, the retention of concrete nouns learned under one of three types of imagery or standard free-recall learning instructions was compared. In the final experiment, the retention of lists of concrete versus abstract nouns was compared. While imagery facilitated learning in several of these situations, in no instance did it result in superior long-term retention. These results seem not to support either a dual-codes model of the operation of imagery in memory or a redintegration model.

The facilitative effects of imagery on performance occur across a wide range of experimental tasks (cf. Paivio, 1971). In general objects and pictures of objects are easier to learn than are their verbal labels, and these verbal labels are in turn easier to learn than are the labels of abstract referents. Several explanations of these findings have been offered. The first is the dual-encoding hypothesis (cf. Paivio, 1971). It proposes that objects, pictures, and, to a lesser extent, concrete words can be encoded in two independent ways, one involving a nonverbal code, an image, the other involving a verbal code, an associate or meaning. The availability of dual codes is presumed to be greatest for objects and pictures, intermediate for concrete nouns, and least for abstract nouns. Dual encoding presumably enhances the probability of an item's being recalled because access to that item can be gained from either code.

While dual codes may well exist (Paivio & Csapo, 1973), it is entirely possible that the advantage for items so encoded stems not from the availability of both codes but instead from the operation of one, the imaginal code. In particular, Begg (1973) has argued that the imaginal coding system itself has a dual advantage over the verbal coding system: (a) an image is more flexible in that it can easily integrate new members into an extant unit; (b) each component of an image is a more effective cue for redintegrating the remaining components. In essence, then, it is the cohesiveness of an image that gives this type of code its presumed advantage over verbal codes.

Alternatively, it is possible that imaginal representations are stronger than are verbal representations, in the sense that they are more accessible to retrieval processes than are verbal representations. All three models can account for the typical advantage that objects and pictures have over concrete materials and the advantage the latter, in turn, have over abstract materials, as measured by immediate recall in any number of tasks.

A further question about the usefulness of imaginal codes can be raised: Do they facilitate retention? That is, when materials that differ in imagery evocation are equated for level of learning are there differences in the rate at which they are forgotten? While no model is explicit on this issue, all three can be extended in such a way as to predict the superior retention of imagery-coded items. If Paivio's dual codes are partially independent, then even after a

This research was supported by a grant from the Temple University Grants-in-Aid Committee. We wish to acknowledge the able and spirited assistance of Michael Greenberg to these studies. Portions of Experiment I were presented at the Eastern Psychological Association Meetings, 1974.

Requests for reprints should be sent to Lynn Hasher, Department of Psychology, Temple University, Philadelphia, Pennsylvania 19122.

time interval that allows for some decay of the codes, access to that memory should be mediated by whatever remains of the two codes, a situation that should result in superior retention relative to one in which access is mediated by a single, verbal code. A redintegrative process might predict superior retention because whatever small portion of the imagery-based memory remains available over time, or perhaps is cued by the experimental context, will be able to reinstate more of the original memory than can be reinstated by the remains of a verbal code. Finally, imaginal codes may be more accessible because they are more resistant to interference than are verbal codes.

In paired-associate tasks there is already some evidence that does not support the prediction of long-term facilitation of imagery codes. Postman and Burns (1973) found greater forgetting for concrete stimulus pairs than for abstract pairs. That there are no retention differences favoring concrete over abstract materials in paired-associate learning could pose a problem for our interpretation of the dual-codes model. If two partially independent codes are better than one on an immediate test of recall, why should they not also be better after a delay? Similarly, a resistance-to-interference interpretation of imagery codes is not supported by these data.

The redintegration hypothesis need not be so troubled by such findings. After all, it may be that redintegration operates best when a single memory unit contains more information than just the two members of a pair. Thus a test of this model may be better accomplished within the framework of a free-recall task where a single memory unit comes to contain several items.

One free-recall study (Begg & Robertson, 1973, Experiment 1) has compared the long-term retention of lists of abstract versus concrete nouns. While superior retention was found for the concrete lists, there are several problems with the study that leave the outcome uncertain (cf. Postman, 1974). For example, a method of acquisition was used in which performance was at ceiling from the beginning of practice. Since perfect performance subsumes unmeasurable variations in strength, it is not possible to determine if the lists were equated at the end of practice. In this particular case, since an equal number of trials was given for both concrete and abstract lists, it is likely that the concrete lists were better learned than the abstract. This acquisition difference could then account for the differences seen at retention. Other studies have also failed to equate materials for degree of learning prior to the retention interval (e.g., Butter & Palermo, 1970; Yuille, 1971).

