On Distinguishing Semantic and Imaginal Mnemonics [1,2]

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Semantic and Imaginal Mnemonics

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Mnemonics, Semantic

Mnemonics, Imaginal

Associative Memory

Abstract

When S is instructed to compose a "mental picture" to associate pairs of words, is he really visualizing or is he just searching out and tagging semantic relationships among the two concepts? These experiments attempt to differentiate these two points of view. Exp. I inquired whether instructions to learn word pairs by mental imagery vs. generating a sentential relation resulted in distinguishably different memory traces at a later retention test. The answer was clearly negative; Ss could not remember their type of mnemonic any better than they could a non-mnemonic bit of control information. Later experiments tried to produce a modality-specific interference effect predicted by the imagery hypothesis, vis., expecting a visual distracting task to interfere selectively with learning by visual imagery, but expecting an auditory distractor to interfere more with learning involving the verbal-semantic system. However, Exp. III found no interaction between visual vs. auditory distraction and imagery vs. rote-repetition learning strategies; similarly, Exp. III found no overall interaction between visual vs. auditory distraction and the concreteness-abstractness of the learning materials. Thus, the results are uniformly negative regarding the specific predictions made by the imagery hypothesis; they are consistent with the verbal-semantic hypothesis which supposes that "mental imagery" instructions cause S to associate the concepts via semantic relational predicates.

On Distinguishing Semantic and Imaginal Mnemonics

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Peter Arnold [1, 2]

The experimental study of mnemonic mediators for verbal material appears to have converged upon two representation systems used by Ss in learning such materials. These are labelled as the "imagery" system and the "verbal" system. Paivio (1971), Bower (1968), Atwood (1971), and many others have discussed these representational modes, and how they become implicated when the person learns new material of various sorts. Specifically, if S is learning a set of word-word paired associates, then, depending on the items themselves and the instructions to S, the pair may be transformed into a verbal phrase linking the two words and/or into a "mental picture" depicting some scenario of the two referents interacting in some way. The primary evidence that imagery is involved in word-pair learning is of three major sorts: (1) Ss give introspective reports of using "mental pictures" to learn certain pairs and these reports correlate with high rates of learning for such pairs, (2) items rated high in concreteness and imagery evocation are learned faster in almost all situations than are abstract, low-imagery items, and (3) instructions to Ss to form "mental pictures" of imaginal interaction among referents of the words of the pair enhances paired-associate learning.

This evidence is not strongly persuasive to a theorist who wishes to argue for a strict "verbal-semantic mediation" hypothesis (for word learning) in opposition to the imagery hypothesis. To state the "verbal-semantic" hypothesis in its extreme form, it would suppose that instructions to "image scenes" in fact lead S to search for and generate plausible semantic (verbal) relationships between the concepts to be associated, and that nothing particularly imagistic occurs. Similar benefits in memory can be obtained by merely telling S to relate the two words of a pair together in a phrase or sentence (e.g., Bower, 1968). The introspective reports would be dismissed, on the semantic hypothesis, as reflecting delusions or inexact use of labels for internal events; in fact it would be argued that people can not discriminate whether they are activating semantic relationships between concepts or are having mental images. Experiment I is relevant to this discrimination issue.

Regarding the evidence that concrete words are learned faster than abstract words, the "verbal-semantic" theorist would interpret this in terms of the complexity of the entries for abstract versus concrete words in S's internal semantic lexicon. Some words are abstract because they refer to very general classes, e.g., furniture vs. chair, animal vs. cat, and thus have a much broader range of denotation and more semantic connections than the concrete term. Other abstract nouns are derived by reifying verbs (e.g., interpretation) or adjectives (e.g., accuracy, anxiety, drowsiness) or adverbs (e.g., difficulty, quickness). In conceptual semantics (see Shank, in press), the entering of such abstract terms into a model of the internal lexicon requires a large amount of unpacking, analysis and many more use-definitional forms than is the case for simple concrete terms with a restricted domain of reference. If this "semantic complexity" argument were true--and modern semantic theories like Shank's (in press) and Quillian's (1966) suggest it has some merit--then it would be a short step for the "verbal semantic" theorist to explain why concrete words are easier to learn than abstract words.

