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Semantic Priming of Pictures and Words: A Levels of Processing Approach

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A semantic priming task in which both pictures and words appeared as primes and targets was used to investigate the order of access to different kinds of stored information by these two types of representation. Level of prime processing was controlled by instructions to categorize (Experiment 1), name (Experiment 2), or report the color of the prime (Experiment 3). Similarly, target processing level was controlled in all three experiments by instructions to either name or categorize the target. Four major findings emerged. First, priming effects were independent of prime and target modality. Second, categorized targets benefitted from the prior presentation of a same category prime while named targets essentially did not. Third, categorized primes produced the greatest amount of priming while color-report primes produced the least. Fourth, both words and pictures could be named more rapidly than they could be categorized. Taken together the results of these experiments suggest that naming represents a shallower level of processing than categorization for both words and pictures. Implications of these results for current models of semantic priming are discussed.

Performance differences which are evident when subjects are required to complete tasks with word or picture stimuli seem to indicate that pictures allow faster access to semantic information than do words. Category decisions are typically made more rapidly to pictures (Potter & Faulconer, 1975; Pellegrino, Rosinski, Chiesi, & Siegal, 1977; Smith & Magee, 1980), and size comparison RTs are shorter for pairs of pictures than for pairs of words (Paivio, 1977). Results in recall and recognition tasks also show a clear pictorial superiority effect (Bousfield, Esterson, & Whitmarsh, 1957; Paivio, Rogers, & Smythe, 1968; Nickerson, 1965). Results in these paradigms suggest that, given a specified presentation rate, pictures are much more likely to have undergone some degree of elaborative, semantic processing than their verbal labels. On the other hand, words are named much more rapidly than pictures (Fraisse, 1968; Potter & Faulconer, 1975), which suggests that words allow quicker access to acoustic–phonetic information than do pictures.

Two general categories of models have been proposed to account for these differences in the way pictures and words appear to be processed, both reflecting this notion of speed of access to different kinds of stored information. The first type of model argues that words and pictures access a common semantic store, but that pictures are able to access this store much more quickly (Potter & Faulconer, 1975; Rosch, 1975). Nelson, Reed and McEvoy's (1977) sensory-semantic model is typical of this approach. In this model, pictures are viewed as accessing the meaning features of a concept directly. Words, on the other hand, allow more rapid access to the phonetic features of a concept although di-

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rect but slower access to the common semantic store is also possible.

The second approach to picture–word processing differences is typified by the dual code model (Paivio, 1971). This model proposes two separate knowledge systems, one verbal in nature, and the second, a nonverbal or imaginal system. Words are assumed to initially access the verbal system where name information is stored. Pictures, on the other hand, initially provide access to the imaginal system where most, although not all, of the semantic information is stored. Thus, words would have access to their name codes more rapidly than pictures, while pictures should enjoy an advantage for most semantic decisions.

Although a number of differences exist between these two approaches, they do share one notable feature. Both types of models assume that words receive phonetic processing before receiving semantic processing. Conversely, pictures are viewed as directly accessing a semantic store with phonetic processing following if required by the task at hand.

This somewhat strict order of access assumption, if correct, suggests four possible patterns of information access. When processing word stimuli to a phonetic level, minimal semantic processing need occur. Similarly, when making most semantic decisions about pictures, phonetic information need not be accessed. On the other hand, semantic decisions about words and picture naming both require deeper levels of processing in the manner described by Craik and Lockhart (1972) and result in activation above and beyond that specifically required by the task. That is, picture naming requires prior semantic activation, whereas access to semantic information by words will be preceded by verbal processing.

The present series of experiments represents a further attempt to evaluate this proposed order of access assumption for pictures and words. The tasks employed in the present studies were variations of the semantic priming paradigm. In the typical priming study stimuli are presented sequentially and subjects are asked to make a lexical (word/nonword) decision about some or all of the stimuli. Meyer and his colleagues (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1975) have demonstrated that responses to a target word can be made much more quickly when the target has been preceded by a word which is semantically similar. Apparently when similar semantic information is available from the first word it can set the stage or prime the subject to process the second word, facilitating that processing. Thus, this paradigm seemed especially well-suited for investigating the means by which words and pictures activate semantic information.

Although the particular priming paradigm developed by Meyer and coworkers has come to be used extensively in recent years (e.g., Neely, 1976; Sanford, Garrod, & Boyle, 1976) it was felt to be inappropriate for investigating the present issues for two reasons. First, it is not exactly clear what is actually involved in making a word/nonword judgment. Lexical decisions about words take approximately 200 milliseconds longer than reading those words (Theios & Muise, 1977). As such, the level of processing required to make a lexical decision is indeterminate. It seems that the decision must occur subsequent to phonetic processing by virtue of the time required by the different tasks. In fact, Meyer and Ellis (Note 1) report that some lexical decisions to letter strings can take as long or longer than decisions about semantic category membership. Thus, the lexical decision task does not allow a determination of the level to which a word must be processed. The second drawback to the lexical decision task is even more obvious: it has little relevance to picture processing.