There is a recent study (Postman & Burns, 1974) which did compare retention of words that differed in concreteness; it also succeeded in equating the terminal levels of learning. Postman and Burns found under some, but not all, conditions less forgetting for the concrete than for the abstract words.

The following studies were undertaken to demonstrate the long-term effectiveness of the imagery code. It seemed possible, independent of any of the above imagery models which may but need not be extended to the issue of long-term retention (e.g., Paivio, 1975), that imagery would be one of the few encoding variables to influence long-term retention (e.g., Hasher & Johnson, 1975; Postman, 1970). On the other hand, it is possible that imagery is a variable like meaningfulness and intralist similarity in that it facilitates acquisition but has no effect on retention (cf. Postman, 1971, pp. 1122–1132).

Experiment 1

We began with a study that compared the retention of lists comprised of pictures with lists comprised of the verbal labels of those pictures. In addition, for each set of materials, there were three types of instructions given to subjects: verbal-elaboration instructions, imagery-elaboration instructions, and standard free-recall instructions. Retention was tested either immediately after the end of learning or two weeks later. We expected to see retention differences in favor of picture lists and also in favor of groups using imagery as a mnemonic.

Method

Design. The design was a 2(Materials) × 3(Instructions) × 2(Retention Interval) factorial. There were thus 12 unique conditions in the experiment.

Materials. Two 18-item lists of pictures of common objects were selected from a set of colorful drawings used in a children's game. Only 14 of the 36 words were contained in the Paivio, Yuille, and Madigan (1968) norms. For these words the mean I rating was 6.58. The two lists were equated for their Thorndike–Lorge (1944) frequency of occurrence. Meaningful similarities within a list were minimized.

For each list, four unique study–trial orders were devised. Items were assigned randomly to position with the exception that each could occupy the first or last two positions only once acoss the four orders. The same orders were used for the two picture lists and the two word lists. The words were photographed in black uppercase letters and the pictures were photographed in color.

Three sets of learning instructions were used in the experiment. In the standard condition, three example items were included in a set of standard free-recall instructions. No suggestion was made about the possibility of grouping items together into rehearsal units. Example items were unrelated to any on the critical list but were similar to those on the list in imagery and frequency values. In the two remaining conditions, instructions were identical with the exception that the sample items were presented along with instructions encouraging the use of the appropriate mnemonic. Thus, in the imagery condition, subjects were instructed to imagine a picture or scene that grouped together several of the items they were trying to learn. Then they were given an example of a scene relating the sample items. In a similar manner, subjects in the verbal condition were told to think of a phrase or sentence that would relate groups of items and an example sentence including the sample items was presented.

Procedure. Subjects learned a single free-recall list by the study–test method. The first study trial began immediately after appropriate instructions were read. Items were presented on a wall for 2.5 sec plus an approximately .8-sec slide-change interval. This rate was selected after approximately 40 pilot subjects reported that they were able to use the imagery instructions. While some might argue that this is a rate too fast for the implementation of mnemonics our subjects reported they could do so and there was evidence in the literature that mnemonic elaborative instructions could be implemented at similar rates (e.g., Prestianni & Zacks, 1974). Written recall followed immediately after the last slide of each study trial and lasted 1.5 min. The recall sheet was then collected and scored during the next study trial. Approximately 2 sec were required for collecting the recall sheet and for starting the projector. Acquisition continued to a criterion of 14 out of 18 items correct plus one trial.

The retention interval began immediately after the attainment of criterion. For both immediate and delayed recall conditions, two successive 4-min written recall tests were given followed by a detailed interview with each subject concerning the strategy or strategies used in learning the list.

Subjects. One hundred and sixty-eight subjects were recruited from introductory psychology courses. There were 12 subjects randomly assigned to each of the six immediate retention conditions and 16 subjects randomly assigned to each of the six delayed recall conditions. Subjects were assigned in randomized blocks of the 12 conditions until 12 slots in the immediate and delayed conditions were filled. The four remaining slots of the delayed conditions were then filled, also according to randomized-blocks assignment. Due to an error, the number of subjects who needed to be replaced is unknown. However, the replacement rate in Experiments 2a and 2b of this series was very low and not related to any particular experimental condition.