The foregoing remarks illustrate how a theorist committed to the "verbal semantic" hypothesis would argue against the evidence allegedly in favor of the imagery hypothesis. One may ask whether there is any evidence that would help decide between these two hypotheses. There appears general consensus that powerful discrimination is provided by studies investigating "modality-specific interference". The area derives from earlier ideas and results of Brooks (1968) adapted to the context of memory experiments. The basic notion is that if visual imagery or visualization involves some specifically visual process, then it must engage some of the same brain mechanisms as are engaged in visual perception. If this is true and if these visual mechanisms have a limited capacity, it follows that visualization will be poor if S is required to time-share visualization of learning materials with visual perception to a concurrent, auxilliary task. On the other hand, S's visualization should not be reduced nearly so much by having him time-share visualization with a non-visual auxilliary task. (The visual and non-visual distracting tasks must be equated in terms of their difficulty when performed singly).

An early memory experiment by Bower (1968) used this logic, trying to show that a visual tracking task interfered more than did a tactual tracking task with memory for word-pairs learned by visual imagery but not when the pairs were learned by verbal rote rehearsal. That experiment gave only weak, marginally significant effects. A subsequent independent experiment by

Atwood (1971) investigated the same point with much larger effects. Because of its critical importance to our Exp. II and III, Atwood's experiment will be reviewed in detail. Atwood had different Ss studying either abstract-noun pairs (actually, phrases) or concrete-noun pairs for one study trial, with different Ss required to perform either a visual or an auditory distracting task at the moment the paired associate was presented auditorily. The visual task was to monitor a visual display and to respond "2" if a 1 appeared or respond "1" if a 2 appeared. The auditory task was similar except the 1 or 2 stimulus was presented auditorily just after the paired associate was read to S by E. Control Ss studied the pairs without any distracting task. A cued recall test given immediately after presentation of the list of pairs gave results confirming the "modality-specific interference" prediction. That is, recall of concrete pairs, for which imagery presumably predominated, was reduced drastically by the visual distracting task but hardly at all by the auditory distraction. Conversely, recall of abstract pairs, for which the verbal-acoustic system presumably predominated, was reduced drastically by the auditory distracting task but not by the visual distraction. The important point is the observed interaction between the presumed learning modality and the modality of the distraction task (the direction of the interaction is also critical). This is the kind of result which creates grave problems for the hard-line "verbal-semantic" hypothesis. Because of its central critical role in differentiating the "imagistic" versus "verbal" hypotheses, however, it is important that Atwood's results be systematically replicated and extended. This is done in Exps. II and III below.

Experiment I

The first experiment addresses the question of whether adult Ss can discriminate between semantic versus imaginal mediators for learning word-word paired-associates. How might one study this? It is not sufficient to simply ask S either at the time he studies a pair or at the time he recalls, since in either case there is no external criterion by which to determine the accuracy of his reports. That would be like accepting someone's claims of ESP without checking the source. We decided to try to determine whether S would image or verbally mediate for learning a given pair by giving him direct instructions with each pair during the study list (a technique used for other problems by Schnorr & Atkinson, 1969). For a random half the word-pairs S saw, he was directed to learn them by visualizing a mental scene of interaction between the referents; for the other pairs, S was directed to learn them by generating a sentence relating one concept to the other (see Bobrow & Bower, 1969).

Suppose that these directives were effective, causing Ss to set up memory traces in two distinctly different "representational systems". How would we ever find this out? Presumably by observing whether the two kinds of memories have distinctly different features, characters, or "internal feels" about them. If this were true, then at a minimum S should be able to report later whether his memory trace is primarily "verbal" or primarily a "mental picture"--that is, given these assumptions, S should be able to remember (in excess of chance) how he learned each item. Thus, at the later retention test, after S tried to recall the "response" word when cued with the "stimulus" word of each pair, he was also asked to indicate whether he had studied that pair under imagery instructions or sentence-generation instructions.