Two tasks which do provide the desired control over the level to which words and pictures are processed are naming and categorizing (here defined as producing the

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name of the concept's semantic category). In Experiment 1 subjects were required to categorize the prime to assure the existence of semantic coding while in Experiment 2 subjects were required to name the prime to assure the existence of phonetic coding. In both experiments half the subjects were required to name the target and half were required to produce its category's name.

Meyer et al. (1975) were the first to report a priming study involving other than the lexical decision task. In their study half the target words were to be named. They discovered that named targets were facilitated by prior exposure to a related prime but to a lesser degree than targets requiring a lexical decision, a result which suggests that the level of processing of the target may be important in this paradigm. More recently, studies using other variations on prime and target processing (Becker & Killion, 1977; Sanford et al. 1977) have provided essentially the same conclusion. That is, in general, the facilitation provided by a related prime is reduced when the target task is naming as opposed to making a lexical or semantic category decision. These findings appear to reflect the minimal semantic involvement in the word-naming task, a possibility derivable from the order of access assumption described above.

The use of pictures in priming paradigms has been much more limited. However, Sperber, McCauley, Ragain, and Weil (1979, Experiment 1) and McCauley, Parmelee, Sperber, and Carr (1980) have reported that picture naming can be facilitated by the prior presentation of a semantically related picture, as the order of access assumption would predict. Unfortunately, in each of these studies, as well as those listed above, the stimuli were all of one type, either pictures or words, making picture–word comparisons difficult. Exceptions can be found in Durso and Johnson (1979) and in Sperber et al. (1979, Experiment 3). In Durso and Johnson's studies pictures and words were intermixed as both primes and targets and subjects were required to name or categorize each stimulus as either natural or man-made. Facilitation, however, was measured in terms of response time to a second appearance of the same concept. Thus, these results are somewhat less relevant to the present discussion. Sperber et al. (1979, Experiment 3) also used the factorial combination of words and pictures as targets and primes and observed facilitation in all situations in a naming task. However, the size of these effects, although significant, were so small (8, 10, 13, and 31 milliseconds, the latter effect in the picture–picture condition) as to suggest a replication might be useful. In any case as the present review indicates the priming paradigm is not tied to the lexical decision task and it appears to have sufficient flexibility to be useful in the present investigation.

In the first experiment reported, primes, either words or pictures, were categorized. These instructions insured that both types of prime received semantic processing, and both should therefore facilitate the related targets which share at least some of this semantic information. In Experiment 2 primes, either words or pictures, were named. According to the order of access assumption these instructions required that picture primes received semantic processing although word primes may not. Thus, picture primes should facilitate related targets more than their word counterparts.

The level to which *target* pictures and words were processed was also manipulated by instructing the subjects to either name or categorize. Targets which require processing to a semantic depth were expected to benefit more from a prior semantic context. Categorized word and categorized picture targets were therefore expected to be facilitated by prior exposure to a related prime. Picture targets which were named were also expected to benefit to a large degree, even though the naming task technically requires the retrieval of only phonetic information. As the order of access assumption suggests, access to name

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information by pictures requires semantic activation. Thus, picture naming should be sensitive to the semantic information provided by a related prime. On the other hand, only minimal facilitation of named word targets was expected due to the assumed lack of semantic involvement in the word-naming task.

Finally, the selection of a categorization task requiring the vocalization of a category name allows the order of access assumption to be examined in two additional ways. First, the result that pictures can be categorized more rapidly than words has typically been obtained in tasks involving a yes/no category decision (Potter & Faulconer, 1975; Pellegrino et al., 1977; Smith & Magee, 1980). If pictures do allow access to category information more rapidly than words, changing the response requirements should not alter this pattern of results. Second, since retrieval of name information by a picture represents a deeper level of processing than retrieval of semantic category information, picture naming should be slower than picture categorizing. Conversely, if retrieval of name information by a word represents a shallower level of processing than retrieval of semantic category information, word naming should be faster than word categorizing. Previous data do appear to support these predictions (Potter & Faulconer, 1975; Smith & Magee, 1980). However, comparing reaction times in a naming task with reaction times in the typically used yes/no categorization task is somewhat problematic. In the present experiments, however, the response requirements in the naming and categorization tasks are more nearly equated, making this type of comparison more viable. Thus, the results of the present studies, particularly from trials on which the prime and target are unrelated, should also allow these issues to be examined.

Experiment 1

Method

Design. Three within-subject factors were factorially combined to produce eight different trial conditions. These factors were mode of prime presentation (word or picture), mode of target presentation (word or picture), and relatedness (same category prime or different category prime). A fourth within-subject factor, blocks, should index the effect of repeating target items and the effect of practice. Subjects were randomly assigned to one of two target task conditions (naming or categorizing). Subjects were also randomly assigned to one of four groups. This factor was a counterbalancing factor which allowed each stimulus item to appear in each condition over the entire experiment.