Results

Acquisition. Learning speed was assessed by the number of trials taken to attain the criterion of 14/18 correct. These values may be seen in Table 1. A 2 × 3 × 2 weighted-means analysis of variance was performed with materials, instructions, and time of test as independent factors. Unless otherwise indicated, the alpha level in this experiment is .05. Picture lists were learned faster than word lists, $F(1, 156) = 5.51$, $MS_e = .73$. Instructions, however, did not influence learning speed, $F(2, 156) = 1.82$. In particular, instructions to image did not facilitate acquisition relative to a standard free-recall condition as has been found elsewhere (Morris & Stevens, 1974). Our standard instructions, however, did not warn subjects against grouping items together as was the case in the Morris and Stevens (1974) study. In addition, as will be noted later, a large number of subjects in the standard-instructed conditions spontaneously used either imagery or grouping strategies in learning.

In order to assess long-term retention, it is critical that groups of subjects be equated in the level of learning attained at the end of acquisition. This was assessed by performance on the final learning trial (Table 1), that is, on the trial following the attainment of criterion. A 2 × 3 × 2 analysis of variance found no significant differences

TABLE 1

MEAN ACQUISITION AND RETENTION PERFORMANCE, EXPERIMENT 1

Instructions and retention interval	Word Lists: Trials to criterion	Word Lists: Terminal trial recall	Word Lists: Loss scores Trial 1	Word Lists: Loss scores Trial 2	Picture Lists: Trials to criterion	Picture Lists: Terminal trial recall	Picture Lists: Loss scores Trial 1	Picture Lists: Loss scores Trial 2
Standard								
Immediate	2.83	15.00	−.75	−.83	2.08	14.92	−.25	−1.00
Delay	2.44	15.94	4.88	4.50	2.31	15.69	4.17	3.31
M	2.64	15.47			2.20	15.31		
Verbal								
Immediate	2.83	15.33	−.92	−.50	2.33	15.67	−.42	−.83
Delay	2.56	15.38	5.81	5.31	2.37	15.06	5.69	5.06
M	2.70	15.36			2.35	15.37		
Imagery								
Immediate	2.25	15.50	−1.00	−.42	1.92	16.42	−.50	−.42
Delay	2.37	15.94	4.75	4.25	2.35	16.06	3.19	2.81
M	2.31	15.72			2.14	16.24		
Grand *M*	2.55	15.52			2.23	15.64		

among the conditions. The apparent advantage of imagery over other types of instructions was not quite significant, $F(2, 156) = 2.25$, $MS_e = 2.61$.

Retention. Loss scores, where each subject's performance at retention is subtracted from his recall on the terminal learning trial, were used as the measure of forgetting. These are seen in Table 1. Loss scores are thought to be the most sensitive measure of retention since they are responsive to whatever small, undetected differences might have occurred on the final acquisition trial. These scores were subjected to a $2 \times 3 \times 2 \times 2$ weighted-means analysis with materials, instructions, and time as between-subject factors and the two successive retention trials as a within-subject factor.

Substantial forgetting was of course seen over the two week interval, $F(1, 156) = 212.15$, $MS_e = 5.10$. Forgetting, however, did not differ for pictures as compared to words, either as a main effect, $F(1, 156) = 1.56$, or in interaction with time, $F(1, 156) = 2.23$. The only evidence that there was any advantage for pictures as compared to words came from the Materials × Retention Tests interaction, $F(1, 156) = 6.09$, $MS_e = .47$. Subjects recalling picture lists showed a greater gain from the first to the second recall trial than did the subjects recalling word lists.

The main effect of instructions was marginally significant, $F(2, 156) = 2.27$, $MS_e = 5.10$. Subjects given verbal-elaboration instructions apparently did poorer than subjects given imagery-elaboration or standard free-recall instructions. No other main effects or interactions were significant. Using two other measures of memory, number of words recalled, and the number recalled expressed as a proportion of the number recalled on the terminal trial, the pattern of results was identical with one exception. For both measures the Instructions × Time effect attained significance, $F(2, 156) = 3.89$, $MS_e = 5.95$, for number recalled. As can be seen in Table 1, there was some tendency towards greater forgetting by subjects given the verbal-elaboration instruction. Subjects given imagery instructions, however, did no better than subjects given standard free-recall instructions.

