JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR **23**, 39–66 (1984)

Recognizing Words, Pictures, and Concepts: A Comparison of Lexical, Object, and Reality Decisions

JUDITH F. KROLL

Mount Holyoke College

AND

MARY C. POTTER

Massachusetts Institute of Technology

A series of five experiments addressed the question of whether pictures and the words that name them access a common conceptual representation. In the first three experiments the processing of words in the *lexical decision task* was compared with the processing of pictured objects in a formally analogous task which we called the *object decision task*. The results showed that the lexical and object decision tasks produce approximately similar response latencies and are similar in their sensitivity to a set of experimental manipulations (e.g., frequency effects, interference effects, semantic facilitation from related words or pictures). In two additional experiments the processing of words was compared with that of pictures in a mixed *reality decision task* in which a decision about whether a word or picture represents a real thing is to be made independent of the surface form. The results indicated that subjects were unable to make amodal decisions of this sort; the response latencies in reality decision were markedly longer than those in either a pure lexical or pure object decision and there was little conceptual transfer across repetitions of different surface forms. Overall, the results of the five experiments suggest that the major component in a lexical or object decision is a form-specific memory representation of the word or visual object.

Does a common conceptual representation underlie the process of recognizing a picture of an object and the word that names it? Comparisons of pictures and words in tasks that require conceptual understanding show few differences in responses to the two surface forms, suggesting reliance on a common code for both (e.g., Banks & Flora, 1977; Guenther & Klatzky, 1977; Potter & Faulconer, 1975; Potter, Valian, & Faulconer, 1977). In tasks that do not clearly require conceptual or semantic access, however, comparisons of pictures and words reveal processing differences which presumably reflect reliance on a surface level of representation (e.g., Durso & Johnson, 1979; Paivio, 1975, 1978). The evidence is thus consistent with a three-code model (e.g., Nelson, Reed & McEvoy, 1977; Potter, 1979; Snodgrass, 1980, 1984) in which there are modality-specific representations for words and pictures as well as an abstract conceptual code common to both. Which codes are used seems to depend on the task.

The research described here is an attempt to examine more closely the relation-

This work was supported in part by Contract MDA 903-76-C-0342 from the Advanced Research Projects Agency. We thank the laboratory at Scientific Applications, Inc., for their assistance in the early stages of this work; Jonathan Grudin, Janell Schwieckert, Kit Oldham, and Jill Schuster Merves for their assistance in testing subjects and analyzing data; Joseph Cohen, Ellen Reese, David Rosenbaum, and Gay Snodgrass for helpful comments on the manuscript; and especially Barbara Faulconer for her creative and artistic efforts in producing the nonobjects used as stimuli in these experiments. Requests for reprints should be sent to Judith F. Kroll, Department of Psychology and Education, Mount Holyoke College, South Hadley, Mass. 01075.

0022-5371/84 $3.00

ship between surface and conceptual representations of words and pictures of objects. The research strategy is to use the lexical decision task together with an analogous task developed for pictured objects. In the lexical decision task (e.g., Coltheart, Davelaar, Jonnason, & Besner, 1977; Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Rubenstein, Lewis, & Rubenstein, 1971) subjects decide whether a string of letters forms a real word. Logically, a lexical decision does not require retrieval of the concept associated with a word; recognition of the surface lexical form should suffice. There is abundant evidence to suggest, however, that lexical decisions are influenced by semantic factors. For example, semantically related words prime each other (Meyer & Schvaneveldt, 1971), and at least part of the priming effect appears to be automatic in that it operates over a brief time interval and is unrelated to subjects' expectations (Fischler, 1977; Neely, 1977). Lexical decisions are also influenced by word concreteness (Day, 1977; James, 1975), a factor unlikely to be represented at the lexical level.

Lexical decisions are not based on conceptual or semantic representations alone, however. There are large effects of word frequency in lexical decision (Frederiksen & Kroll, 1976; Scarborough, Cortese, & Scarborough, 1977), a factor presumably relevant to the surface form (although measures of word frequency are also correlated with conceptual familiarity as seen in Experiment 1). Also, lexical decision time is influenced by the degree of word-likeness of nonwords, suggesting that subjects are responsive to surface orthography (Rubenstein, Richter, & Kay, 1975; Schulman & Davison, 1977).

The goal of the present research was first to develop an analogous decision task for pictures (a task which we call the *object decision task*) and then to use it as a way of directly comparing the role of form-specific and conceptual representations in word and picture processing. The object

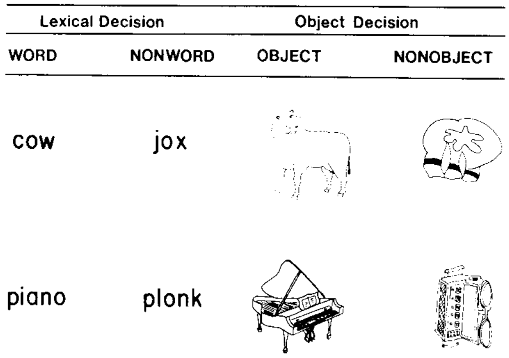


FIG. 1. Examples of the materials used in the lexical and object decision tasks.

decision task is formally analogous to the lexical decision task; subjects decide whether pictures of objects represent real things. In the lexical decision task, using nonwords that conform to the orthographic rules of English ensures that the subject consults the lexicon before making a decision. Similarly, we attempted to construct pictures of pseudo-objects (or nonobjects) that represented a high approximation to real objects. The procedure for generating pseudo-objects is described in detail in Experiment 1. Examples of the materials used in the lexical and object decision tasks are shown in Figure 1.

The first section of this paper (Experiments 1–3) consists of a set of experiments designed to look for possible parallels between the lexical and object decision tasks. If lexical and object decisions rely on the same conceptual representation, then the two tasks should be influenced in similar ways by experimental manipulations which are thought to affect conceptual processing. The second section of the paper (Experiments 4 and 5) consists of two experiments in which the two tasks are mixed into a single *reality decision task*. To the extent that lexical and object decisions rely on conceptual processing, and to the extent that words and pictures of objects share a common conceptual representation, mixing the tasks should produce little disruption in overall performance relative to conditions in which the two tasks are performed separately.

Section 1: Comparing Lexical and Object Decisions

In the first section three experiments are described in which lexical and object decisions on corresponding words and pictured objects were made by separate groups of subjects. Experiment 1 was designed to determine whether subjects could make object decisions in roughly the same amount of time and with the same degree of accuracy as they make lexical decisions. In Experiment 2 the question was whether the introduction of meaningful distractors in the other surface format would produce equivalent interference in the two tasks. Finally, in Experiment 3 semantic priming effects were compared in the two tasks. To anticipate the results of this section, the pattern of data for lexical and object decisions looked remarkably similar across the three experiments.

Experiment 1: Baseline Comparison of Lexical and Object Decisions

In Experiment 1 separate groups of subjects were asked to make either lexical or object decisions. The two tasks were made as comparable as possible by using words in the lexical decision task that named the objects pictured in the object decision task.

Method

Stimulus materials. The materials in the object decision task were line drawings of 120 real objects. These were divided into two sets of 60 each which were paired with the same set of 60 nonobjects. All of the objects had one-word names. The nonobjects were line drawings of closed figures with an object-like appearance, created by tracing parts of drawings of real objects and regularizing the resulting figures. The complete set of nonobjects is included in Appendix A along with the results of a rating scale in which a group of subjects rated each nonobject on how similar it appeared to a real object.

The materials in the lexical decision task were the 120 words that best named the objects and 120 pronounceable nonwords, divided into two equivalent sets. The words and nonwords varied in length from three to eight letters. The words and pictures used were chosen from a larger set of items in which words and pictures had been equated (as a group) for visual threshold (Potter & Faulconer, 1975). Drawings were excluded if previous naming data (Potter, Note 1) had indicated any substantial disagreement among subjects as to what the pictured object should be called.

For each surface form there were two versions of the stimulus materials, each consisting of 60 positive and 60 distractor items. Only the nonobjects were repeated in the two versions of the object decision task. The positive items in each version (the words and the pictures of real objects) were equated for length and frequency of the word names. The resulting items were categorized as being of high or low frequency, according to whether the word label was ranked above or below a value of 35 times per million in the Kučera and Francis (1967) word count. The mean frequency of the high frequency words was 122 times per million and that of the low frequency words was 10 times per million. A large number of semantic categories were represented, including animals, food, clothing, furniture, tools, vehicles, and musical instruments. The two versions of the materials that were constructed for each task were also counterbalanced so that instances of all categories were present in both forms.

Apparatus and procedure. The subject was seated at a table 0.5 m in front of a rear projection screen. A rectangle (16.5 cm high × 25.4 cm wide) was marked off in the center of the screen as the fixation area. A response box with two buttons (one for the *yes* response, one for the *no* response) was positioned at a comfortable distance in front of the subject. Slides of the stimulus materials were projected using a Kodak carousel projector equipped with a Lafayette tachistoscopic shutter. The exposure duration was 500 milliseconds. A Marietta digital timer was used to measure response time (to the nearest millisecond) from the onset of the stimulus. Each subject received 140 trials of which the first 20 were practice. In the middle of the experiment the subject was given a short break.

In lexical decision subjects were told that they would see a brief flash containing a row of letters. Sometimes the row of letters would form a real English word and sometimes it would not. Subjects were instructed to press the *yes* button if they saw a word, and the *no* button otherwise. Subjects were encouraged to guess if they were not sure about their decision and to try to respond on the basis of their first impression. In object decision, subjects were given similar instructions: "Press the *yes* button if you see a picture of a real object, and the *no* button otherwise." In both the lexical and object decision groups, subjects were told to respond as quickly and as accurately as possible.

Subjects. Twelve subjects performed each task. Within each task subjects were randomly assigned to one of the two versions of the stimulus materials. The subjects were college students who were paid $3.00 for their participation. All subjects were screened for normal or corrected-to-normal visual acuity and for English as their native language.

Results and Discussion

Mean response times and error rates for the lexical and object decision tasks are given in Table 1. The response times (RTs) and error rates for the two tasks were comparable; none of the differences between the two tasks was significant. Overall, positive responses were faster than negative responses in both tasks, $F(1,22) = 31.86$, $p < .001$, and slightly less accurate, $F(1,22) = 5.34$, $p < .05$. There were no interactions between the modality of the task (word or picture) and the type of response. Hence, recognizing an object seems to be no more difficult than recognizing a word. Superficially, the existence of only 26 letters in the alphabet might have led one to expect that the algorithms for accessing lexical memory would be far simpler and faster than those used to recognize a novel drawing. On the other hand, our visual system has developed to recognize objects, not words, so perhaps the facility of object recognition should not be surprising.