Subjects. Twenty-four University of Western Ontario undergraduates (8 males and 16 females) were paid $5.00 to participate in this experiment. All were native English speakers.

Stimulus materials and equipment. Six categories were chosen from Battig and Montague's (1969) category norms such that each category contained at least twelve items which could be unambiguously represented by a simple line drawing ("picture") and were clearly members of only one of the designated categories. The six categories which fulfilled these criteria best were animals, body parts, clothing, furniture, kitchen utensils, and vehicles. A complete list of the 72 stimulus items used is presented in the Appendix. The pictures of each of these items were obtained from children's coloring books. Since items were to be repeated, four 23.0 × 25.6 cm cards were prepared for each. The item's name was printed in uppercase letters on two of the cards. Copies of the pictures were glued on the remaining two cards.

Every concept was presented once as a prime and once as a target in each of two 72-trial blocks. The two appearances of each concept in a block were always in different modalities. That is, a concept presented as a picture target in block one also appeared as a word prime in the same block. In the second block, the modalities

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of the prime and target were reversed. Thus, concepts presented as picture primes and word targets in block one were presented as word primes and picture targets in the second block. As such, across the two blocks each concept appeared once in each of the prime–target by modality combinations.

Within the confines outlined above the factor of relatedness was mapped onto the stimulus pairs in the following manner. Within block one, one half of the concepts in each category were assigned related, same category, primes with the remaining targets being assigned unrelated primes. These relationships were reversed in block two. Thus, across both blocks, each target was paired once with a related prime and once with an unrelated prime. Also reversed in block two was the modality of the prime for any particular target. Thus, for example, if a word target in block one was preceded by a related picture prime, when the same concept appeared as a picture target in block two it was preceded by an unrelated word prime.

The result of this manipulation was that across the two blocks, each target concept appeared in exactly two of the eight conditions resulting from the factorial combination of relatedness, mode of prime presentation, and mode of target presentation. In order that each concept appear in all eight of these conditions, four lists of target items were prepared. Across these four lists, each target concept appeared once in each of the eight conditions. Each list was presented to one group of subjects. The target items within blocks were presented to each subject in a unique random order. Assignment of primes to targets was also unique and random within the bounds of the assigned list for each subject's group, with the additional restriction that target items were not preceded or followed by same category items within three trials of one another. This precaution was taken to avoid intertrial priming.

A Ralph Gerbrands Co. (Model 1-3B-1C) three-field tachistoscope was used to present the stimuli. A Hunter Klockounter timer (Model 120) was used to time the subjects' vocal responses. An Electro-Voice Inc. (Model 621) microphone connected to a Lafayette Instruments Co. (Model 19010) voice-activated relay controlled the prime stimulus field and stopped the timer at the initiation of the subjects' vocal response to the target.

Procedure. Subjects were tested individually. As each subject arrived he or she was assigned to one of the two target task conditions (naming or categorizing) and one of the four groups. Before the experiment subjects were told that they would be seeing a series of pictures and words, all of which would belong to one of six categories. A list of the categories was provided, and subjects were instructed to become familiar with the relevant categories. They were informed that these category labels constituted the six possible responses in any categorization task. When subjects reported they felt confident that they could recall the categories, the list was removed and task instructions consonant with target task assignment followed. Subjects were told to respond as quickly as possible, but to avoid making errors.

On each trial the prime appeared immediately following a verbal warning from the experimenter. Subjects categorized the prime which was removed immediately upon the initiation of the subject's response. Reaction time to this response was not recorded although subjects were unaware of this. One second later, the target word or picture appeared in the viewing screen to be named or categorized depending on target task condition. The next trial followed a brief (approximately 5-second) interval during which the experimenter recorded latency to the target and reset the equipment. The 144 trials were presented with a short, 3-minute break between blocks. Errors were recorded, and those pairs of stimuli were put back into the to-be-presented stimulus pairs in the middle or

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at the end of the block, depending upon where in the block the error occurred. The entire session took approximately 45 minutes.

Results

Since errors occurred on less than 1% of the trials in each condition these few trials were not analyzed. Table 1 contains the mean target latencies for correct responses in all conditions, as well as the respective priming effects.

Target latencies were analyzed in a 2 (target task) × 2 (blocks) × 2 (relatedness) × 2 (mode of prime presentation) × 2 (mode of target presentation) × 4 (groups) analysis of variance, with both subjects and items treated as random factors. Subjects was nested within target task and groups while items was nested within all other factors except subjects. Designation of two crossed factors as random necessitated the use of pooled error terms which were calculated as described by Kirk (1968, p. 212). The reported statistics are the resulting quasi-F ratios (F'). The respective degrees of freedom for each pooled error term were calculated using Satterthwaite's (1946) adjustment. The analysis indicated there were main effects for both relatedness, $F'(1,18) = 88.97$, $p < .001$, and mode of target presentation, $F'(1,21) = 27.52$, $p < .001$. That is, there was an overall facilitation of related targets, and words were generally responded to more quickly than were pictures.