Intrusions. While the intrusion rate on the two retention tests was low, ranging on the delayed test from .25 to 1.68 items per subject, a pattern emerged that was systematic across both word and picture lists and also across immediate and delayed tests of recall: There were more intrusions under verbal instructions than under either imagery or standard instructions, $F(2, 156) = 6.57$, $MS_e = .86$. Perhaps the verbal-instructed subjects

TABLE 2

Frequency of Reported Dominant Strategy, Experiment 1

Reported strategy	Word lists: Instructions: Standard	Verbal	Imagery	Word lists: Total	Picture lists: Instructions: Standard	Verbal	Imagery	Picture lists: Total
Groups or categories	13	5	4	22	8	5	5	18
Sentences or phrases	1	6	0	7	1	5	1	7
Pictures or scenes	10	15	24	49	12	14	19	45
Other	1	1	0	2	1	0	0	1
Nothing	3	1	0	4	6	4	3	13

confused the nouns they generated during acquisition with those that were actually presented on the list. An alternative explanation for both the high intrusion rate of these subjects and their poor recall has to do with the fact that subjects reported difficulty in implementing the verbal strategy during learning. Many reported changing strategies midway through learning. The failure to devise a stable acquisition strategy, or retrieval plan, may have resulted in greater forgetting. Whatever the explanation, these results are not consistent with those of an earlier study (Postman & Burns, 1973) which showed more decoding errors (intrusions) for concrete than for abstract words.

Postexperimental interview. On the basis of the postexperimental interview, various learning strategies could be identified (see Table 2). Across all conditions, slightly more than half the subjects reported using imaginal strategies as their dominant method of learning. Another 25% of subjects reported using categorizing or grouping strategies. Finally, sentences or phrases were used by about 8% of the subjects. It should be noted that almost all subjects reported using more than one strategy during acquisition. This is consistent with other findings (Boltwood & Blick, 1970).

A further test of the effect of imagery on retention was accomplished by sorting subjects into three groups, imagery, categories, or sentences, on the basis of their dominant learning strategy. The acquistion and retention scores for these new assortments of conditions were then submitted to a weighted-means analysis of variance. No systematic relation was found between reported use of mnemonic strategies and either acquisition or retention scores. Postman and Burns (1973) also reported the lack of any relationship between subject reports and loss scores.

Discussion

As has been found in other studies, the imageability of materials does indeed facilitate acquisition in a free-recall task: Lists comprised of pictures were more easily learned than lists comprised of their verbal labels (e.g., Bahrick & Boucher, 1968). What has not been found in this study is any relation between imagery and retention. Picture lists were no better remembered than word lists. Lists organized by an imagery mnemonic were no better recalled than lists organized by subjects given standard free-recall instructions. In addition, when subjects were sorted into mnemonic conditions on the basis of their own reports, there were no systematic effects of imagery on either acquisition or retention. This finding must be viewed with caution since subjects returning after a 1- or 2-week interval may well have confused the strategy they used in learning. Whatever interpretation is to be placed on the mnemonic strategy evidence, one outstanding result is clear: Lists of pictures are not better remembered than are lists of concrete nouns.

There is an exception to a strong conclusion regarding the lack of an imagery effect on retention: A greater improvement in recall was seen across the two retention test trials for subjects who learned lists of pictures than for subjects who learned lists of words. One might argue that this improvement reflects a redintegration or hypermnesia process (e.g., Shapiro & Erdelyi, 1974) applicable to pictures but not to words. However, the conditions and materials under which similar increases in recall have been found when the subject receives no feedback about his performance vary widely (e.g., Hasher & Johnson, 1975; Richardson & Gropper, 1964). While this does not deny the operation of a redintegration mechanism, imagery seems to be at best an uncertain component of it.

We began a second set of studies because, on two counts, we remained unconvinced that there is no relation between imagery and long-term retention. Our first concern was with the possibility that the present materials resulted in an insensitive test of the utility of imagery. Although pictures were learned faster than words, a finding usually attributed to the operation of imagery and so one which led us to expect retention differences, an imagery-based explanation of the lack of such differences is possible. Given the high-imagery values of the words we used it is possible that by the end of learning, the extent of imagery formation was equivalent for the two sets of materials.