TABLE 1
MEAN RESPONSE TIMES (msec) TO MAKE LEXICAL AND OBJECT DECISIONS ABOUT WORDS AND PICTURES OF OBJECTS IN EXPERIMENT 1

Decision	Yes	No
Lexical	632 (.04)[a]	703 (.03)
Object	617 (.05)	676 (.03)

Note. Error rates are given in parentheses.

According to the view that similar patterns of reaction times and errors imply similar underlying processes, these data can be taken as support for reliance on a common conceptual representation in processing words and pictures (Snodgrass, 1984). The argument is weak, however, because similar response patterns in lexical and object decision could be explained in a number of other ways. For example, it is impossible to equate the distractors in the two tasks, and it is known that subjects respond faster to both positive and negative items when the distractors in a lexical decision task are less word-like. Thus, the similarity between the two tasks could conceal a true difference that was masked by compensating differences between the nonwords and nonobjects.

In addition to the overall analyses of RTs and errors, a number of finer-grain analyses were performed to see whether lexical and object decisions were influenced by the same variables. These additional analyses were restricted to the set of positive items in each task.

Frequency effects. Since the positive items were chosen to represent a range of frequencies (measured by the frequency of the word's name), it was possible to obtain a rough estimate of the frequency effect in each condition. This post hoc analysis of frequency effects was accomplished by comparing the mean RTs and errors for items of relatively high frequency (over 35 per million in the Kučera and Francis, 1967, word count) with those for items of relatively low frequency (less than 35 per million). An analysis of variance was performed on *yes* responses as a function of frequency class (high or low) and task (lexical or object decision). The result was a significant frequency effect in both tasks $F(1,22) = 22.76$, $p < .001$. The frequency effect was smaller than that typically found in lexical decision tasks (here it was 35 milliseconds in lexical decision and 24 milliseconds in object decision), although this was probably a result of the crude division of frequency classes and the omission of very low frequency items since few picturable objects fit into that category. Of greater interest is the fact that the size of the frequency effect did not interact with task; the small frequency effect was reliable for both lexical and object decision even though the measure of frequency was a measure of frequency of printed words.

The fact that both tasks appear to be influenced by familiarity in similar ways is consistent with the common-code model, in that it suggests that at least part of the frequency effect is due to conceptual frequency rather than to lexical or visual frequency per se. On the other hand, it is likely that word frequency is correlated with object frequency, in which case, the two frequency effects could each reflect modality-specific processing.

Rank-order correlation. If lexical and object decisions are both based on access to a common concept, then the relative availability of particular concepts should influence each type of decision in the same way; concepts which represent familiar ideas should be recognized more rapidly than concepts which represent less familiar ideas. To see whether this was true, a rank-order correlation was computed on the 120 positive item means collapsed across the two versions of each task. The resulting correlation was significant, $r_s = .41$, $p < .025$, supporting the idea that similar processes, and perhaps the same conceptual representation, underlie lexical and object decisions. Again, although the obtained similarity between the two tasks is consistent with the common-code model, it could also be due to the similar degree of familiarity of the name and the appearance of given objects. Only if it can be shown that the words gain in functional frequency when one sees their referents, and vice versa, could one be sure that the correlation is attributable to retrieval of a common code at the time of decision.

Are pictures named in object decision? One possibility for the correlation between the two tasks that we have not yet considered is that the same surface form, the object's name, is used in both decisions. If an object must be named, or its verbal code accessed, before an object decision can be made, then object decisions should take approximately 200–300 milliseconds longer than lexical decisions because that is the additional time it takes to attach a verbal label to a picture, compared to a written word (Cattell, 1886; Potter & Faulconer, 1975; Smith & Magee, 1980). This idea is consistent with dual-code models such as Paivio's (1978) in which conceptual information is primarily accessed via the verbal system. This predicted difference was not supported by the data just presented; lexical and object decisions took about the same time to perform.

We have argued that the similarity between lexical and object decisions may just be a resemblance; the two tasks may involve different processes which happen to finish in the same overall time. The next set of experiments considers some alternative procedures for determining whether the overall similarity of lexical and object decisions found in Experiment 1 was just a superficial resemblance or a true reflection of the use of the same underlying conceptual code.

Experiment 2: Filtering Pictures or Words

In Experiment 1 the time and accuracy of decisions about words and pictured objects appeared similar. This similarity does not necessarily imply access to a common representation; lexical and object decisions could rely on modality-specific representations which are processed similarly. These possibilities were tested in Experiment 2 by asking subjects to filter out the other modality. Consider a subject who is participating in a lexical decision task with instructions to respond *yes* to words and *no* to nonwords. What if a picture of an object were presented as a distractor? An object, like a word, has meaning. If retrieval of a conceptual representation is part of the basis for lexical and object decisions, then rejection of real items in the wrong modality might be difficult, just as it is difficult to ignore meaningful words in Stroop-type interference tasks (Rosinski, Golinkoff, & Kukish, 1975; Smith & Magee, 1980). Pictures of nonobjects, however, should be rejected quickly in a lexical decision task because they are neither words nor meaningful. If lexical decisions are based on modality-specific codes, however, then pictures of real objects and nonobjects should both be relatively easy to filter out (i.e., to reject as not a word). The same argument holds for the complementary case in which an object decision is performed and words or nonwords appear as distractors.

Method

The stimulus materials, apparatus, and procedure were identical to those described for Experiment 1, with the following exceptions. The 60 negative trials in each experiment were now divided into three categories of 20 items each: same-form distractors, other-form *real* items, and other-form distractors. The other-form real items were always taken from the version of the positive set not used for that subject. That is, if *cat* was seen as a positive item in lexical decision, then the picture of a cat was not used as a distractor. The materials were counterbalanced across subjects so that the entire set of items appeared as positive targets and as distractors.

Subjects. Twelve subjects performed each task. Within each task subjects were randomly assigned to one of the two versions of the stimulus materials. The subjects, recruited from the same subject pool as that for Experiment 1, were paid $3.00 for their participation. All subjects were screened for normal or corrected-to-normal visual acuity and for English as their native language.

Results and Discussion

Mean response latencies and errors in performing the lexical and object decision tasks are shown in Table 2. For both tasks, distractors of the other modality were extremely easy to reject. The mean response time for both other-form real items and other-form distractors was approximately 225 milliseconds faster than the time to reject same-form distractors. In addition, there were *no* errors on either type of other-form stimuli in either of the tasks. Clearly, subjects were able to filter out items in the irrelevant form. There was, however, a substantial reduction in the speed and accuracy with which the same-form distractors were rejected. An analysis of variance comparing lexical and object decisions in Experiment 2 yielded no significant differences between the tasks, $F(1,22) < 1$. A separate analysis of the negative trials revealed a highly significant effect of the stimulus type on RTs, $F(2,44) = 331.01$, $p < .001$, and errors, $F(2,44) = 38.89$, $p < .001$. The same-form distractors were significantly slower and more likely to produce errors than were the other-form stimuli.

TABLE 2
MEAN RESPONSE TIMES (msec) TO MAKE LEXICAL AND OBJECT DECISIONS ABOUT WORDS AND PICTURES OF OBJECTS WHEN DISTRACTORS INCLUDE BOTH SURFACE FORMS (EXPERIMENT 2)

		No		
Decision	Yes	Same-form distractor	Other-form real	Other-form distractor
Lexical	586 (.01)	757 (.15)	523 (.00)	520 (.00)
Object	624 (.04)	760 (.10)	544 (.00)	555 (.00)

Note. Error rates are given in parentheses.

There was no suggestion of an interaction between task and pattern of RTs (or errors) for negative trials.

Frequency effects. As in Experiment 1, the positive items in each task were categorized into high and low frequency classes. An analysis of variance performed on *yes* responses as a function of frequency class (high or low) and task revealed a small but significant frequency effect, $F(1,22) = 11.67$, $p < .01$. The magnitude of the frequency effect was 25 milliseconds in lexical decision and 13 milliseconds in object decision. The comparable effects in Experiment 1 were 35 milliseconds in lexical decision and 24 milliseconds in object decision.

The diminished frequency effect in Experiment 2 is consistent with a peripheral filtering explanation in which it is assumed that an initial judgment was made on the basis of the surface form of the stimulus. If there was a mismatch on the basis of surface features (a possible basis for peripheral filtering), then the item was quickly rejected. If the surface features matched, however, there was an additional stage of memory access as in normal lexical or object decision. If subjects sometimes responded positively simply on the basis of a modality match (as the increase in false positives to same-form distractors suggests), then the positive trials would have consisted of a mixture of fast responses without lexical or object access (and hence without frequency effects) and slower responses with access. The result would be a dilution of the frequency effect of the kind observed.

An examination of the error RTs for the same-form distractors supported this explanation. The average RT for the 15% false positives to nonwords in the lexical decision was 523 milliseconds, which was faster than the 586-millisecond average RT for true positives and almost identical to the average RT for correct rejection of picture distractors, 522 milliseconds. Similarly, in the object decision task, the average RT for the 10% false positives to nonobjects was 563 milliseconds, again faster than the 624-millisecond average RT for true positives, and close to the 550 milliseconds for rejection of verbal distractors. Thus, when other-form stimuli are mixed with same-form distractors in both lexical and object decisions there appears to be a change in decision strategy to allow for peripheral filtering.[1]

Since the conditions of the present experiment permit a change in decision criteria, these data do not constitute a strong test of conceptual involvement in lexical and object decisions, other than to indicate that access to a conceptual representation is neither automatic nor mandatory under these conditions. A more direct way to ex-

[1] A similar result has been reported by Scarborough, Gerard, and Cortese (1984) in a bilingual lexical decision task. In their task, subjects were told to respond positively to one language (either English or Spanish) and to reject the other language. Their results showed that there were no frequency effects on the time to reject the distractor language. Like the present results, the results of the Scarborough et al. study suggest that subjects were able to successfully filter the distractor stimuli even when they shared surface characteristics.

amine the conceptual contribution to lexical and object decisions is to see whether both tasks benefit equally from semantic priming. If the semantic priming effect discovered by Meyer and Schvaneveldt (1971) for lexical decision is due to lexical organization and to associations specific to words, then we would not expect equivalent facilitation for pictures of related objects.