More central to the issues being investigated were the two significant interactions. The relatedness by target task interaction, $F'(1,19) = 51.04$, $p < .001$, reflects the minimal facilitation provided by related primes when target items were named as opposed to categorized. Application of Tukey's WSD procedure for the analysis of simple main effects revealed a significant priming effect when related targets were categorized ($p < .001$), but no significant facilitation when targets were named ($p > .05$). The target task by mode of target presentation interaction, $F'(1,34) = 70.10$, $p < .001$, focuses on the issue of whether Potter and Faulconer's (1975) results can be replicated using the present categorization task. Further analysis of this interaction involved data from only the unrelated trials because the differential priming effects in the two tasks made across task comparisons on related trials meaningless. Tukey's WSD procedure revealed (1) words were named more rapidly than pictures, (2) words were named more rapidly then they were categorized, and (3) pictures were categorized more rapidly than words (all p's $< .001$). There was no difference between naming and categorization times for pictures ($p > .05$).

TABLE 1
MEAN REACTION TIMES (IN msec) AS A FUNCTION OF TARGET TASK, RELATEDNESS, PRIME MODALITY, AND TARGET MODALITY IN EXPERIMENT 1

Target task	Related	Unrelated	Facilitation
Naming			
WW	777	803	26
PW	753	770	17
PP	1007	1026	19
WP	983	997	14
Mean	880	899	19
Categorization			
WW	792	1064	272
PW	841	1106	265
PP	763	972	209
WP	818	998	180
Mean	804	1035	231

EXPERIMENT 2

Method

Subjects. Twenty-four University of Western Ontario undergraduates (5 males and 19 females) were paid $5.00 to participate in this experiment. None of these subjects had participated in Experiment 1 and all were native English speakers.

Procedure. The procedure was identical to that described for Experiment 1 with the exception being that subjects were instructed to name the prime stimuli.

Results

As in the first experiment, errors oc-

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curred on less than 1% of the trials in each condition, and these trials were therefore not analyzed. Mean latencies for correct responses as a function of mode of prime and target presentation, and relatedness for both target tasks are presented in Table 2 with the respective priming effects.

Target latencies were subjected to the same analysis of variance as in Experiment 1. The analysis showed main effects for relatedness, $F'(1,13) = 30.11, p < .001$, mode of target presentation, $F'(1,20) = 35.39, p < .001$, and target task, $F'(1,26) = 43.58, p < .001$. These results indicate (1) there was a general facilitation by related primes, (2) words were responded to more quickly than pictures, and (3) over all conditions, targets were named faster than they were categorized.

Additionally, the relatedness by target task interaction was once again significant, $F'(1,12) = 26.00$, $p < .001$, reflecting the minimal facilitation provided by related primes when targets were named as opposed to categorized. Tukey's WSD procedure for the analysis of simple main effects showed the mean latency to related categorized targets to be significantly less than the mean latency to unrelated categorized targets ($p < .001$) while the facilitation obtained when targets were named was not reliable ($p > .05$). Also, the target task by mode of target interaction was again significant, $F'(1,20) = 40.42$, $p < .001$. Analysis of the data from unrelated trials using Tukey's WSD procedure again revealed (1) words were named more rapidly than pictures and (2) words were named more rapidly then they were categorized (p's $< .001$). However, pictures were now named more rapidly than they were categorized ($p < .001$) while there was no difference between words and pictures in categorization times ($p > .05$).

TABLE 2

MEAN REACTION TIMES (IN msec) AS A FUNCTION OF TARGET TASK, RELATEDNESS, PRIME MODALITY, AND TARGET MODALITY IN EXPERIMENT 2

Target task	Related	Unrelated	Facilitation
Naming			
WW	640	640	0
PW	666	691	25
PP	877	881	4
WP	874	875	1
Mean	764	771	7
Categorization			
WW	1041	1189	148
PW	1110	1171	61
PP	1041	1172	131
WP	1028	1163	135
Mean	1055	1174	119

DISCUSSION OF EXPERIMENTS 1 AND 2

The patterns of priming observed in both Experiments 1 and 2 suggests the following two generalizations about target processing. First, the facilitation provided by a related prime, be it named or categorized, appears to be essentially limited to targets which are categorized. Named targets appear to benefit only minimally from the semantic information provided by a related prime. Second, these effects appear to be essentially independent of target modality. The minimal facilitation involved in naming word targets is in line with the order of access assumption described earlier. Naming requires access only to phonetic information, and since this constitutes a shallow level of processing for words little facilitation was expected in this condition. Phonetic access by pictures, on the other hand, is assumed to follow semantic access, and the absence of facilitation when pictures were named is not consistent with the order of access assumption.