Now, Ss can probably remember all sorts of events surrounding the presentation of a pair, including whether E told S to image or generate a sentence to learn the pair (e.g., think of E's instruction as a word which is stored along with each paired-associate). So some kind of control for this incidental memory for the instructions is required. Experiment I solves this problem by having a condition in which the instructional cue to image or to generate a sentence was the location (left or right) of the word pair at the top of an IBM card. The control condition had Ss always imaging (or always generating sentences) for all pairs of the list, but having to recall later whether each pair had been presented on the left or right side of the display card. Now, if imagery and sentence-generation establish different types of traces, then S's ability to remember the mode of learning should summate with his incidental memory for the left-right position of the presented pair, thus enabling him to discriminate better between left versus right items than would be the case for the control condition. That is, the discrimination for the control condition would be mediated only by incidental memory for the left-right location, whereas it would be mediated by that information plus the differential features of the memory traces in the differential mnemonic condition. Conversely, by this logic, if location memory is as good for control conditions as for the differential mnemonic conditions, one would seriously question whether the directives to image or generate sentences are causing distinctly different memory traces to be established. Experiment I arranges for these comparisons on a within-S basis.

Method

Each S studied and was tested immediately on 3 different lists of 24 concrete word pairs. The S learned one list under each of 3 mnemonic conditions. In the "Mixed" (or Differential Mnemonic) condition, S was instructed to form a mental picture to learn pairs shown to the left on the study card, and to think up a relational sentence to learn pairs shown to the right on the card (locations were reversed for half the Ss). Each list comprised a deck of 24 IBM cards, with 12 cards having their pairs printed in the upper left corner and 12 cards having their pairs printed in the upper right corner. The two kinds of cards occurred in random order, differently for each S and for each list. In the "Pure" (or Single Mnemonic) conditions, S was instructed to learn all 24 pairs of a given list by a particular mnemonic. One pure list was learned using an imagery method, and one was learned using the sentence-generation method. Ss were tested in groups, were handed decks of 48 cards at the start of each list and instructed how that deck of pairs was to be learned. The Ss then went through the deck, turning and studying the pair cards one at a time for 12 sec. in time with a tape recorded signal. If the pair was to be learned by a sentence mnemonic, S was required to write down the verb he had thought up to link the two nouns. He wrote his linking verb in a space on the card between the two nouns. If the pair was to be imaged, then S merely made a check mark between the two nouns. After 10 sec. had elapsed, during which Ss performed the appropriate study task, a second tape recorded signal directed Ss to devote 2 sec. to a pair-rating task that will be described later. Following the 24 study cards were 24 test cards each presenting the stimulus word (left hand member) of the pair in the center of the card. The order of the cue cards was identical to the order of the study pairs. S was asked to try to recall in writing the "response" member paired with each cue. For the Mixed list, S further recalled whether he had been instructed to study the test pair (of the cue) by picturing a scene or generating a sentence. Accordingly, he circled PICT or SENT on the test card after he had tried to recall the response term. Similarly, in the pure conditions, Ss had to circle LEFT or RIGHT accordingly as they thought the tested pair had been presented on the left or right side of its study card (guessing if necessary). Test trials were paced at an 8 sec. rate by having Ss turn over cue cards in time with tape recorded signals. The first 6 sec. of each test interval were allotted for the noun recall task; the remaining 2 sec. was for the recall of the mnemonic method or position of study. Ss recalled by writing their responses on the cue card; whether or not S could recall the response term, he was forced to circle LEFT or RIGHT (or PICT or SENT) for the side on which he thought the pair had been presented during the study trial. The 3 lists of the day used the Mixed, Imagery, and Sentence mnemonic methods once each in the 6 possible orders across different groups of Ss. Immediately following completion of the third test list, delayed testing began on each of the preceding study lists. These delayed tests were repeats of the preceding three tests and were given in the same order as the originals.

To test an auxilliary minor hypothesis, we also had S rate (on each study card) how easy it was for him to associate the two words together. The rating scale went from 5 = very easy to associate, down to 1 = very difficult to associate. The question was whether these ratings taken during study of each pair would correlate with later recall despite the fact that items had been selected to be homogeneous in difficulty. All words were nouns with both concreteness and imagery ratings exceeding 4.5 in the norms published by Paivio, Yuille & Madigan (1968).

The Ss were 18 male and 18 female Stanford undergraduates fulfilling a service requirement for their introductory psychology course.