Experiment 3: Semantic Priming

In Experiment 3 the Meyer and Schvaneveldt (1971) semantic priming paradigm was used in the object and lexical decision tasks. If semantic priming is the result of access to a general conceptual memory system that is common to words and pictured objects, then we might expect similar priming effects in both tasks. If semantic priming is due exclusively to lexical organization and word-specific associations, then we might only expect to find a semantic priming effect in the lexical decision task. Furthermore, if only associative relationships give rise to semantic facilitation, then we might expect to find a larger semantic priming effect for words that are associatively related to one another than for words only related semantically or conceptually. To test this hypothesis in Experiment 3 we compared the priming effect for pairs of items that were related only by virtue of membership in the same superordinate semantic category with the effect of sharing the same superordinate category and also being highly associated.

Method

The materials and procedure were similar to those described for Experiment 1. The major changes were that (1) two items were presented simultaneously on a single trial, one above the other, for both tasks; (2) the subject had to decide whether *both* items were real words (in lexical decision) or pictures of real objects (in object decision); (3) half of the positive pairs were semantically related and associated, and half were semantically related but not highly associated; (4) the materials were presented tachistoscopically; and (5) the response was vocal rather than manual. The details of these changes are described below.

Stimulus materials. Positive trials consisted of pairs of real items (words in lexical decision, pictures of objects in object decision). Half of the real items were semantically related and half were unrelated. The unrelated pairs were formed by randomly scrambling members of related pairs. Of the related pairs, one-quarter were selected from norms of free association (Postman & Keppel, 1970), such that they were highly associated as well as semantically related. The criterion for high association was that the second item of each word pair had to be a primary response to the first item with a relative frequency of .20 or greater. The remaining three-quarters of the related items were semantically related but not highly associated. Semantic relatedness was determined by subjective ratings taken from an independent group of subjects. A description of these ratings and the actual stimulus pairs used are given in Appendix B. An example of the distinction between "semantically related and associated" and "semantically related only" can be seen in the following word pairs: dog–cat, arm–leg (associated as well as related) versus cow–horse, apple–banana (semantically related but not highly associated). Unrelated pairs were formed by interchanging items within the associated pairs or the semantically related only pairs. Since items forming associated pairs may also differ from semantically related items in a variety of ways (e.g., they are often words of higher frequency), the two types of unrelated pairs provide a good control for item-specific differences.

Negative trials consisted of mixed pairs of real and distractor items (words and nonwords in lexical decision, pictures of objects and nonobjects in object decision), and pure pairs of two distractors (two nonwords in lexical decision, two nonobjects in object decision). Half of the mixed pairs contained a real item in the top position of the stimulus array and half contained a real item in the bottom position. Each of the three types of negative trials occurred equally often.

Two versions of the materials, each consisting of 96 pairs, were constructed such that each positive item appeared in both related and unrelated conditions but in different versions. Thus, within a version of the materials no item was repeated. Of the 96 pairs in each version 48 were positive pairs (both members real) and 48 were negative pairs (32 mixed pairs, 16 pure distractor pairs).

Apparatus and procedure. Stimulus pairs were presented in one field of a three and one-half field tachistoscope (Scientific Prototype Model N-1000). The items appeared one above the other, centered horizontally within the visual field. The distance between the two items was approximately 1.2 cm. A second field contained a fixation display consisting of two line segments indicating the position of the two stimulus items. A different fixation field was used in the word and picture conditions to accommodate differences in the vertical visual angle of the word and picture displays.

Each subject was tested in an individual session that lasted approximately 30 minutes and consisted of two blocks of 48 trials, preceded by a block of 24 practice trials using different stimulus materials. Subjects were instructed to respond as quickly as possible by saying *yes* if both items were real words (in lexical decision) or pictures of real objects (in object decision) and by saying *no* otherwise. Their spoken responses activated a voice key (Scientific Prototype audio threshold detection relay, 761 G), which stopped a counter (Scientific Prototype Model N-1002) which had been activated at the onset of the stimulus display. Reaction time was measured to the nearest millisecond.

A surprise memory task, in which subjects were asked to write down as many of the items as they could recall from the experiment, followed the lexical or object decision task.

TABLE 3

MEAN RESPONSE TIMES (msec) TO MAKE LEXICAL AND OBJECT DECISIONS FOR RELATED AND UNRELATED PAIRS OF WORDS AND PICTURES OF OBJECTS IN EXPERIMENT 3

Decision	Related pairs	Unrelated pairs	Diff.
Lexical	822 (.03)	840 (.03)	18
Object	807 (.05)	856 (.07)	49

Note. Error rates are given in parentheses.

Subjects. Thirty-two college-age students were each paid $2.50 for participation. Half the subjects were randomly chosen to perform each decision task. All subjects had normal or corrected-to-normal visual acuity and were native English speakers.

Results and Discussion

Decision latencies for positive responses to related and unrelated stimulus pairs are shown in Table 3 for both the lexical and object decision tasks. The overall pattern of results is similar for both tasks: related pairs were judged to be real words or pictures of real objects more rapidly than unrelated pairs, $F(1,30) = 30.55, p < .01$. The magnitude of the semantic facilitation effect, although significant for both lexical and object decisions, was noticeably larger for pictures (49 milliseconds) than for words (18 milliseconds), $F(1,30) = 6.63, p < .05$. Although there were somewhat more errors in object decision (5.9%) than in lexical decision (3.0%) the difference was not statistically reliable. In addition, there were no reliable differences in errors between the related and unrelated conditions in either task, $F(1,30) < 1$.

One way in which the priming of pictures and words might differ is in the role of word associations. If the primary mechanism for lexical priming is associated (as reflected in association norms),whereas the primary mechanism for picture priming is semantic relatedness, that difference could account for the smaller priming effect for words, since only one-quarter of the related pairs were also associated. To evaluate this hypothesis, the reaction times and errors for positive items (related and unrelated) in both tasks were compared for the two types of related pairs (semantically related and associated vs semantically related only). These data are shown in Table 4. It is important to remember that the unrelated pairs were constructed by scrambling related pairs of the same type: related associated pairs were recombined to form unrelated "associated" pairs, semantically related pairs were recombined to form unrelated pairs using the same items. Inspection of the data in Table 4 reveals no effect of association on the magnitude of the semantic priming effect, either for words or for objects. Overall, there was a significant effect of association value on reaction times, $F(1,30) = 24.95$, $p < .01$, and on errors, $F(1,30) = 6.44$, $p < .05$. There was also a significant interaction between task (lexical or object decision) and association value in the reaction time analysis, $F(1,30) = 12.9$, $p < .01$. The effect of association was entirely due, however, to the fact that *both* related and unrelated combinations of the words used in associated pairs produced faster reaction times in lexical decision than did the words in the semantically related only conditions. (This difference in materials was not significant in the object decision task.) The striking result is that despite the large difference between the subgroups of words, the magnitude of the semantic relatedness effect was virtually identical (15 milliseconds for associated and related pairs, 18 milliseconds for semantically related only pairs). The hypothesis that words might be primed differentially by associates thus received no support from the present experiment.

The fact that the words that enter into associative relationships were accepted more rapidly in lexical decision, which their conceptual counterparts in object decision showed no such benefit, suggests the presence of a factor correlated with associative strength that influences a stage of word recognition but not object recognition. The failure to find an enhancement of the semantic priming effect due to association replicates a previous result of Fischler (1977) for the lexical decision task. It further supports the idea that the effect of semantic facilitation is not within the lexicon (where word-specific associations might reside), but in an amodal conceptual system.

Negative trials. Reaction times and errors for the three types of negative trials were compared for the lexical and object decision tasks. Recall that there were negative trials in which both items of the pair were distractors (pure negatives) and other trials in which one item was a distractor and the other was real (mixed negatives). The position of the real item in mixed negative trials was balanced so that it appeared on the top of the display half of the time and on the bottom for the remaining trials. The results are shown in Table 5. In both tasks

TABLE 4

MEAN RESPONSE TIMES (msec) TO MAKE LEXICAL AND OBJECT DECISIONS ABOUT WORDS AND PICTURES OF OBJECTS THAT ARE HIGHLY ASSOCIATED AS WELL AS SEMANTICALLY RELATED COMPARED TO WORDS AND PICTURES OF OBJECTS THAT ARE ONLY SEMANTICALLY RELATED (EXPERIMENT 3)

	Semantically related and associated			Semantically related only		
Decision	Related	Unrelated	Diff.	Related	Unrelated	Diff.
Lexical	776 (.02)	791 (.01)	15	838 (.03)	856 (.04)	18
Object	804 (.02)	843 (.04)	39	808 (.06)	860 (.07)	52

Note. Error rates are given in parentheses.

TABLE 5

MEAN RESPONSE TIMES (msec) TO REJECT DISTRACTOR PAIRS IN LEXICAL AND OBJECT DECISION (EXPERIMENT 3)

	Type of distractor pair		
Decision	Top real, bottom distractor	Top distractor, bottom real	Both distractors
Lexical	1078 (.28)	975 (.15)	953 (.06)
Object	991 (.16)	965 (.17)	892 (.04)

the time to reject mixed pairs was longer than the time to reject pure distractor pairs, and the time to reject mixed pairs with the real item on the top was longer than the time to reject mixed pairs with the real item on the bottom. This overall pattern was significant for both RTs, $F(2,60) = 28.47$, $p < .01$, and errors, $F(2,60) = 17.77$, $p < .01$. The mixed conditions which produced the longest RTs also produced the most errors. A post hoc Newman–Keuls test revealed significant error differences for the pure vs mixed comparison only; the two types of mixed trials were not statistically different.

The pattern of negative responses was slightly different in lexical and object decisions as revealed by both RTs, $F(2,56) = 3.64$, $p < .05$, and errors, $F(2,56) = 3.29$, $p < .05$. In lexical decision, there was a clear effect of the position of the real item in mixed negatives: when the real word appeared in the top position of the array, lexical decision times were longer and less accurate than they were on trials in which the real item appeared in the bottom position: $q(4,56) = 7.41$, $p < .01$ for RTs, and $q(4,56) = 4.56$, $p < .05$ for errors. In object decision, the difference between the two positions of the real object in mixed negatives was not significant for RTs, $q(3,56) = 2.08$, $p > .05$, or for errors, $q(2,56) < 1$, suggesting a difference in processing order for pictures and words.