A second and more basic concern was with the nature of the imagery used by subjects in learning. Instructions for the second experiment were based on information provided by subjects who showed excellent retention over the two-week interval of the first experiment. These subjects reported the use of very particular types of imagery mnemonics. Specifically, a few such subjects reported using highly idiosyncratic images, "the *ship* I was stationed on in the Navy." Others reported imagery that was filled with physical activity, "I imagined myself carrying a *drum* while walking on the grass." Perhaps it is the case that imagery is an effective mnemonic if the image is of a particular type; a static image of "red *shoes*" may not be sufficient to facilitate retention. The utility of action or enactive imagery in immediate memory tasks has been reported (e.g., Lampel, 1973; Lippman, 1974). Perhaps then, the type of imagery formed during learning is a more important determinant of long-term memory than the fact that an image is formed. Consequently, our instructions in Experiment 2a sought to vary the types of imagery used during acquisition in order to determine if these would result in differential long-term retention.

Experiments 2a and 2b

In Experiment 2a, subjects learned free-recall lists of concrete nouns under one of four instructional sets: (a) free recall, which, in this experiment, although not in Experiment 1, included advice to subjects about grouping items together as they learned; (b) static imagery, which encouraged subjects to form a static image of each word; (c) idiosyncratic imagery, which encouraged subjects to form images of items as they themselves had seen them outside the laboratory; (d) action imagery, which encouraged subjects to form images that included some action they might perform with the items. Based on the postexperimental inquiry of Experiment 1, we expected to find that subjects who used action or idiosyncratic plus action images would remember more of the list they had learned after a week's retention interval than would other subjects.

Experiment 2b consisted of two groups of subjects who learned and recalled free-recall lists comprised of abstract nouns equated for meaningfulness and frequency with the concrete nouns of Experiments 1 and 2a. One group recalled immediately after the end of learning, the other after a week's retention interval. The retention of these abstract-noun lists was compared to the retention of the concrete-noun lists learned in Experiment 2a. We assumed that the retention of concrete words would be better than the retention of abstract words. It should be noted that these experiments are initially presented as two separate studies because we began the second experiment before we considered it important to include the two conditions of Experiment 2b. We believe it appropriate to make these comparisons because the two studies partially overlapped in time, and, in addition, there is evidence that time of the academic year does not influence performance in learning tasks (Underwood, Schwenn, & Keppel, 1964).

Method

Design. Experiment 2a, in which the effectiveness of different types of imagery was compared, was a 4 × 2 factorial design. Subjects learned a list of concrete nouns under one of four instructional sets: static imagery, idiosyncratic imagery, action imagery, or free recall. Retention was tested for each of these conditions at one of two times, immediately after the end of learning or 1 week later.

Experiment 2b consisted of two groups of subjects who learned a list of abstract nouns under free-recall instructions and whose retention was tested either immediately after the end of learning or 1 week later.

Materials. The two lists of 18 concrete nouns used in Experiment 1 were also used in Experiment 2a. For Experiment 2b, two lists of 18 abstract nouns were required. The mean imagery rating for the abstract lists was 4.10 (Paivio, Yuille, & Madigan, 1968). While this imagery rating was somewhat high for the abstract words, the words were selected to be similar in meaningfulness with the words on the concrete lists; m = 6.38 for abstract words, 6.92 for concrete. In addition, the abstract lists were also equated with the concrete lists for Thorndike–Lorge (1944) frequency of occurrence; the two abstract lists each had 13–14 A and AA words and the remaining words a mean of 25.02, while the two concrete lists had 9–10 A and AA words and a mean of 23.38 for the remaining words.

Four orders of presenting items were devised so that the position a word occupied was varied across study trials. In particular, the initial and terminal positions were occupied by different items across successive orders of presentation. These orders were used for each of the lists in the study. In addition, two different orders through the sequence of four were used equally often for each list. Each concrete list and running sequence was used equally often in the eight conditions of Experiment 2a, as was each of the abstract lists in the two conditions of Experiment 2b.