The importance of the processing an item receives, as opposed to the modality of the item, is also demonstrated by a comparison of the facilitation produced by the different prime tasks. Categorized primes in Experiment 1 produced an average facilitation of 231 milliseconds, while named primes in Experiment 2 produced a mean priming effect of only 119 milliseconds. No differences attributable to the modality of the prime were evident in either experiment. In particular, picture naming, a task which supposedly necessitates semantic access

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did not produce any more of a facilitative effect than did word naming, a task which supposedly does not. The absence of any picture–word differences in facilitation produced by related named primes, coupled with the minimal facilitation gained by both modes of named targets, suggests that picture naming and word naming may be much more similar processes than the order of access assumption appears to allow. Similarly, the absence of any modality differences in the facilitation provided or gained by categorized primes and targets suggests that the information activated by this task may be quite similar for both pictures and words. Further, it appears that for both pictures and words the task of retrieving a semantic category name represents a deeper level of processing than retrieving the concept's name.

An examination of the reaction times to name and categorize on unrelated trials lends at least moderate support to this alternate conceptualization of picture and word processing. In both Experiments 1 and 2 words were named more rapidly than they were categorized, reinforcing the idea that naming a word requires a shallower level of processing than categorization. On the other hand, the naming–categorization comparison for pictures is not entirely clearcut. In Experiment 2 pictures were, in fact, named more rapidly than they were categorized. However, no such effect was obtained in Experiment 1. This lack of an effect in Experiment 1 is most likely due to the fact that these subjects had a considerable amount of practice at categorizing and, in particular, at using the six category names, since categorization was also their priming task. Thus, for these subjects, in comparison to those in Experiment 2, certain components of the categorization process, for example, response selection, may have been artificially facilitated, eliminating the naming advantage. This suggestion is reinforced by the results in Experiment 3 which also show a naming advantage for pictures when the priming task is not categorization. Thus, the lack of a difference in Experiment 1 does not appear to contradict the conclusion that, in general, retrieving a category name represents a deeper level of processing than naming for pictures.

The reaction time results on unrelated trials address one further question. That is, would the picture advantage typically found in yes/no categorization tasks (e.g., Potter & Faulconer, 1975) be replicated with the present categorization task? Experiment 1, in which the categorization responses are highly practiced, did, in fact, produce a 100-millisecond picture advantage. However, in Experiment 2 the picture advantage shrunk to a nonsignificant 12 milliseconds. Thus, faced with these somewhat discrepant results a definitive answer to this question is not yet possible. As such, the question will be reexamined in Experiment 3.

Experiment 3

The general pattern of results from Experiments 1 and 2 does appear to support the idea that producing a category name represents a deeper level of processing than producing a concept's name for both pictures and words. Based on this idea, these results also support the hypothesis that the amount of priming is a function of depth of prime processing. However, before accepting this conclusion at least two alternate explanations of these results are worth considering. The first would be that the amount of priming might simply reflect the time spent processing the prime. Since it appears to take longer to categorize than to name both pictures and words this type of explanation could, in a general way, account for the results of Experiments 1 and 2. However, at a more specific level it would also predict less priming by named words than by named pictures, a result which did not obtain. As such, its potential as an explanation of the priming results seems somewhat limited.

A second suggestion could be derived by considering the task demands made in the two tasks being compared. In the categorize–categorize task of Experiment 1, re-

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lated primes benefitted not only from semantic overlap but also from response (although not stimulus) repetition, while in the name–categorize task of Experiment 2, responses were never repeated. Thus, it could be argued that this advantage, coupled with the one out of line point in Experiment 2 (the picture–word mean) which pulled the mean priming effect down, could account for the difference between tasks. However, while this explanation may have some validity, the 112-millisecond difference between these conditions is much larger than any response repetition effects reported in the literature (e.g., Hinrichs & Krainz, 1970; Hinrichs & Suelzer, 1978). Nonetheless, the results of the first two experiments do not allow this explanation to be ruled out. Thus, one purpose of Experiment 3 is to evaluate both the processing time and response repetition hypotheses about the differential priming effects in Experiments 1 and 2.

The prime task selected for Experiment 3 had to meet four criteria. First, it was felt that prime processing should be to a shallower level than that involved in naming primes so that less facilitation would be expected. Second, response repetition should not be involved. Third, processing time should be at least as long as in the naming task in order to rule out the processing time hypothesis. Finally, the task must be relevant to both pictures and words. The task selected was color naming.

The color-naming task has been demonstrated by Warren (1972, 1974) to be a viable method for examining the pattern of information access in words. The level of processing required to report the color of a word or picture should be equally shallow and the facilitation obtained when subjects report the color of the prime should reflect the shallow level of processing required by this task relative to the prime tasks used in Experiments 1 and 2. In addition, as demonstrated in numerous Stroop studies (e.g., Klein, 1964) color naming of concrete words takes somewhat longer than pronouncing the words. Even though no data appear to be available directly bearing on the issue, the same can most likely be said for pictures, although to a lesser extent. In any case, the lack of a prime modality effect in Experiment 3 should allay any worries of this sort.