Overall, the patterns of results for the lexical and object decision tasks look quite similar and bear a strong resemblance to Meyer and Schvaneveldt's (1971) original results. The pattern of negative responses that Meyer and Schvaneveldt obtained was as follows: 1087 milliseconds (28% error) to reject mixed negatives with the real item on top, 904 milliseconds (8% error) to reject mixed negatives with the real item on the bottom, and 884 milliseconds (3% error) to reject pure negatives. The main difference between our lexical decision results and their results is in the magnitude of the semantic priming effect; we found an 18-millisecond difference between related and unrelated word pairs, while they found an 85-millisecond difference between related and unrelated pairs. (Meyer & Schvaneveldt's actual results were 940 milliseconds (9% error) for the unrelated pairs and 855 milliseconds (6% error) for the related pairs.) The longer RTs and higher error rates for both the related and unrelated conditions in their experiment may have contributed to a large semantic priming effect in their study than in ours. An important difference between the two studies, however, is that the words in our experiment were necessarily concrete nouns (object labels). To the extent that word concreteness influences lexical retrieval (James, 1975; Kroll, Supraner, & Merves, Note 2), the smaller effect of semantic facilitation in this experiment might be attributable to the fact that concrete words are often accessed more rapidly than abstract words, and thus are less susceptible to priming influences.

Two other studies have reported small effects of semantic facilitation (Sperber, McCauley, Ragain, & Weil, 1979) and word frequency (Scarborough, Gerard, & Cortese, 1979) with picturable nouns. The Sperber et al. study examined semantic priming effects in word- and picture-naming. Their results were strikingly similar to ours: the magnitude of semantic facilitation for words (19 milliseconds) was much smaller than that for pictures (51 milliseconds). An examination of the relatedness ratings included in Appendix B suggests a possible reason for the difference in the magnitude of the priming effect in lexical and object decisions: overall, pictures were rated as being more closely related to one another than words (see Table B-1). The greater perceived relatedness for pictures might have produced greater facilitation (i.e., faster RTs) in object decision when the pair of pictures was actually related, and possibly some interference (i.e., slower RTs) when the pairs were unrelated. The net result would be an increase in the magnitude of the semantic priming effect for pictures relative to words. The data in Table 3 offer some support for this kind of analysis in that RTs were faster for pictures than for words on related pairs, but the reverse was true for unrelated pairs. A different explanation for differential patterns of semantic priming for pictures and words has recently been given by Huttenlocher and Kubicek (1983). They propose that semantic priming affects the speed of perceptual identification of pictures but not words. These two explanations are not easily distinguished by the present data.

The results of the incidental memory task given at the end of the experiment will be presented in a later section of this paper.

Summary of Results

In Experiments 1–3 consistent parallels were found between the lexical and object decision tasks under conditions in which the two tasks were performed by separate groups of subjects. The overall response times and pattern of errors were similar for the two tasks (Experiment 1), the apparent ease in filtering out distractors of the other modality was the same for both tasks (Experiment 2), and there were effects of semantic priming for both lexical and object decision (Experiment 3). The only distinct differences between the tasks were the size of the semantic facilitation effect (it was larger for pictures than for words) and the pattern of negative responses (which suggested that pictures were processed in parallel while words were processed serially).

It was argued that reliance on a common conceptual representation in lexical and object decisions would produce the kinds of parallel results obtained here. While the observed parallels are consistent with a common locus of representation for words and pictured objects, they do not, when considered alone, provide a critical test of the common-code hypothesis. For one thing, the presentation of pictures and words blocked between subjects might have permitted the use of independent strategies for each surface form. These strategies might bear some resemblance to each other without requiring the use of the same representation.

The next section of the paper addresses another prediction of the common-code hypothesis, namely, that mixture of the two surface forms should not have a disruptive influence on the processing of either surface form.

SECTION 2: REALITY DECISIONS FOR MIXTURES OF WORDS AND PICTURES

In the second section two experiments are described in which the lexical and object decision tasks are mixed into a single *reality decision task*. If the results of the first three experiments reflect access to a common conceptual representation for words and pictured objects, then forcing subjects to treat pictures and words independently of their surface form should not radically alter the pattern of results.

Experiment 4 provided a test of the common-code hypothesis by mixing the pictures and words that had been presented separately in Experiment 1. In Experiment 5 the question asked was whether the facilitation that typically results from repetition of words in lexical decision (e.g., Scarborough et al., 1977) would also hold across surface forms (from words to pictures and vice versa). The results of this section revealed changes in performance when pictures and words were mixed and little evidence for facilitation across surface forms.

Experiment 4: Comparing Words and Pictures in Reality Decision

In Experiment 4 subjects were asked to decide whether individual words, pictures of objects, pseudo-words, and pictures of nonobjects were real or not real when they were presented in a mixed sequence.

Method

Stimulus materials. The materials were identical to those described in Experiment 1. To construct the sequence for the reality decision task, the materials from the lexical and object decision tasks were randomly intermixed and divided into versions so that the total length of the experiment was identical to Experiment 1. The result was four versions of reality decision, each consisting of 60 positive and 60 negative trials. Additional constraints were that an equal number of each type of stimulus appears in each version and that any given item appears in a given version in one surface form only (i.e., an item presented as a word would not be repeated as a picture within that version of the materials). The same procedure was used to construct practice lists.

Apparatus and procedure. Except for a change in instructions alerting subjects to the mixture of words and pictures, the apparatus and procedure were identical to those described in Experiment 1.

Subjects. Twenty-four subjects performed the reality decision task, one-quarter of whom saw each of the four versions of the stimulus materials. The subjects, recruited from the same subject pool used in Experiment 1, were paid $3.00 for their participation. All subjects were screened for normal or corrected-to-normal visual acuity and for English as their native language.

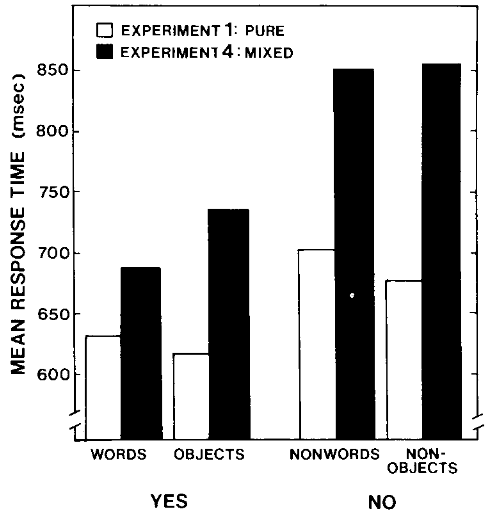


FIG. 2. Mean response times (milliseconds) to accept words and pictures of objects and reject nonwords and nonobjects in Experiment 1 (pure lexical and object decision tasks) and in Experiment 4 (mixed reality decision task).

Results and Discussion

Mean response times for reality decisions are shown in Figure 2 where they are directly compared to the data obtained for pure lexical and object decisions. Two aspects of the reality decision results distinguish them from the earlier lexical and object decision results. First, the overall response latencies were substantially longer in the mixed task. Second, the average time to accept a picture of an object as real was approximately 47 milliseconds longer than the time to accept a word as real, $F(1,23) = 50.9$, $p < .001$, in the reality decision task. The difference between words and pictures held only for real concepts, however; both pseudo-words and nonobjects were rejected equally slowly. The average increase in time to reject both types of distractors was approximately 150 milliseconds in reality decision compared to the previous pure conditions. The large and similar increase in time to reject the two types of distractors might be taken to suggest the operation of a response deadline not present under pure conditions.

An analysis of variance performed on RTs and errors in reality decision showed a significant interaction between the response class (whether an item was real or a distractor) and the modality of the item (word or picture), $F(1,23) = 5.59$, $p < .025$. A post hoc Newman–Keuls test supported the description of the results we have already offered: real words were accepted more rapidly than pictures of real objects, $q(2,23) = 5.12$, $p < .01$, but there was no difference in time to reject the word and picture distractors, $q(2,23) < 1$. In addition, the difference between real words and pseudo-words was significant, $q(3,23) = 17.7$, $p < .01$, as was the difference between real objects and nonobjects, $q(3,23) = 13.0$, $p < .01$.

The error rates were low in reality decision (less than 5%) but there were some reliable differences between conditions for the few errors that were made. Words were judged slightly more accurately than pictures (2.7 and 3.4%, respectively) but the difference was only significant when the real items were analyzed separately, $F(1,23) = 4.73$, $p < .05$, with 1.1% errors for real words, and 4.3% errors for real objects. An overall analysis of variance of errors also revealed a significant interaction between response class (real or distractor) and modality (word or picture), $F(1,23) = 4.84$, $p < .05$, such that real words were judged more accurately than nonwords, $q(4,23) = 3.6$, $p < .05$, but real objects and nonobjects were judged with equal accuracy.

Frequency effects. An analysis of frequency effects, analogous to the one performed on the pure data of Experiment 1, revealed a frequency effect of larger magnitude in reality decision (45 milliseconds in Experiment 4 compared to 30 milliseconds in Experiment 1). The frequency effect was also similar for pictures (43 milliseconds) and words (46 milliseconds).

The reality decision data make it clear that decisions about words and pictures were not based solely on a conceptual representation in this task. Reliance on a common representation would not have produced the substantial increase in response time under mixed conditions that we found in Experiment 4. The overall increase in RT in reality decision is similar to a result reported by Meyer and Ruddy (Note 3) in a mixed bilingual lexical decision task: when German and English words were presented in mixed orders for lexical decision, there was an increase of approximately 60 milliseconds compared to the corresponding times when German and English words were presented separately. Scarborough and Gerard (Note 4) have also reported a similar result for a mixed bilingual lexical decision task with Spanish and English words. Interestingly, in the Scarborough and Gerard study, the time to respond to pseudo-words was markedly longer in the mixed conditions than in the pure conditions, like the results of Experiments 1 and 4 in our study.

It is important to note that the overall increase in decision time in the reality decision task cannot be attributed to a change in expectation resulting directly from the mixing of pictures and words. When pictures and words are mixed in tasks that *require* conceptual access (e.g., categorization), there is not a consistent increase in response time (Potter, Note 1). The increase in response time here suggests that subjects cannot easily make use of a common conceptual representation when asked to verify the existence of a concept in different surface forms.

The increase in response latencies in reality decision, when compared to the pure conditions of Experiment 1, suggested that a single conceptual representation was not the *sole* basis for making a lexical or object decision. To the extent that a lexical decision or object decision depends on a surface representation of a word or picture, one would expect some overall increase in response time when the two tasks are mixed. The differential increase in latencies for picture decisions in the context of reality decision, however, suggests that the overall increase in decision time does not reflect a simple addition of time attributable to switching between the two surface representations. In addition, the time to judge *both* types of distractors was long (the overall difference between *yes* and *no* responses was 65 milliseconds in Experiment 1, and 142 milliseconds in Experiment 4). The rejection latencies for pseudo-words and nonobjects were equivalent, but there were a few more errors on pseudo-words.