Results

We examine first the proportions of immediate paired-associate recall for the several mnemonic conditions. These are shown in the top of Table 1. It is immediately apparent that there are virtually no differences among conditions in paired-associate recall. This instructions to generate sentential relations produced as good learning as did instructions to visualize mental pictures. This was true in the Mixed list conditions and in the Pure list conditions. This result is not particularly disturbing since earlier comparisons of the two mnemonic procedures (see Bower, 1968) have shown them

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Insert Table 1 about here

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to produce about equal levels of recall. Because the delayed test results are virtually identical to the immediate test data, they are not presented here.

The more disturbing result appears in the bottom half of Table 1 which gives the percentages of correct immediate recall of the location of the study pair or the type of mnemonic in the Mixed condition (chance level is 50%). It is readily apparent that there were no significant differences in recall among any of these conditions; each was close to the mean of 70% correct remembering of the location of the pair's presentation. Again, delayed test data are not presented because they show precisely the same relationships as the immediate test data. According to the logic which led to this experiment, this null outcome means that S's memory of an earlier pair is about the same qualitatively whether he was directed to learn it by imagery or by finding a semantic relation between the members of the word pair. That is, no discriminative information is retained in the memory trace *per se* to tell S whether it was learned by constructing a sentence or an image.

To this null result, the "verbal-semantic" theorist should react with equanimity; it is exactly as he expected, since to his view of the world "imagery instructions" can only be interpreted by S as a directive to find semantic pathways linking two concepts--which is also what S does when instructed to find a semantic relation among the words of a pair. The result should cause mild indigestion to the imagistic theorist, since differential recall should have resulted had Ss been able to use different mnemonic representations. His defense, or explanation of the null result, of course, is to allege that Ss do not or can not follow E's instructions. For instance, with all concrete pairs, it might be argued that Ss just "naturally" encode these into images when told to find relations, and so their internal representations would not differ for the two mnemonic instructions. The imagistic theorist would point out that there was no independent guarantee that S was following E's instructions. They would claim, for instance, that if S had been required to actually write a sentence versus draw a picture of his image (as did Paivio & Foth, 1970), then one might have detected a real difference in the nature of the resulting memory traces.

But in counterargument, the "verbal-semantic" theorist would point to the fact that Ss reported complying with the mnemonic instructions and that imagistic theorists (like Bower, 1968) can not just assume S's compliance or noncompliance with E's mnemonic instructions if and when it is convenient for the theorist to do so. Furthermore, to an overwhelming extent, Ss accurately wrote a linking verb when told to make up a sentence, and entered a check mark on their study card when told to image. Second, the verbal theorist would claim that the verbal hypothesis explains the data more parsimoniously. Third, he would reject the write-a-sentence vs. draw-a-picture task as any more definitive than the current task; memory for what S did to learn a word pair would improve with that extended procedure since S would be having a much longer time engaged in the two differential activities, and that by itself would enhance recall of the activities surrounding learning of a pair. Remembering by such an experimental group would have to exceed an obvious control group. With that requirement, the outcome of the comparison is no longer so intuitive.

The net upshot of this debate is a stand-off; the data are perfectly in line with the verbal-semantic hypothesis and, on their face, embarrassing to the imagistic hypothesis; but they can be interpreted with special assumptions so as to blunt their force against the imagery hypothesis. Clearly, if a difference in retention favoring the Mixed over the Pure conditions had been found, the imagery theorist would be in a much stronger position than he is with the actual results.

Experiment II

Our next experiment attempts to extend Atwood's (1971) results to somewhat different variables. Atwood found that a visual character task interfered more with learning of imageable (concrete) materials whereas an auditory distractor task interfered more with learning of non-imageable (abstract) materials. The following experiment attempts to show similar selective interference of a visual as contrasted to an acoustic distracting task with noun pairs learned under imagery instructions versus under rote-repetition instructions. Each S learned several different paired-associate lists under several conditions: With imagery or rote-repetition learning instructions; and with either no interfering task, or with a visual or an auditory distracting task carried out immediately after each pair was presented. On the basis of Atwood's results, it was anticipated that visual distraction would interfere more than auditory distraction with pairs being learned by imagery; in contrast, there would be either no difference or a difference in the reverse direction comparing recall of rote-repetition pairs learned with the visual or auditory distracting task.