The second aim of Experiment 3 was to again evaluate the name–categorize difference for pictures and the picture–word difference in the categorization task. If picture naming represents a shallower level of processing than categorizing, it should be accomplished more rapidly. As the reader may recall, the previous results were mixed with a significant difference emerging in Experiment 2 but not Experiment 1. Similarly, the advantage of pictures over words in the categorization task was reliable only in Experiment 1. By again considering results on unrelated trials Experiment 3 should, hopefully, provide a resolution of these ambiguities.

The final reason for undertaking Experiment 3 was to attempt to replicate the basic pattern of priming results from Experiments 1 and 2, that is, substantially more priming when the target task is categorizing and the lack of both prime and target modality effects. As noted previously, the mean in the picture–word condition in the categorization task in Experiment 2 was somewhat out of line. There appears to be no reason why this condition should produce less facilitation than the others. In fact, according to the order of access assumption, it represents deeper processing of both prime and target than any of the other conditions. Thus, a discrepancy of this sort, if replicable, would be a cause for concern. Given these considerations, Experiment 3 was designed to be a replication of Experiments 1 and 2 with the only change being the nature of the prime task.

Method

Design. The design is identical to that described for Experiments 1 and 2.

Subjects. Twenty-four University of Western Ontario undergraduates (9 males and 15 females) were paid $5.00 to partici-

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pate in this experiment. None had participated in either of the first two experiments, and all were native English speakers.

Materials and equipment. The same 72 items selected from the six categories used in Experiments 1 and 2 constituted the stimulus set in this experiment. Since the prime task required subjects to report the color of the word or picture, two of the cards created for Experiments 1 and 2 for each concept were replaced, one containing the name of the item and the second holding a picture of the item. These cards were exchanged for cards containing the name or picture of the concept printed or drawn in colored ink. The colors used were red, blue, and green. Four members of each of the six categories were drawn or printed in each of these colors.

Assignment of primes to targets was carried out as in Experiment 1, with the primes appearing in color, and the targets in black. The same tachistoscope, timer, microphone, and voice-activated relay were used.

Procedure. The procedure was identical to that reported for Experiments 1 and 2 with the exception being that subjects were required to report the color of the prime stimuli.

Results

As before, errors were practically nonexistent (less than 1%) and were not analyzed. The mean correct latencies for targets in all conditions are presented in Table 3, with the respective priming effects.

An analysis of variance identical to that in Experiments 1 and 2 showed main effects for relatedness, $F'(1,15) = 7.42$, $p < .025$, mode of target presentation, $F'(1,15) = 19.31$, $p < .001$, and target task, $F'(1,28) = 17.90$, $p < .001$. These effects indicate (1) there was a general facilitation by related primes, (2) words were responded to more quickly than pictures, and (3) over all conditions, targets were named faster than they were categorized.

The target task by relatedness interaction

TABLE 3

MEAN REACTION TIMES (IN msec) AS A FUNCTION OF TARGET TASK, RELATEDNESS, PRIME MODALITY, AND TARGET MODALITY IN EXPERIMENT 3

Target task	Related	Unrelated	Facilitation
Naming			
WW	752	740	−12
PW	718	735	16
PP	903	912	9
WP	906	909	3
Mean	820	824	4
Categorization			
WW	1093	1151	58
PW	1064	1105	41
PP	986	1053	67
WP	1008	1071	63
Mean	1038	1095	57

was again significant $F'(1,13) = 6.98$, $p < .025$. Subsequent Tukey WSD tests showed that the facilitation produced by color-named primes was restricted to targets which were categorized. That is, the 57 milliseconds of facilitation provided by related primes when targets were categorized was significant ($p < .001$) while no benefit was accrued by named targets ($p > .05$). Also, the target task by mode of target presentation interaction was again significant, $F(1,13) = 58.68$, $p < .001$. Concentrating on the unrelated trials, Tukey's WSD procedure revealed (1) words were named more rapidly than pictures ($p < .001$), (2) pictures were categorized more rapidly than words ($p < .001$), and (3) both pictures ($p < .05$) and words ($p < .001$) were named more rapidly than they were categorized. One additional effect, the blocks by mode of target presentation interaction, was also significant, $F'(1,12) = 8.04$, $p < .025$, reflecting a practice effect that was limited to picture targets. Mean latency to picture targets in block one was 1002 milliseconds as compared to 934 milliseconds in block two. Word latency remained stable from block one to block two (923 milliseconds and 917 milliseconds, respectively).