What is the basis for judging pictures and words in reality decision? The long decision times to reject both types of distractors and the increased magnitude of the word frequency effect for both words and pictures (relative to Experiment 1) is consistent with an extended memory search in which negative decisions are made by default on the basis of a deadline. What of the asymmetry between picture and word decisions? The result is potentially important since it represents the first instance in these experiments of an absolute difference for pictures and words. Why should pictures take almost 50 milliseconds longer to judge as real than words? If subjects were implicitly naming the pictures an even larger difference between picture and word latencies would be expected; the obtained difference was small relative to the 200–300 milliseconds additional time required to access a picture's name (Potter & Faulconer, 1975). In addition, if the magnitude of the word frequency effect can be taken as an index of the degree of memory search, then the almost identical frequency effect for pictures and words suggests similar memory search processes. It will be seen in the next experiment that the puzzling asymmetry between words and pictures does not replicate. Thus it is concluded that the apparent difference between pictures and words in this experiment probably reflected sampling error.

What is clear about the results of Experiment 4 is that the mapping of mixed surface forms onto a single decision class results in increased decision latencies. Whether this increase is simply due to greater uncertainty or to distinct differences between picture and word processing remains to be seen. The similarity between reality decisions and mixed bilingual lexical decisions suggests that the increased decision time in each is probably not due to specific differences in surface features (pictorial vs alphabetic) but to a separation of two representational systems (imaginal vs lexical).

Experiment 5: Repetition Facilitation in Reality Decision

Finding that lexical and object decisions are disrupted by a mixture of surface forms underscores the role of form-specific memory representations for these tasks. This conclusion does not rule out a conceptual component in the decision process, nor access to a common concept following a form-specific decision. In Experiment 5 evidence was sought for conceptual access by examining the nature of repetition effects within and across surface forms. If reality decisions involve some contact with the concept common to both surface forms, then repetitions across surface forms should produce some facilitation. It was expected that repetitions within surface forms would produce facilitation, since Scarborough et al. (1977) have shown reliable repetition facilitation when words are repeated in lexical decision. Previous attempts to demonstrate across-form repetition effects have failed (e.g., Scarborough et al., 1979), but the failures may be attributable to the use of tasks in which pictures and words are not processed to the same degree (e.g., naming).

Method

Stimulus materials. The materials were identical to those described for Experiment 4. The design of the repetition sequences, however, required that eight separate versions of the materials be constructed. Within each version there were four blocks of 64 trials each, plus an occasional filler item. Each block contained eight instances of each type of stimulus (words, objects, nonwords, and nonobjects) presented twice. Nonwords and nonobjects were always presented in exactly the same form on the second presentation. Words and objects were presented in the same form in half of the repeated trials, and in the other form in the remaining half of the trials. Within each block of trials half of the repetitions occurred after a lag of 3 trials and half after a lag of 10 trials. In a few instances it was necessary to add a few filler items to extend the length of the block to accommodate all of the repetition constraints. The number of filler items varied between two and three per block. The eight versions of the materials that were constructed represented a counterbalancing of format and order of presentation within a repetition sequence (i.e., word–word, word–object, object–word, object–object), and lag (i.e., 3 or 10 trials). An additional constraint was that no version contained more than two instances of a given concept. A practice list consisting of 24 trials and 3 filler trials was constructed to represent the structure of the experimental lists.

Apparatus and procedure. The apparatus was identical to that described for Experiment 3. The procedure was similar to the one described for the reality decision task in Experiment 4 except that subjects were told that they could expect to see some repeated trials. Following the reality decision task, subjects were given an unexpected recall task.

Subjects. Thirty-two college-age students were each paid $2.50 to participate in the experiment. The subjects were randomly assigned to one of the eight versions of the experiment. All subjects had normal or corrected-to-normal visual acuity and were native English speakers.

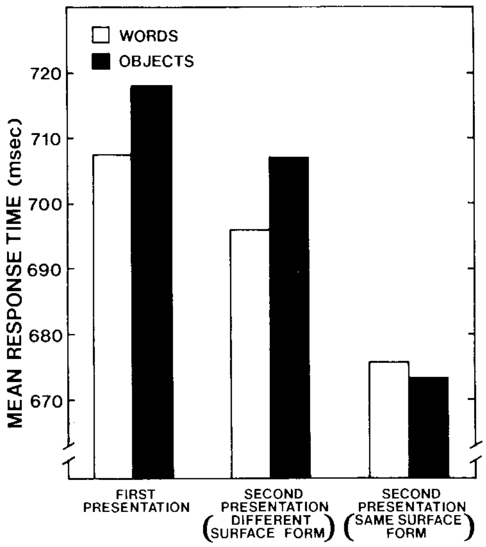


FIG. 3. Mean response times (milliseconds) to accept words and pictures of objects on the original presentation and after repetitions in the same or different surface form. (Experiment 5)

Results and Discussion

Overall, there was a significant repetition effect on response times for real items, $F(1,31) = 38.19$, $p < .001$, and for distractors, $F(1,31) = 89.05$, $p < .001$. The average repetition effect was 25 milliseconds for the real items (713 milliseconds on the first presentation, 688 milliseconds on the second) and 101 milliseconds for the distractors (858 milliseconds on the first presentation, 757 milliseconds on the second). Thus, reality decisions, like lexical decisions, benefit from multiple exposures of the same items. The main focus of this experiment, however, concerned the relative magnitude of the repetition effect across and within surface forms. Mean response latencies for repeated reality decisions about words and pictured objects are shown in Figure 3. The data shown in Figure 3 make it quite clear that the repetition effect, for both words and pictured objects, was substantially larger within form than across forms. An analysis of variance performed on these data indicated a significant interaction between the type of presentation (original or repeated trial), the surface form of the original presentation (word or picture), and the surface form of the repeated presentation (word or picture), $F(1,31) = 26.82$, $p < .001$. Post hoc Newman–Keuls tests showed that the repetition effect was significant for both within-form conditions; repeated words were judged more rapidly on repeated trials, $q(5,31) = 7.89$, $p < .01$, as were repeated pictures, $q(8,31) = 11.47$, $p < .01$.

Across surface forms there was a small but significant repetition effect for word decisions that had been preceded by picture decisions about the same concept, $q(5,31) = 4.78$, $p < .05$, but no repetition effect for picture decisions that had been preceded by the corresponding words, $q(2,31) = 0.0$. The smaller repetition effect across surface forms than within surface forms suggests that the major factor contributing to repetition facilitation is surface level rather than conceptual processing. This conclusion is supported by the results of other repetition studies showing little facilitation across surface modality (Scarborough, et al., 1979), across a bilingual's two languages (Scarborough, Gerard, & Cortese, 1984), or across unrelated contexts (Carroll & Kirsner, 1982). The small repetition effect obtained when words followed pictures may reflect conceptual facilitation. Recall that objects produced a larger effect of semantic facilitation in Experiment 3 than words did, and a slightly larger repetition effect than words did in the present experiment. Thus pictures may produce more conceptual activation than words, which in turn might produce an asymmetric repetition effect. Alternatively, some small part of the repetition effect may be attributable to practice (repeated trials always come after initial presentations), so it is difficult to know what to make of this cross-modality effect.

There was no overall effect of lag, $F(1,31) < 1$, nor was there any interaction between lag and the repetition effect, $F(1,31) = 2.44$, $p > .05$.

An analysis of errors indicated that error rates were low throughout the conditions of the experiment (average error rate was 2.8%). There were a few more errors made on the initial presentations (3.3%) than on repeated presentations (2.2%), $F(1,31) = 5.4$, $p < .05$.

Repetition effects for distractors. The largest repetition facilitation in the experiment occurred for the repeated distractor trials. The time to decide that a distractor was not real was facilitated by repetitions; on initial presentations the mean time to reject distractors was 858 milliseconds, and on repeated trials it was 787 milliseconds. The repetition effect was highly significant, $F(1,31) = 89.05$, $p < .001$. For the distractors there was an effect of lag, $F(1,31) = 4.24$, $p < .05$, such that repeated decisions after a lag of three trials were approximately 10 milliseconds faster than repeated decisions after a lag of ten trials. There was also a significant main effect of distractor modality, $F(1,31) = 5.25$, $p < .05$, such that pseudo-words were rejected more rapidly than nonobjects (813 and 832 milliseconds, respectively).

The overall error rate for distractors was 5.4%. There were no significant differences in error rate for any of the experimental conditions.

Data from the surprise recall task will be reported in the general discussion.

The repetition effect and reality decision. The results of Experiment 5 show that reality decisions are facilitated by prior presentations of identical words and pictures. Although the results of Experiment 4 suggested that reality decisions were somewhat different from separate lexical and object decisions (overall response times were longer in the mixed conditions and there was a word advantage for real items), the finding of a strong repetition effect, largely attributable to facilitation of the identical perceptual forms, is consistent with previous studies of the repetition effect in lexical decision. In addition, the asymmetry between positive responses to words and pictures was marginal or nonexistent in the conditions of the present experiment.

actions between surface forms and processing could provide such definitive evidence? Probably the strongest case can be made for comparisons involving across and within-form transfer. If the processing task under consideration is based on a single idea or concept underlying both words and objects, then there should be little consequence for processing whether the surface forms are mixed or blocked. That is, the ultimate form of representation, resulting from having seen a picture of an object and the nature of processing that representation (be it facilitatory or inhibitory), should also result from having seen the word that names the pictured object. In addition, if processing is based on a common concept, it should be possible to mix not only pictures and the words that name them, or words in one language with words in another, but all three, with little or no decrement in performance.

Where do these considerations leave us in interpreting the results of the experiments we have presented here? The results of Experiments 1 and 2, showing parallels between the two tasks, may be regarded as necessary but not sufficient evidence for the conceptual model. The results are also compatible with a dual-code model (e.g., Paivio, 1978), as long as a reasonable account of the "coincidental" similarities can be given. Likewise, the finding of semantic facilitation in Experiment 3 for each of the tasks is consistent with a common-code model, but not definitive support for one. A stronger test of semantic facilitation effects would be to look at priming across, as well as within, surface forms. Vanderwart (1984) has recently performed such a test for lexical decisions. In her study, lexical decisions were preceded by picture or word primes that were related or unrelated to the target words. She found strong priming effects for both types of primes and interpreted her results as support for reliance on a common conceptual code in lexical decision.