Method

The design was a 2x3 factorial carried out within each S, with one learning list exemplifying each of the 6 conditions. One factor was learning method (imagery vs. repetition); the other factor was the distractor task (none, visual, or auditory). Each list was composed of 25 concrete noun pairs of high imagery value ($I > 6.0$ in the norms of Paivio et al., 1968). The condition of a given list was rotated between Ss. The S would study a list at a 5 sec. rate, then receive an immediate cued recall test also at a 5 sec. rate on that list, doing this for 6 successive lists. Instructions regarding learning method and the distractor task were given appropriately before each list. To insure that S was following instructions properly, he was carefully monitored on studying a 10-pair practice list on which his memory was first tested; these recall scores were not analyzed by pre-experimental decision. After this practice using the instructed learning method and distractor task, S began the final 25 pairs of the appropriate list which were to controbute useable data.

The imagery instructions asked S to visualize a "mental picture" of some vivid interaction between the two referents of the pair. The rote-repetition instructions directed S to silently repeat the word pair over and over to himself during the study interval. In the control condition, Ss simply engaged in these learning activities for the final 4 sec. following a 1 sec. visual presentation of the pair (printed on a 3 x 5 in. flash card).

The visual distracting task was as follows: Immediately after the 1 sec. paired-associate card was removed, E exposed another card with 5 digits. The S had to examine these rapidly for presence of the target digit 5; if the target appeared in the array, he was to tap once on the table with a pencil he held; if the target did not appear in the array, he was to tap twice. Half of the distracting array cards had a target 5, and half did not. Five sec. after the 1 sec. pair card, the next pair card was shown. The auditory distractor task was similar in most respects to the visual task above. Here, immediately after the paired-associate card was shown, and removed, E read aloud 5 digits (in 2 sec.), and S tapped once or twice accordingly as the target digit 5 was present or absent from E's array. (Errors on these simple distracting tasks were exceedingly rare).

The cued recall tests followed immediately after the study list; all 25 pairs were tested at a 5 sec. rate in the same order as they had been studied. The Ss were 12 Stanford undergraduates, 6 males and 6 females, who volunteered for service in the experiment. Each S received a different order of the 6 conditions within the day.

Results

The major results are shown in Table 2 which reports proportions of correct paired-associate recall for the 6 experimental conditions. A first

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Insert Table 2 about here

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finding is that learning strategy produces a very large difference, with imagery exceeding rote-repetition by 2 to 3 orders of magnitude. A second finding is that either distractor task reduces recall below the control condition, the proportionate reduction being roughly the same for the two mnemonic conditions. The disturbing feature of the data in Table 2 is that the auditory and visual tasks do not differ in their effects, certainly not in the way anticipated on the basis of Atwood's results. Each S was assigned an interaction score based on the difference between his "visual-auditory" scores under imagery in contrast to the repetition condition; however, the mean of these scores did not differ reliably from zero ($t_{11} = -.28$, $p > .10$). Whereas a modality-specific interaction was anticipated, Table 2 reveals only a simple distraction effect, which is of significance only for a general "limited-channel" hypothesis.

Two female Ss said that they frequently formed images even under the rote repetition directives. These two Ss elevated the overall levels of recall in the rote-repetition conditions of Table 2. Although eliminating their data reduces the recall proportions in the "Repetition" row of Table 2 (to .27, .12, and .13), it does not alter the absence of interaction in their pattern.

In summary, then, this attempted extension of the "modality-specific interference" effect has failed. We obtained a simple main effect due to imagery instructions, and another due to distractions extraneous to the memorizing task. But the critical interaction eluded us; we were unable to show that visual perception interferes selectively with visual imagery used during memorization.

Experiment III

The prior experiment failed to produce the anticipated interaction in recall between mnemonic method and modality of the distracting task. There were, of course, many differences between Atwood's experiment and the extension of it attempted in Exp. II. One obvious difference is that Atwood compared learning of abstract versus concrete pairs whereas Exp. II compared pairs learned by instructed imagery versus pairs learned by rote repetition. A second difference is that our distracting task (i.e., monitor a display for a target digit) was slightly more complex than Atwood's; also Ss were required to pay attention to the distracting task for a longer time when it was in the auditory mode than when it was in the visual mode.