Finally, a post hoc analysis was undertaken to compare the size of the priming effects in the target categorization conditions in Experiments 1, 2, and 3. As

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anticipated, significantly more priming was observed in the categorize–categorize task of Experiment 1 (231 milliseconds) than in the name–categorize task of Experiment 2 (119 milliseconds), F' (1,17) = 14.65, $p <$ .01. Also as anticipated, less priming was observed in the color report–categorize task of Experiment 3 (57 milliseconds) than in the name–categorize task of Experiment 2, although the magnitude of this effect was somewhat less pronounced, $F(1,15) = 4.18$, $p < .06$.

Discussion

Three points need to be made about the results of Experiment 3. First of all, the basic pattern of results in Experiments 1 and 2 was once again obtained. That is, significant facilitation was observed only in the categorization task and there were no modality effects for either prime or target stimuli. In particular, the facilitation observed in the picture–word condition differed only minimally from the facilitation observed in the other conditions. As mentioned above we can conceive of no reason why this condition should have been any different from the others, especially in the name–categorize task of Experiment 2. Thus, the failure to replicate this difference in both Experiments 1 and 3 suggests that the difference in Experiment 2 is unlikely to be a real one.

The second point is that both of the ambiguous effects from the first two experiments were clearly evident in Experiment 3. Pictures were categorized, on average, 66 milliseconds faster than words and pictures were named, on average, 152 milliseconds faster than they were categorized. The former effect indicates that the picture categorization advantage generalizes beyond the yes/no tasks used previously. The latter effect supports the claim that for pictures, as well as for words, naming does represent a shallower level of processing than does categorizing.

The final point to be made about the results of Experiment 3 is that less facilitation was observed in the present target–categorization task than in the target–categorization task of Experiment 2. This difference is not subject to the same interpretation problems as the analogous difference between the target–categorization tasks of Experiments 1 and 2. That is, it cannot be explained in terms of response repetition since no responses were repeated in Experiments 2 and 3. Further, it does not appear to be due to differential processing times for the primes since the prime task in Experiment 3 is, if anything, more time consuming than the prime task in Experiment 2 (see Klein, 1964). Instead, this difference appears to substantiate the hypothesis that depth of prime processing, along with the required depth of target processing, is an important determinant of the amount of facilitation observed in a semantic priming task.

General Discussion

Most models of picture and word processing have inherent the assumption that words allow access to name information first, followed by semantic information, while for pictures the opposite is true. The present research represented an attempt to evaluate this order of access assumption.

The present results are quite consonant with this description of word processing. To begin with, words can be named more rapidly than they can be categorized. In addition, word primes and word targets both appear to produce more priming when they are categorized than when they are named, indicating deeper processing in the categorization task. When considering pictures, however, essentially identical results were obtained, although the reaction time difference between naming and categorizing was somewhat smaller. Thus, contrary to the order of access assumption, picture naming does not appear to represent a deeper level of processing than determining a picture's semantic category. Instead, as with words, the opposite may very well be true.

The implication of this conclusion is not

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necessarily that a picture's name is the first piece of stored information that an individual can retrieve. A more likely implication is simply that there must be considerable flexibility in the way pictures allow access to stored information. The way in which memory is accessed when the task is picture naming may be quite different than when a different type of information must be retrieved. In fact, certain types of decisions about pictures may not necessitate accessing information about the pictured concept at all. For example, a picture of a kangaroo may allow an individual to answer a question like "is this concept an animal?" although the individual may never have seen nor heard of a kangaroo before. All an individual need do is determine a few key features that delineate pictures of animals from pictures of other objects or, at least, from whatever other pictures are being used in the experiment. These features could then be matched against the visual features of the kangaroo picture, allowing a correct decision to be reached. Further, if the nonanimal pictures are not visually similar to the animal pictures being used in an experiment of this sort, subjects may find it expeditious to use this strategy consistently, even when presented pictures of highly familiar animals. Thus, picture processing reaction times may not be as reflective of information retrieval times as experimenters may wish.

By requiring a category name response in the present experiments we felt we would minimize the problems caused by this flexibility of picture processing. Yet, the lack of a difference between naming and categorizing reaction times in Experiment 1, in contrast to the results in Experiments 2 and 3, indicates that we may not have been entirely successful. The results of Experiment 1 appear to be due to the fact that the priming task was also categorization. Subjects were apparently able to take advantage of this added familiarity with the six categories and their labels to make the task easier and to eliminate the naming advantage. The present data do not allow a determination of which aspect of picture processing (e.g., feature analysis, response selection, etc.) was actually benefitting from this added familiarity. However, the nature of this mechanism aside, the fact that it can be affected by familiarity suggests that with additional practice it may have been possible to produce categorization latencies that were actually shorter than naming latencies. Thus, simply comparing reaction times across tasks would appear to be a risky way to evaluate the order of access assumption. The priming task, however, does not seem to be susceptible to the same problems. That is, although the naming advantage was eliminated, categorized pictures still led to more priming as both primes and targets than did named pictures. Thus, priming tasks may provide a better means of investigating issues of this sort.