We have said that the strongest evidence for or against a common-code model should be obtained when surface forms are mixed. The reality decision task, in which lexical and object decisions are mixed, provides such a test. The results of the two reality decision experiments (Experiments 4 and 5) show clear evidence for at least partial reliance on form-specific codes: in both experiments decision times were elevated relative to the pure decision times of the first experiment, and in Experiment 5 there was little evidence (except for the case in which words were preceded by pictures) for a repetition effect across forms. While these experiments suggest reliance on a form-specific representation, they do not allow a precise evaluation of the degree to which the task involves a conceptual code as well.

Semantic Processing in the Lexical Decision Task

What constitutes good evidence for one representational model over another? At the broadest level an answer to this question requires a consideration of the assumptions made in using a particular task as well as the assumptions underlying particular experimental manipulations. For example, we were motivated to devise the object decision task as a way to study semantic processing for pictured objects because we assumed that the analogous lexical decision task was sensitive to conceptual factors, an assumption which has recently been challenged as being too strong (e.g., Carroll & Kirsner, 1982; Koriat, 1981). Although lexical decisions can be facilitated by semantically related primes, Koriat (1981) has shown that the degree of semantic relatedness has no effect on the magnitude of the semantic priming effect, suggesting that the prime may influence a decision process after the target is presented and partially processed, rather than biasing the course of target processing itself. Thus initial processing could be form-specific before the hypothesized common code is retrieved. On this view, we would not have been surprised by our results, showing primary dependence on form-specific representations, nor would we have been surprised by the results reported by Scarborough et al. (1984) showing that bilingual subjects seem to keep their two languages separate in a lexical decision task.

One proposal concerning lexical decisions is that there are two bases for a lexical decision, one based on perceptual recognition, and a second based on meaning (Jacoby & Dallas, 1981). To the extent that a lexical (or object) decision is based on meaning, one would expect to find similar results for pictures and words and for words in two different languages. To the extent that a lexical (or object) decision is based on what Jacoby and Dallas call "perceptual fluency" one might expect to see little evidence of conceptual transfer from one form to the other.

Incidental Recall following Lexical, Object, and Reality Decisions

As a final way of evaluating the level of processing in the present decision tasks, we looked at incidental memory performance following completion of the reaction time tasks in Experiments 3 and 5. The results, like those reported by Carroll and Kirsner (1981) and Jacoby and Dallas (1981), show a dissociation between the effect of certain variables on lexical or object decisions and later recall.

In Experiment 3 separate groups of subjects performed lexical or object decisions in which pairs of related or unrelated items had to be judged simultaneously. There was a semantic relatedness effect for both tasks, although the magnitude of the effect was larger in the object decision. In addition, an analysis of the contribution of associative strength to the relatedness effect yielded negative results; the magnitude of the relatedness effect was as large for pairs related only by virtue of membership in the same superordinate category as for pairs that were also highly associated. The incidental recall data, shown in Table 6, tell a very different story. For both the lexical and object decision tasks, episodic memory for words and objects was enhanced by the presence of an *associative* relationship beyond semantic relatedness. An analysis of variance on these data revealed a significant effect of task, $F(1,30) = 12.27$, $p < .01$, with object decision producing superior recall to lexical decision (19 and 12%, respectively). There was also a significant effect of relatedness over all conditions, $F(1,30) = 36.08$, $p < .01$, with better recall for items appearing in a related context than for those appearing in an unrelated context (21 and 10%, respectively). Of greatest interest, however, was the significant effect of association, $F(1,30) = 87.4$, $p < .01$, and the significant interaction between the effect of relatedness and association, $F(1,30) = 15.38$, $p < .01$. For incidental recall following *both* lexical decision and object decision, memory for items appearing in related pairs was greatly enhanced by the presence of an associative relationship, $q(2,30) = 8.38$, $p < .01$. Memory for items appearing in pairs that were semantically related only was no better than memory for items appearing in unrelated pairs. These data show that the association value played an influential role in episodic memory for words and pictures, although it did not seem to influence semantic priming in the reaction time task. In addition, although we found an overall picture superiority effect (recall was superior following object than lexical decision), the association effect did not interact with the modality of the task. The independence of the picture superiority effect and the semantic relatedness effect in memory has been reported in a number of other studies in which incidental memory tasks follow lexical decision or naming of words and pictures (Vanderwart, 1984; Kroll & Potter, Note 5). It suggests that pictures and words share the same conceptual representations, since the relatedness effects presumably reflect the nature of the relationships represented in conceptual memory. Superior memory for pictures is more likely to be a

TABLE 6
MEAN PERCENTAGE RECALL FOLLOWING LEXICAL OR OBJECT DECISION IN EXPERIMENT 3

	Semantically related and associated			Semantically related only		
Decision	Related	Unrelated	Diff.	Related	Unrelated	Diff.
Lexical	27	6	21	9	5	4
Object	32	15	17	16	14	2

consequence of some aspect of the surface representation for pictures, than a reflection of semantic encoding.

In Experiment 3 we also looked at memory for real items when they appeared in the context of mixed negatives. Because overall recall was so poor (less than 4%) these data were not analyzed in greater detail. The fact that recall was poor supports the conclusion that filtered items received shallow processing.

The incidental recall data collected following the repeated reality decision task in Experiment 5 also produced results that differed from the reaction time data. The data are given in Table 7. The recall measure does not distinguish between the initial and repeated presentation of a stimulus. With the simple recall task we used, it was impossible to tell which of the two stimulus presentations the subject was recalling. The measure is thus a reflection of conceptual recall as a function of the modality of the stimulus presentations on the initial and repeated trials. The aspect of interest here of these data is that the form of the repetition influenced episodic memory in a different way than it influenced reality decision latencies. Reality decisions were facilitated by within-form repetitions, but not significantly by across-form repetitions. Recall, however, was best following mixed repetitions, intermediate following repetition of a picture, and worst following repetition of a word. The effect of the form of the repetition was significant, $F(1,31) = 30.08$, $p < .01$. Post hoc Newman–Keuls tests revealed significant differences between pure word and picture repetitions, $q(2,31) = 4.22$, $p < .01$, but not between the two mixed repetitions, $q(2,31) = 2.25$, $p < .05$. The mixed repetitions produced better memory than the pure repetitions in all comparisons except those between pure picture repetitions and words followed by pictures.

Overall, the results of the incidental memory task show that recall of words and pictures was influenced by conceptual factors in similar ways; memory for both surface forms was a function of semantic relatedness and association value of the context in which they were seen. The finding that mixed repetitions were remembered more often than identical repetitions is more ambiguous. It could mean that pictures and words were ultimately processed to a conceptual level, or alternatively, that two separate codes were independently retrieved. Finally, the independence of the picture superiority effect and conceptual processing suggests that the source of superior memory recall for pictures lies in the nature of the surface representation for pictures rather than in an elaborated conceptual representation.

TABLE 7
MEAN PERCENTAGE RECALL FOLLOWING REALITY DECISIONS IN EXPERIMENT 5

	Percentage
Within-form repetitions	
Word–word	15
Picture–picture	23
Across-form repetitions	
Word–picture	27
Picture–word	31

CONCLUSIONS

This paper reports a set of experiments which compare the processing of words and pictures in lexical, object, and reality decision tasks. The results show that object decisions are similar to lexical decisions when the tasks are performed separately, but that mixing the two tasks into a single reality decision task greatly reduces processing speed. The results do not offer unambiguous support for either the dual-code model or the common-code model. They do suggest, however, that there is an important form-specific component in lexical, object, and reality decisions, and they point to an important qualification of the logic whereby semantic priming effects are automatically taken as evidence for reliance on conceptual processing. Because these decision tasks appear to be sensitive to both form-specific and conceptual factors, further studies comparing pictures and words in such tasks may help to determine the precise nature of form-specific memory representations and their relation to concepts.

APPENDIX A: NONOBJECT RATINGS

A group of 100 undergraduates was given the task of rating the degree to which the nonobjects used in our study resemble real objects. Subjects told to rate, using a 7-point scale, a nonobject as a "1" if it looked very much like a real object and as a "7" if it looked nothing like a real object. Intermediate values were to be assigned to intermediate judgments. The complete set of 88 nonobjects was reduced and printed on a single page. Subjects placed their ratings next to the picture of the nonobject.

The average ratings for each of the nonobjects is given in Table A-1. The average response time to reject each nonobject is also given for the pure object decision experiment (Experiment 1) and for the reality decision experiment (Experiment 4). Pictures of the nonobjects are provided in Figure A-1. The first 60 pictures are ordered according to the response times obtained in Experiment 1. Note that only the first 60 pictures were used in our experiments; the remaining 28 pictures were either discarded or used in practice sessions.

To see whether there was a relationship between the nonobject ratings and rejection latencies in Experiments 1 and 4 a set of correlations was computed. In the pure condition of the object decision in Experiment 2, the correlation between rejection time and rated object similarity was $r = -.31$, $p < .025$. In the mixed condition of the reality decision in Experiment 4, the correlation between the rejection time and rating was $r = -.52$, $p < .01$. The significant negative correlations suggest that nonobjects that resemble real objects were more difficult to reject as distractors in object decision.

APPENDIX B: SEMANTIC RELATEDNESS RATINGS

In Experiment 3 related pairs were formed by pairing coordinate members of the same superordinate category. Unrelated pairs were formed by repairing related items with items from a different superordinate category. The items were then rated by an independent group of subjects. The reasons for obtaining ratings for the related and unrelated pairs were (1) to check the degree to which the related and unrelated pairs were discriminable (since we had paired them intuitively) and (2) to determine the influence of the surface form of the items in a rating task.

An initial set of 64 related and 64 unrelated pairs was rated for sematic relatedness. Subjects were instructed to rate the pairs on a 7-point scale on which a rating of "1" meant closely related and "7" meant unrelated. Each of four different forms of the scale, corresponding to all possible combinations of word and picture pairs, was administered to 25 subjects. The 100 subjects who participated in the study were students in an introductory psychology class. They were randomly assigned to one of the four versions of the materials: (1) word pairs; (2) picture pairs; and (3) and (4) mixed picture–word pairs.

The overall results of the relatedness ratings are shown in Table B-1. With regard to the discriminability of the related and unrelated pairs, it was clear that subjects agreed with our intuitive categorizations. The distributions of ratings for related and unrelated pairs were almost nonoverlapping. An analysis of variance of these data also indicated a significant effect of the modality of the rated items, $F(3,378) = 135.4$, $p < .001$, and a significant interaction between the modality and semantic relatedness of rated item, $F(3,378) = 16.93$, $p < .001$. The interesting result was that picture pairs, overall, were rated as being more closely related to one another than word pairs or word–picture mixtures. A comparison of the pure word and pure picture ratings showed that the higher perceived relatedness for pictures held for both related, $q(2,378) = 15.2$, $p < .01$, and for unrelated pairs, $q(2,378) = 8.6$, $p < .01$.