For such reasons, we decided to try to replicate Atwood's basic result using procedures more like his. We compared learning of abstract versus concrete pairs with S learning while performing Atwood's visual or auditory distracting task or neither task. Several procedures of Atwood's experiment were changed. First, we used abstract and concrete pair lists that were equally long whereas Atwood had used different number of items for his abstract and concrete lists, which seems a flaw of his design. Second, Atwood used different groups for each of his 6 conditions, which seems inordinately inefficient. (Also, two of his groups were composed completely before the remaining four groups were tested.). Instead we used a within-S design wherein abstract-concrete pairs was a within-list variable, and nature of auxilliary task was a between-list variable experienced by each S. This presumably increases the statistical sensitivity of the design since between-S variability is not confounded with between-treatments variance.

Method

Each S received a study-test cycle on 3 lists of 20 paired associates. The items were noun pairs presented by tape recorder in the context of meaningful declarative sentences, as was done by Atwood. Retention was tested by cueing with the first noun (grammatical subject) for recall of the second noun (grammatical object). The 20 sentences within each list used 10 abstract noun pairs and 10 concrete pairs. The concrete nouns were selected for values greater than 6.0 on both concreteness and imagery ratings in the norms of

Paivio, et al. (1968). The abstract nouns had both concreteness and imagery ratings less than 3.5. Both sets of nouns were selected to balance for their Thorndike-Lorge frequency and their meaningfulness (m) values in the Paivio et al. tables.

Each S learned one of his lists under a control condition (no distracting task), one list with visual distraction, and one list with auditory distraction. The nature of each task was explained to S just before he began the appropriate list. The sentences linking the noun pairs to be learned were read over a tape recorder at the rate of one every 5 sec. (Atwood's timing interval). When appropriate, the distracting task was introduced by E immediately at the end of each tape-recorded sentence. The visual distracting task consisted of showing S a 1 or 2 printed on a 3 x 5 in. card, and S was to tap twice or once, respectively, on the table with a pen held in his hand. After S's tap, the distractor card was removed and about 3 sec. "dead-time" elapsed until the next sentence occurred on the tape. The auditory distracting task was similar; immediately following the taped sentence, E said "one" or "two" and S replied by saying aloud the opposite number. The control list involved no distractor tasks. The 3 conditions were experienced in the 6 possible orders within the session by different Ss. Also, which sentence list combined with which distractor task was varied in a balanced fashion across Ss. The 10 abstract and 10 concrete sentences appeared in a haphazard order within each list.

An immediate recall test followed study of each list. The cue was the first noun, spoken aloud by E at a 5 sec. rate, and S orally recalled the second noun of the cued sentence if he could. The sentences were tested in the same order as they had been studied, ensuring a constant retention interval of 20 intervening events for each pair.

A first cycle through the experimental design with 12 Ss (6 males and 6 females) produced an unexpected result, so the design was replicated with another set of 6 males and 6 females. The Ss were Stanford undergraduates fulfilling a service requirement for their introductory psychology course. They were tested individually.

Results

The results of interest appear in Table 3, which reports proportions of pairs correctly recalled for the 6 conditions, presented separately for females and males. A variety of effects are obvious to inspection of the results in Table 3. First, for all conditions there is a large difference in recall in the expected direction between concrete and abstract pairs.

Insert Table 3 about here

Second, there is an overall lowering of recall given either distractor task (except for males with concrete items). Third, there appears to be an interaction (in the anticipated direction) between the distractor task and concreteness for females but not for males. A statistical test for sex differences in the interaction assigned to each S an interaction score based on the difference between his "auditory-visual" recall difference for concrete pairs and this difference for abstract pairs. A comparison of these interaction scores for females versus males fell just short of statistical significance, $t_{(22)} = 2.04$, $< .05 p < .10$. Pooling together males and females, the overall interaction between concreteness and the visual versus auditory distractor task is clearly not significant, $t_{22} = 0.24$.