Procedure. The procedure for the two studies was identical and will be described for both. As in Experiment 1, all subjects were run individually. The first study trial began immediately after appropriate instructions were read. Words were presented via a Kodak Carousel slide projector for 2.5 sec, with an approximately .8-sec slide-change time. A 1.5-min written recall test was used. The recall sheet was then collected and scored during the next study trial. About 2 sec were required for collecting the recall sheets and for starting the projector. Acquisition continued to a criterion of 14 correct words plus the one trial in progress during the scoring of what turned out to be the criterion trial.

For subjects in the immediate recall conditions, the test of retention began immediately after the terminal trial. Subjects were given 3 min. to write down as many of the words as they could. Their recall sheets were collected and the subjects were reminded of the particular strategy that had been suggested at the beginning of the experiment, handed another blank sheet of paper, and asked to recall again. Three min. were allotted for the second recall. This same test procedure was followed for subjects in the delayed retention conditions. Delayed subjects were dismissed immediately after the terminal learning trial and were told not to worry about the second part of the study during the week's interval. After the second recall test, all subjects were interviewed to determine the type and number of learning strategies employed.

Subjects. Sixteen subjects served in each of the eight conditions of Experiment 2a, and 12 subjects in the two conditions of Experiment 2b, for a total of 152 subjects. Subjects were assigned randomly across a block of eight conditions for the concrete conditions (Experiment 2a) and a block of two for the abstract conditions (Experiment 2b). The abstract conditions were not run in tandem with the concrete conditions, but did partially overlap them in time, and all subjects were run within the same academic year. All subjects were members of an undergraduate introductory psychology course and most received extra credit for their participation. In all, 10 subjects needed to be replaced: 3 delay subjects failed to return for the second part of the study; 7 other subjects were discarded because of equipment problems.

Results and Discussion

Experiment 2a. Two 4 × 2 analyses of variance were performed on acquisition measures, the first on trials to criterion, the second on performance on the terminal learning trial. Again, the alpha level was .05, except where otherwise indicated. As is obvious from Table 3, these analyses revealed no significant sources of variation. Learning speed was equivalent across all four instructional sets, $MS_e = 1.68$. The lack of differences on the terminal test trial indicates that the levels of learning were equated across all conditions, $MS_e = 2.22$.

Loss scores were used as the measure of forgetting and a 4 × 2 × 2 repeated-measures analysis of variance that included the two successive recall tests as a factor was done. Substantial forgetting was seen across the week's interval, $F(1, 120) = 125.84$, $MS_e = 9.66$. Forgetting, however, did not

TABLE 3

Mean Acquisition and Retention Scores, Experiment 2a

Instructions and retention interval	Trials to criterion	Terminal recall	Loss scores	
			Trial 1	Trial 2
Free recall				
Immediate	2.44	15.31	−.38	−.31
Delay	3.25	15.25	3.75	3.56
M	2.84	15.28		
Static imagery				
Immediate	2.50	15.38	−.62	−.88
Delay	2.38	15.50	3.94	3.50
M	2.44	15.44		
Idiosyncratic imagery				
Immediate	2.81	16.06	−.56	−.50
Delay	3.19	15.25	4.38	3.88
M	3.00	15.66		
Action imagery				
Immediate	2.81	15.38	−.81	−1.00
Delay	2.31	15.50	3.75	3.06
M	2.56	15.44		

differ among the instructed conditions ($F < 1$). The only other significant effects involved the improvement seen across the two recall tests, $F(1, 120) = 8.70$, $MS_e = .52$, which was greater at the delayed test of recall than at the immediate test, $F(1, 120) = 4.33$. This same pattern of results was obtained for two other measures of memory: number of words recalled and the proportion of terminal-trial words recalled.

We were hesitant to conclude that the use of imagery had no effect on retention because of the possibility that subjects had failed to follow the specific instructions they were given. The postexperimental interviews confirmed that while more subjects in the imagery conditions reported using this mnemonic than did subjects in the free-recall condition, the particular type of imagery did not necessarily conform to our instructions.

With respect to the broader question addressed in Experiment 1, of whether or not imagery in general influences retention, we must report more negative evidence. First, while reported use of imagery was higher in the imagery-instructed conditions than in the free-recall conditions, no differences in retention were observed. Secondly, we again sorted subjects into two groups based on whether or not a subject reported using imagery during learning. A 2 × 2 weighted-means analysis of variance was performed that included reported imagery use versus nonuse and retention intervals as factors. Imagers learned a half trial faster (2.61) than did nonimagers (3.11). This difference was not significant, $F(1, 66) = 2.21$, $MS_e = 1.86$. Again, reported imagery did not influence retention ($F < 1$).