The rating data we have described served to validate our intuitions about related and unrelated word and picture pairs. In addition, however, we observed an unexpected interaction, with the surface form being rates such that pictures were consistently rated as more closely related to each other than words. One

TABLE A-1
MEAN OBJECT SIMILARITY RATINGS FOR A SET OF 88 NONOBJECTS AND CORRESPONDING RESPONSE TIMES TO REJECT THOSE NONOBJECTS AS DISTRACTORS UNDER PURE (EXPERIMENT 1) AND MIXED (EXPERIMENT 4) DECISION CONDITIONS

Non-object	Mean rating	Mean RT		Non-object	Mean rating	Mean RT		Non-object	Mean rating	Mean RT	
		Expt 1	Expt 4			Expt 1	Expt 4			Expt 1	Expt 4
1	3.6	557	753	31	5.2	673	808	61	5.7	—	—
2	5.9	564	772	32	5.9	680	733	62	5.4	—	—
3	5.3	565	749	33	4.4	680	932	63	4.6	—	—
4	5.5	586	748	34	1.7	682	1076	64	2.6	—	—
5	5.6	597	—	35	4.8	682	818	65	2.9	—	—
6	5.6	598	767	36	4.2	683	806	66	3.1	—	—
7	2.7	602	826	37	3.4	688	1031	67	4.3	—	—
8	2.8	602	833	38	3.9	689	790	68	3.2	—	—
9	5.9	605	775	39	3.1	690	862	69	3.7	—	—
10	5.4	609	810	40	5.4	690	762	70	1.6	—	—
11	5.2	616	875	41	5.6	694	840	71	4.6	—	—
12	6.2	617	823	42	5.3	695	793	72	4.4	—	—
13	3.6	621	965	43	5.9	712	810	73	2.5	—	—
14	3.9	625	975	44	2.9	713	894	74	1.6	—	—
15	4.3	625	767	45	4.0	719	896	75	3.3	—	802
16	4.9	625	800	46	3.2	721	971	76	5.0	—	—
17	5.7	627	810	47	4.3	722	866	77	2.4	—	—
18	5.7	637	885	48	3.1	725	889	78	3.4	—	—
19	4.1	643	857	49	2.9	745	926	79	3.6	—	—
20	5.4	645	844	50	5.5	746	844	80	4.8	—	—
21	5.1	645	915	51	3.0	750	884	81	5.1	—	—
22	3.8	650	961	52	3.3	754	813	82	4.5	—	—
23	3.7	652	732	53	3.4	763	922	83	6.1	—	—
24	2.4	657	786	54	5.6	764	883	84	2.4	—	—
25	4.9	658	879	55	3.6	789	876	85	5.9	—	—
26	3.6	660	805	56	5.3	797	785	86	3.7	—	—
27	5.2	664	876	57	3.1	803	1030	87	2.3	—	—
28	4.8	666	819	58	3.4	804	921	88	3.2	—	—
29	3.3	666	859	59	4.3	810	869				
30	4.0	671	892	60	2.8	819	958				

Note. RTs are in msec.

TABLE B-1
MEAN RELATEDNESS RATINGS FOR 64 RELATED AND 64 UNRELATED PAIRS AS A FUNCTION OF THE MODALITY OF PRESENTATION

Modality of presentation	Related pairs	Unrelated pairs
Pure		
Words	2.35	6.42
Pictures	1.75	6.08
Mixed		
$Version_1$	2.45	6.47
$Version_2$	2.86	6.57
Mean	2.66	6.52

Note. Twenty-five subjects contributed ratings to each of the four versions of the materials. The pairs were rated on a 7-point scale, with a rating of "1" being closely related and "7" being unrelated.

possible interpretation of these results is that pictures can be related on a greater number of dimensions than their word labels. Rating of words may represent a prototypical view of the concept, while ratings of pictures may also represent a particular sense of the meaning of the concept. Interestingly, observers were able to find some similarities even among unrelated picture pairs that were easily discriminated from related pairs. An alternative dimension for picture ratings may have been scenic coherence as well as semantic relatedness. For example, when presented with a picture of a duck and a picture of a kite, the observer might have judged whether the two things could be viewed in the same scene (e.g., a park scene), as these two things might.

The materials selected for use in Experiment 3 are shown in Table B-2. The first 6 items shown for each version of the materials were highly associated pairs taken from the Postman and Keppel (1970) norms for word association. The criterion for high association was that the second item of each pair had to be a primary response to the first item with a relative frequency of .20 or greater. The remaining 18 items for

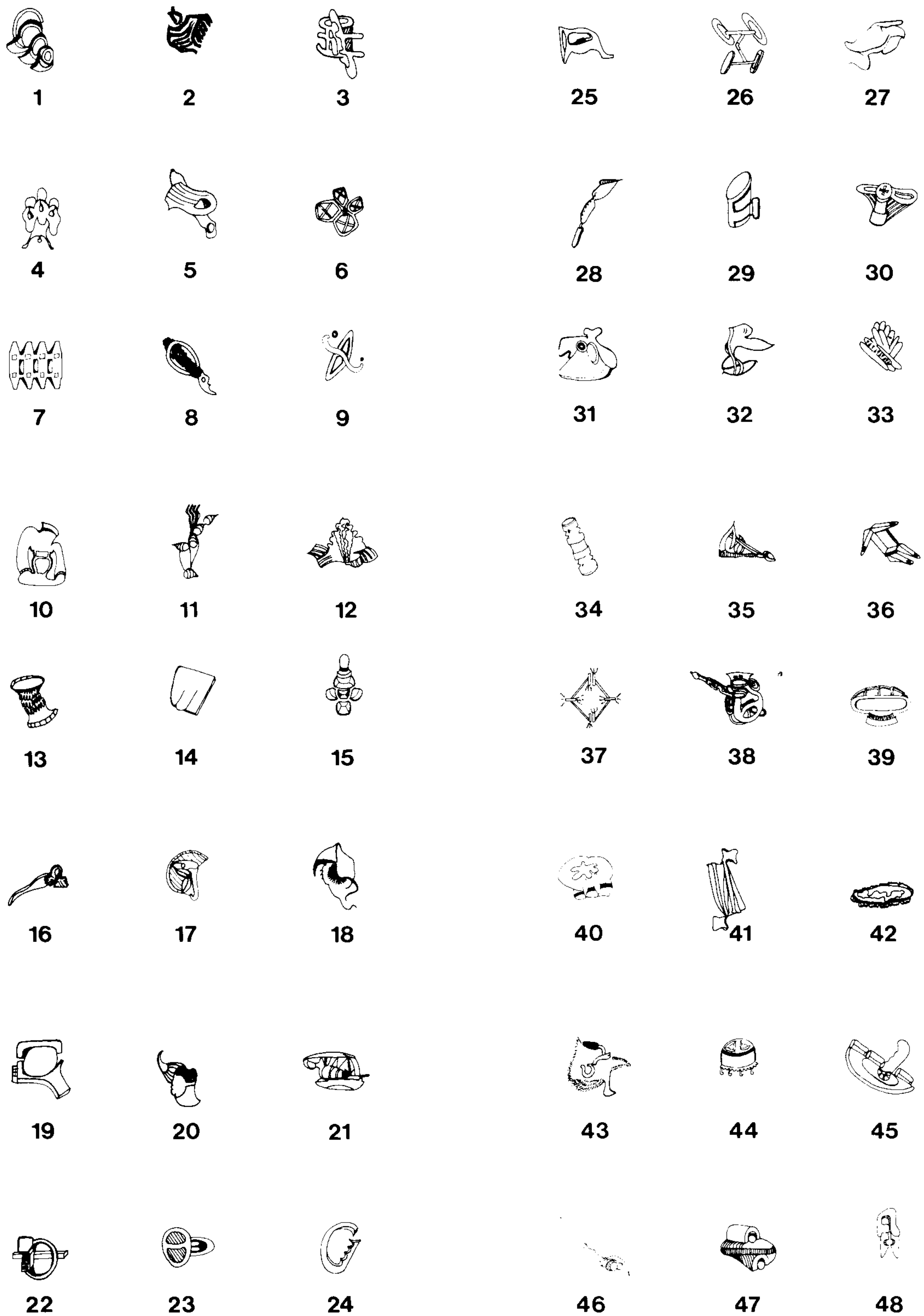
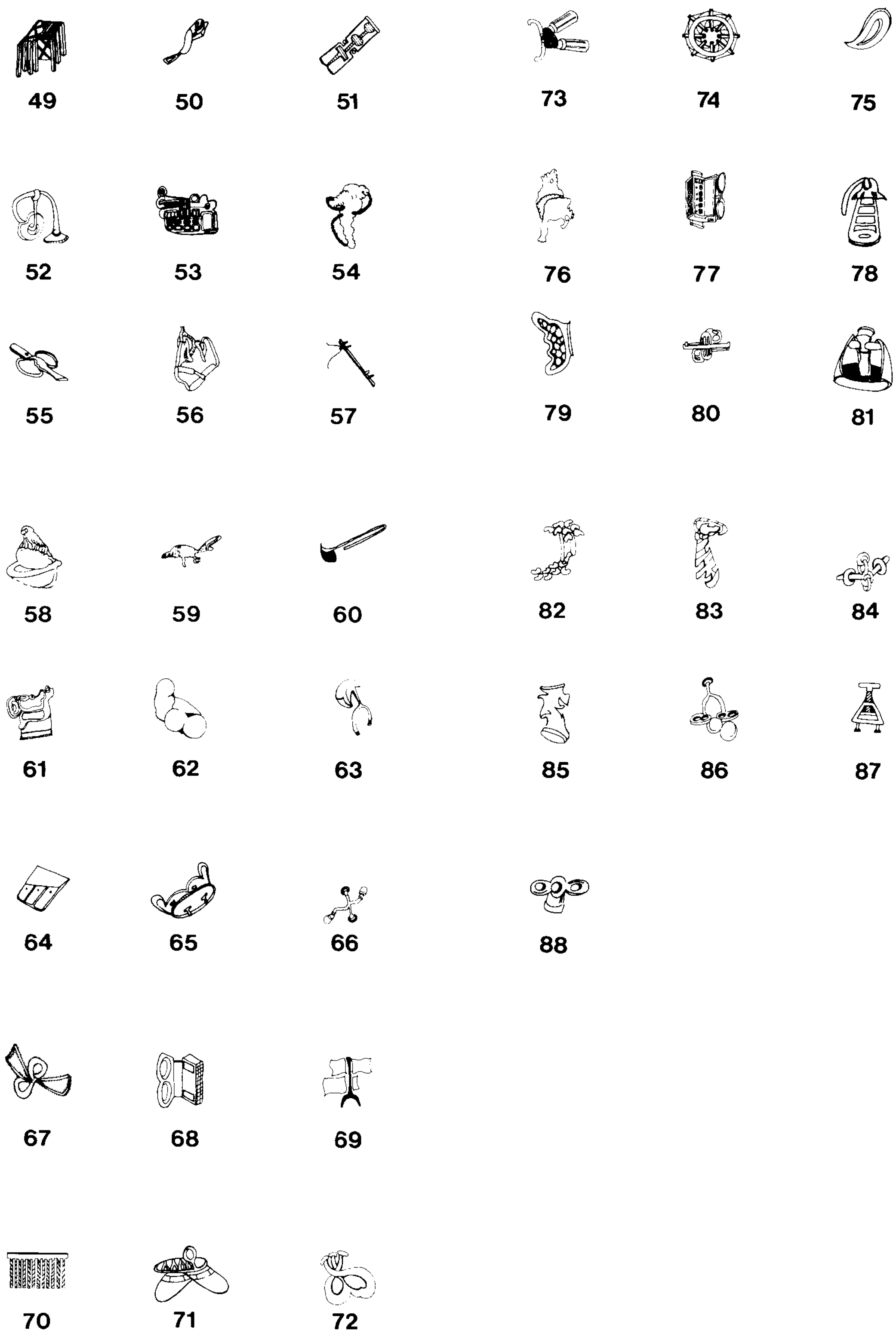