Discussion

The important outcome of Exp. III is a failure to produce the interaction critical to the modality-specific-interference hypothesis. In fact, the data suggest that such interaction as there might be will itself vary with the sex of the Ss. Females tend to show the visual-auditory interaction in the direction Atwood reported; males show slightly the opposite pattern. This pattern of results was suggested by our first group of 12 Ss, which led us to test a second group of 12 Ss; the pattern was maintained in this second group though not strongly enough to be statistically significant. In his published reports, Atwood does not identify the number of males versus females in his several conditions, and no analyses by sex of Ss were reported.

Any failure to replicate leads one to search for differences among the experiments and there are indeed several procedural differences between Exp. III and Atwood's. The most obvious difference is our use of a within-subject design whereas Atwood used a between-subject design. Each S in Exp. III experienced all 6 conditions, with variations in concreteness within each list and variations in distractor-task across lists; on the other hand, each S in Atwood's experiment learned just one list under one condition. Conceivably, warm-up or general practice effects (which were indeed present in our data) operate differentially so as to eliminate on later lists within the session the critical interaction which might be restricted to the initial list learned. To check this we analyzed the learning scores on only the first-list for Ss in Exp. III. The Control, Visual, and Auditory lists were experienced first by 8 Ss each. However, in this re-analysis, there was no hint that the critical interaction between materials and distractor task was present on the first list Ss learned. In fact, the recall proportions were slightly in the "wrong" direction, suggesting that the visual distractor reduced recall of abstract pairs more than did the auditory distractor. It is realized, however, that this comparison is none too powerful because of the small number of observations involved in this part of the experiment.

It is not clear why Atwood's critical result was not replicated. The imagistic analysis which implies the modality-specific-interference effect does not refer explicitly to between-S versus within-S variables; that theory expects an interaction in either type of experiment. The interaction result may be none too reliable since apparently other investigators have had difficulty replicating Atwood's results (see results by Brooks, referenced in footnote by Paivio, 1971, pg. 374).

In summary of our three experiments, the conclusions are not particularly favorable to an imagery hypothesis as contrasted to a verbal-semantic hypothesis. Subjects asked to generate meaningful linking sentences learn paired-associates just as well as when they are asked to mentally picture imaginary scenes of interaction. Also, Ss cannot remember later whether they were told to image or to construct a sentence to learn a pair--at least, they remember no better than appropriate controls. Furthermore, two specific tests of the modality-specific-interference hypothesis have failed. It appears that a visual perception task interferes no more than an auditory task with learning by "visual imagery"; similarly, these distractor tasks interfere about equally with the learning resulting from rote repetition. Furthermore, the visual and auditory perception tasks did not differ reliably in their interference with learning of concrete pairs nor with learning of abstract pairs. Therefore, the results are essentially negative with respect to those specific predictions which differentiated the imagery hypothesis from the "verbal-semantic" hypothesis for learning of word pairs. Possibly other differentiating predictions can be found or more sensitive experimental tests arranged. But in the meantime it appears that, regarding paired-associate learning with words, there is no good reason to prefer the imagistic over the semantic hypothesis. (The comparative efficacy of pictures versus words as learning materials is a logically separate issue). Indeed, in the verbal learning context, it is not obvious that the two hypotheses are any longer differentiable in an objective fashion (see Anderson, submitted).

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Table 1

Percentage correct paired-associate recall and location identification for the mnemonic conditions of Exp. 1.

	LIST TYPE	Imagery	Sentence
PA Recall	Mixed	.50	.55
	Pure	.56	.53
Location Recall	Mixed	.69	.69
	Pure	.69	.73

Table 2

Proportions of correct cued recall according to learning strategy and distractor task.

Learning Strategy	CONTROL (No Task)	DISTRACTION Visual	DISTRACTION Auditory
Imagery	.77	.61	.57
Repetition	.31	.21	.19

Table 3

Proportions of recalled pairs across conditions for female and male Ss.

Sex	Type	Control	Visual	Auditory
			LIST TASK	
Females	Concrete	.87	.63	.77
	Abstract	.41	.30	.29
Males	Concrete	.81	.82	.78
	Abstract	.53	.35	.43

Footnotes

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2. Requests for reprints should be sent to Dr. Gordon H. Bower, Department of Ps ychology, Stanford University, Stanford, California 94305.