Experiment 2b. The performance of the two conditions learning abstract lists in 2b was compared to that of the eight conditions learning concrete lists in Experiment 2a by means of a 2 × 2 unweighted-means analysis of variance. All eight concrete conditons were included in the analysis because together they represent the best estimate of learning and retention with these materials.

The acquisition and retention scores may be seen in Table 4. Abstract lists were learned slightly slower than concrete lists, although this difference did not quite attain significance, $F(1, 148) = 3.60$, $p = .054$, $MS_e = 1.63$. It should be noted that there is reason to believe that the learning-speed advantage that concrete materials have over abstract is more pronounced in mixed-list than in unmixed-list free-recall tasks (cf. Postman & Burns, 1974). There were no other acquisition speed differences. There were also no differences among conditions with respect to performance on the terminal learning trial, all $Fs < 1$.

Retention was assessed using loss scores. The 2 × 2 × 2 analysis showed, of course, significant forgetting across the week's inter-

TABLE 4

Mean Acquisition and Retention Scores, Experiments 2a and 2b

List type and retention interval	Trials to criterion	Terminal trial recall	Loss scores	
			Trial 1	Trial 2
Concrete nouns				
Immediate	2.64	15.53	−.59	−.67
Delay	2.78	15.37	3.95	3.50
Abstract nouns				
Immediate	2.92	15.50	.50	.17
Delay	3.58	15.00	3.92	3.08

val, $F(1, 148) = 60.62$, $MS_e = 9.44$. However, the difference between abstract and concrete materials was not significant, as either a main effect ($F < 1$) or in interaction with time, $F(1, 148) = 1.87$. As in the earlier studies, there was significant improvement across the two test trials, $F(1, 148) = 13.27$, $MS_e = .55$. Again, this same pattern of results was found for the two other measures of recall, number of items recalled, and proportion of terminal-trial items recalled.

Thus, when the retention of unmixed lists of abstract nouns is compared with the retention of unmixed lists of concrete nouns, there is no difference in the rate of forgetting (Postman & Burns, 1974). It should be noted that in the Postman and Burns study, a second set of conditions was comprised of mixed lists of abstract and concrete nouns. In that case, retention was superior for the concrete members of the list. It is possible, as Postman and Burns suggest, that some of the advantage concrete items have under mixed-list conditions is accounted for by retrieval phenomena such as the inhibition of weak items by strong ones (Tulving & Hastie, 1972).

A final point should be made with regard to intrusions. In the present study, subjects who recalled abstract nouns made more intrusion errors than did subjects who recalled concrete nouns, $F(1, 148) = 6.29$, $MS_e = 1.24$. Such a finding does not agree with high intrusion rates reported for concrete response terms in paired-associate learning (Postman & Burns, 1973) which have been interpreted as the product of decoding a representation in memory from an image to a word form.

General Discussion

These studies present us with no evidence that imagery facilitates long-term retention. Imagery does not facilitate retention when picture lists are compared to concrete-noun lists nor when concrete-noun lists are compared to abstract-noun lists. Imagery does not facilitate retention when subjects are instructed to use it as a mnemonic. This failure can of course be attributed to the well-known difficulty of modifying subjects' strategies with instructions (Paivio & Csapo, 1973). The possible failure of our instructional manipulations does not, however, also account for the fact that for subjects who reported using imagery as a device retention was no different than for subjects who reported not using imagery. Thus whether imageable materials are acquired under free-recall conditions of practice, as in these studies and others (Postman & Burns, 1974), or under paired-associate conditions (Postman & Burns, 1973), they seem to have no special advantage when their stability and strength are tested over a long retention interval.

Such results of course do not agree with predictions that we have made on the basis of either the Paivio (1971) dual-codes hypothesis or the Begg (1973; Begg & Robertson, 1973) organization-redintegration hypothesis. Because free-recall learning should allow for the formaton of larger memory chunks than is possible under paired-associate conditions, we believed that we might observe the operation of the organizational and redintegrative aspects of the imagery code. With respect to the failure of the present results to confirm our extension of the Begg hypothesis in particular, it should be noted that there is evidence elsewhere in the free-recall literature that fails to show a relation between the extent of organization and either immediate (e.g., Frincke, 1968) or delayed recall (Postman, 1970).