FIG. A-1. Pictures of 88 nonobjects used as distractor stimuli in the object decision task. The first



60 nonobjects (with a single exception noted in Table A-1) were used in the experiments reported here.

FIG. A1—*Continued.*

TABLE B-2
MATERIALS USED IN EXPERIMENT 3: POSITIVE RELATED ITEMS ONLY

Related and Associated Pairs			
Version A		Version B	
Pair	Associative strength	Pair	Associative strength
leaf–tree	43.4	dog–cat	64.2
socks–shoes	52.2	chair–table	43.0
thread–needle	56.0	door–window	40.0
hand–gloves	28.6	arm–leg	32.0
truck–car	34.0	ostrich–feather	29.0
coat–hat	20.0	shirt–tie	23.0
Semantically Related but Not Highly Associated Pairs			
Version A		Version B	
Pair	Subjective relatedness	Pair	Subjective relatedness
cake–pie	1.52	chicken–turkey	1.44
apple–banana	2.00	cow–horse	1.96
kettle–coffeepot	1.36	television–radio	1.64
globe–map	1.56	hammer–screwdriver	1.92
kangaroo–monkey	2.56	comb–brush	1.24
stove–toaster	2.48	bread–cheese	2.40
carrot–corn	2.60	book–pencil	2.96
shovel–wheelbarrow	2.80	kite–balloon	2.72
sheep–pig	2.20	bicycle–rollerskate	2.76
church–house	3.00	ear–eye	1.92
harp–drum	2.80	piano–violin	2.04
pear–strawberry	2.24	slingshot–gun	2.80
snail–frog	2.84	doll–teddybear	1.88
zebra–elephant	2.64	igloo–tent	2.08
butterfly–spider	2.44	stairs–ladder	1.80
lion–giraffe	2.40	deer–rabbit	2.36
fork–knife	1.40	barn–windmill	3.56
boat–anchor	2.20	pliers–file	3.00

each version were semantically related pairs selected from the larger set of related items that had been rated for subjective relatedness.

REFERENCES

BANKS, W. P., & FLORA, J. Semantic and perceptual processes in symbolic comparisons. *Journal of Experimental Psychology: Human Perception and Performance*, 1977, **3**, 278–290.

CARROLL, M., & KIRSNER, K. Context and repetition effects in lexical decision and recognition memory. *Journal of Verbal Learning and Verbal Behavior*, 1982, **21**, 55–69.

CATTELL, J. M. The time it takes to see and name objects. *Mind*, 1886, **11**, 63–65.

COLTHEART, M., DAVELAAR, E., JONNASON, J. T., & BESNER, D. Access to the internal lexicon. In S. Dornic (Ed.), *Attention and performance VI*. Hillsdale, N.J.: Erlbaum, 1977.

DAY, J. Right-hemisphere language processing in normal right-handers. *Journal of Experimental Psychology: Human Perception and Performance*, 1977, **3**, 518–528.

DURSO, F. T., & JOHNSON, M. Facilitation in naming and categorizing repeated pictures and words. *Journal of Experimental Pscyhology: Human Learning and Memory*, 1979, **5**, 449–459.

FISCHLER, I. Semantic facilitation without association in a lexical decision task. *Memory & Cognition*, 1977, **5**, 335–339.

FORSTER, K. I., & CHAMBERS, S. M. Lexical access and naming time. *Journal of Verbal Learning and Verbal Behavior*, 1973, **12**, 627–635.

FREDERIKSEN, J. R., & KROLL, J. F. Spelling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology: Human Perception and Performance*, 1976, **2**, 361–379.

GUENTHER, R. K. & KLATZKY, R. L. Semantic classification of pictures and words. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, **3**, 498–514.

HUTTENLOCHER, J., & KUBICEK, L. F. The source of relatedness effects on naming latency. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1983, **9**, 486–496.

JACOBY, L. L., & DALLAS, M. On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, 1981, **110**, 306–340.

JAMES, C. T. The role of semantic information in lexical decisions. *Journal of Experimental Psychology: Human Perception and Performance*, 1975, **1**, 130–136.

KIRSNER, K., & SMITH, M. Modality effects in word identification. *Memory & Cognition*, 1974, **2**, 637–640.

KORIAT, A. Semantic facilitation in lexical decision as a function of prime–target association. *Memory & Cognition*, 1981, **9**, 587–598.

KUČERA, H., & FRANCIS, W. N. *Computational analysis of present day American English*. Providence, R.I.: Brown Univ. Press, 1967.

MEYER, D. E., & SCHVANEVELDT, R. W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, 1971, **90**, 227–234.

NEELY, J. H. Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, 1977, **106**, 226–254.

NELSON, D. L., REED, V. S., & MCEVOY, C. L. Learning to order pictures and words: A model of sensory and semantic encoding. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, **3**, 485–497.

PAIVIO, A. Neomentalism. *Canadian Journal of Psychology*, 1975, **29**, 263–291.

PAIVIO, A. A dual coding approach to perception and cognition. in H. L. Pick and E. Saltzman (Eds.), *Modes of perceiving and processing information*. Hillsdale, N.J.: Erlbaum, 1978.

POSTMAN, L., & KEPPEL, G. *Norms or word association*. New York: Academic Press, 1970.

POTTER, M. C., & FAULCONER, B. A. Time to understand pictures and words. *Nature* (*London*) 1975, **253**, 437–438.

POTTER, M. C. Mundane symbolism: The relations among objects, names, and ideas. In N. R. Smith & M. B. Franklin (Eds.), *Symbolic functioning in childhood*. Hillsdale, N.J.: Erlbaum, 1979.

POTTER, M. C., VALIAN, V. V., & FAULCONER, B. A. Representation of a sentence and its pragmatic implications: Verbal, imagistic, or abstract? *Journal of Verbal Learning and Verbal Behavior*, 1977, **16**, 1–12.

ROSINSKI, R. R., GOLINKOFF, R. M., & KUKISH, K. S. Automatic semantic processing in a picture–word interference task. *Child Development*, 1975, **46**, 247–253.

RUBENSTEIN, H., LEWIS, S. S., & RUBENSTEIN, M. A. Evidence for phonemic recoding in visual word recognition. *Journal of Verbal Learning and Verbal Behavior*, 1971, **10**, 645–657.

RUBENSTEIN, H., RICHTER, M. L., & KAY, E. J. Pronounceability and the visual recognition of nonsense words. *Journal of Verbal Learning and Verbal Behavior*, 1975, **14**, 651–657.

SCARBOROUGH, D. L., CORTESE, C., & SCARBOROUGH, H. S. Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, 1977, **3**, 1–17.

SCARBOROUGH, D. L., GERARD, L., & CORTESE, C. Accessing lexical memory: The transfer of word repetition effects across task and modality. *Memory & Cognition*, 1979, **7**, 3–12.

SCARBOROUGH, D. L., GERARD, L., & CORTESE, C. Independence of lexical access in biligual word recognition. *Journal of Verbal Learning and Verbal Behavior*, 1984, **23**, 84–99.

SCHULMAN, H. G., & DAVISON, T. C. B. Control properties of semantic coding in a lexical decision task. *Journal of Verbal Learning and Verbal Behavior*, 1977, **16**, 91–98.

SMITH, M. C., & MAGEE, L. E. Tracing the time course of picture–word processing. *Journal of Experimental Psychology: General*, 1980, **109**, 373–392.

SNODGRASS, J. G. Toward a model for picture and word processing. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), *Processing of visible language*. New York: Plenum, 1980. Vol. 2.

SNODGRASS, J. G. Concepts and their surface representations. *Journal of Verbal Learning and Verbal Behavior*, 1984, **23**, 3–22.

SPERBER, R. D., MCCAULEY, C., RAGAIN, R., & WEIL, C. M. Semantic priming effects on picture and word processing. *Memory & Cognition*, 1979, **7**, 339–345.

VANDERWART, M. Priming by pictures in lexical decision. *Journal of Verbal Learning and Verbal Behavior*, 1984, **23**, 67–83.

WARREN, C., & MORTON, J. The effects of priming on picture recognition. *British Journal of Psychology*, 1982, **73**, 117–129.

Reference Notes

1. Potter, M. C. Unpublished manuscript, Massachusetts Institute of Technology, 1975.
2. Kroll, J. F., Supraner, A., & Merves, J. S. *Lexical access for concrete and abstract words.* Unpublished manuscript, Mount Holyoke College, 1982.
3. Meyer, D. E., & Ruddy, M. G. *Bilingual word-recognition: Organization and retrieval of alternative lexical codes.* Paper presented at the meeting of the Eastern Psychological Association, April 1974.
4. Scarborough, D. L., & Gerard, L. *Language processing in bilinguals.* Paper presented at the meeting of the Eastern Psychological Association, April 1981.
5. Kroll, J. F., & Potter, M. C. *Can pictures and words prime each other?* Paper presented at the eighteenth annual meeting of the Psychonomic Society, November 1977.

(Received May 1982)