The surprising results of these studies suggest that imagery may be a member of a set of materials and subject variables which, while they typically influence learning speed, appear to have no consequences when memory is assessed after a long delay.

References

Bahrick, H. P., & Boucher, B. Retention of visual and verbal codes of the same stimuli. *Journal of Experimental Psychology*, 1968, *78*, 417–422.

Begg, I. Imagery and integration in the recall of words. *Canadian Journal of Psychology*, 1973, *27*, 159–167.

Begg, I., & Robertson, R. Imagery and long-term retention. *Journal of Verbal Learning and Verbal Behavior*, 1973, *12*, 689–700.

Boltwood, C. E., & Blick, K. A. The delineation and application of three mnemonic techniques. *Psychonomic Science,* 1970, *20,* 339–341.

Butter, M. J., & Palermo, D. S. Effects of imagery on paired-associate recall as a function of retention interval, list length, and trials. *Journal of Verbal Learning and Verbal Behavior,* 1970, *9,* 716–719.

Frincke, G. Word characteristics, associative-relatedness, and the free-recall of nouns. *Journal of Verbal Learning and Verbal Behavior,* 1968, *7,* 366–372.

Hasher, L., & Johnson, M. K. Interpretive factors in forgetting. *Journal of Experimental Psychology: Human Learning and Memory,* 1975, *1,* 567–575.

Lampel, A. K. The child's memory for actional, locational, and serial scenes. *Journal of Experimental Child Psychology,* 1973, *15,* 266–277.

Lippman, M. Z. Enactive imagery in paired-associate learning. *Memory and Cognition,* 1974, *2,* 385–390.

Morris, P. E., & Stevens, R. Linking images and free recall. *Journal of Verbal Learning and Verbal Behavior,* 1974, *13,* 310–315.

Paivio, A. *Imagery and verbal processes.* New York: Holt, Rinehart & Winston, 1971.

Paivio, A. Imagery and long-term memory. In R. A. Kennedy & A. Wilkes (Eds.), *Studies in long-term memory.* New York: Wiley, 1975.

Paivio, A., & Csapo, K. Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology,* 1973, *5,* 176–206.

Paivio, A., Yuille, J. C., & Madigan, S. A. Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement,* 1968, *76,* (1, Pt. 2).

Postman, L. Effects of word frequency on acquisition and retention under conditions of free-recall learning. *Quarterly Journal of Experimental Psychology,* 1970, *22,* 185–195.

Postman, L. Transfer, interference and forgetting. In J. W. Kling & L. A. Riggs (Eds.), *Experimental psychology.* New York: Holt, Rinehart & Winston, 1971.

Postman, L. Does imagery enhance long-term retention? *Bulletin of the Psychonomic Society,* 1974, *3,* 375–377.

Postman, L., & Burns, S. Exerimental analysis of coding processes. *Memory and Cognition,* 1973, *1,* 503–507.

Postman, L., & Burns, S. Long-term retention as a function of word concreteness under conditions of free recall. *Memory and Cognition,* 1974, *2,* 703–708.

Prestianni, F. L., & Zacks, R. T. The effects of learning instructions and cueing on free recall. *Memory and Cognition,* 1974, *2,* 194–200.

Richardson, J., & Gropper, M. S. Learning during recall trials. *Psychological Reports,* 1964, *15,* 551–560.

Shapiro, S. R., & Erdelyi, M. H. Hypermnesia for pictures but not words. *Journal of Experimental Psychology,* 1974, *103,* 1218–1219.

Thorndike, E. L., & Lorge, I. *The teachers' word book of 30,000 words.* New York: Columbia University, Teachers College, Bureau of Publications, 1944.

Tulving, E., & Hastie, R. Inhibition effects of intralist repetition in free recall. *Journal of Experimental Psychology,* 1972, *92,* 297–304.

Underwood, B. J., Schwenn, E., & Keppel, G. Verbal learning as related to point of time in the school term. *Journal of Verbal Learning and Verbal Behavior,* 1964, *3,* 222–225.

Yuille, J. C. Does the concreteness effect reverse with delay? *Journal of Experimental Psychology,* 1971, *88,* 147–148.

(Received March 10, 1975; revision received August 9, 1975)