Although the present data do not support the order of access assumption for pictures they do support the hypothesis that the amount of priming observed is a function of depth of both prime and target processing. As such, it seems appropriate to evaluate the implications of these results for current models of semantic priming. The two models which seem to be the most popular models of this process are Morton's (1969) logogen model and Collins and Loftus' (1975) semantic network/spreading activation model. Although these models differ in many ways their basic accounts of semantic priming are quite similar. Concepts are represented at locations in memory. The location for Concept A has a resting activation level which is raised whenever the representation of a semantically similar concept is presented. If a representation of Concept A is then presented access to its location is more rapid due to its heightened activation. Although these models are technically both models of word processing they can be extended fairly easily to account for similar effects in picture processing (e.g., Seymour, 1973; Paivio, 1978).

As currently conceptualized neither

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model would predict the depth of prime and target processing effects observed in the present studies. Consider first the depth of target processing effect. Since both models localize priming at the input level, its effects should be fully manifest by the time the concept's memory location has been accessed. What a subject is required to do with the concept (e.g., name it or categorize it) should be independent of the priming of the earlier process. Thus, there appears to be no reason why a depth of target processing effect should emerge.

Considering the depth of prime processing effect, what is needed is an account of how activation would build in semantically related concepts. The account offered by Collins and Loftus, and apparently by Morton as well, is that activation would build with time spent processing the prime. However, as noted earlier, this hypothesis has trouble with the specifics of the priming differences in Experiments 1 and 2. Further, it cannot predict the priming difference between Experiments 2 and 3 since less priming was observed in Experiment 3 even though the prime task, at least for words, was more time consuming. Thus, as these models stand, neither appears to be able to account for the depth of prime processing effect either.

This discussion is not meant to imply that either the logogen or semantic network/ spreading activation model should simply be rejected. In fact, with an appropriate choice of a few additional assumptions both models would probably be able to account for the present data. However, rather than considering what assumptions would be necessary, we would like to suggest an alternate conceptualization.

One aspect of these models which may be constraining them unnecessarily is their requirement that all priming be explained in terms of the memory access/input process. Meyer et al. (1975) and Becker and Killion (1977) have shown that this input process can be influenced by priming manipulations with their demonstrations that the factors of visual degradation and semantic relatedness interact. However, as Sternberg (1969) has pointed out, an interaction only indicates that the factors affect at least one stage in common, not that neither factor affects any of the other stages. Myers and Lorch (1980) have recently argued that priming can also occur at a second stage in the processing sequence by facilitating the retrieval of information relevant to the required decision. An explanation of this sort would also be quite amenable to the present data.

The depth to which a prime is processed would determine how much semantic information is retrieved about that concept. The more information available from the prime, the easier it is to retrieve and evaluate similar information about the target. Thus, when the target task is categorization, this evaluation and decision process would be facilitated. When the task is naming, even picture naming, this activated information has much less relevance to the decision required and, thus, much less, if any, postaccess facilitation would follow. As mentioned earlier, in a lexical decision task the level of target processing is indeterminate. Thus, the degree to which postaccess priming contributes would be indeterminate as well.

Even if this analysis is correct in that picture and word naming do not benefit from postaccess priming it is perhaps still somewhat surprising that in the present studies these tasks showed very little priming at all. Although the size of these effects is not totally out of line with those reported elsewhere (e.g., Sperber et al., Experiment 3), the literature also contains numerous examples of much larger priming effects in naming tasks (e.g., Sperber et al., Experiments 1 and 2). One hypothesis that might be suggested to explain this discrepancy would focus on the fact that subjects saw each concept four times (twice as a word, twice as a picture) throughout the experiment. As Durso and Johnson (1979) have demonstrated, repeated presentation

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of a concept, even in a different modality, can facilitate its processing. These repetition effects may have, essentially, washed out the priming effects that one would observe in a typical naming study.

One way of attempting to evaluate this explanation would be to consider whether there is any evidence that differential priming is observed in the two trial blocks. In block one each concept was presented twice, once as a prime and once as a target, (and, of course, in different modalities). Thus, approximately half of these targets were repeated concepts and half were not. In block two, of course, all targets would have been presented previously. In Experiments 2 and 3 there is absolutely no evidence that the size of the priming effect diminished over blocks. In fact the small differences were in the opposite direction (in Experiment 2, 5 and 9 milliseconds in blocks one and two, respectively; in Experiment 3, 0 and 8 milliseconds in blocks one and two, respectively). Only in Experiment 1 is there a suggestion that the priming effect diminishes over blocks (35 milliseconds in block one, 3 milliseconds in block two). However, given that this effect did not reach significance, nor did it replicate, nor has the repetition procedure caused problems in other studies (e.g., Sperber et al.) this explanation for the lack of significant priming appears to have limited viability.

An explanation which may be more viable would be one based on what appears to be the major difference between the present studies and most other priming studies. That is, in every study finding priming of word or picture naming all trials were blocked in that the primes and targets were always of one modality. Only in the present studies and in Sperber et al. (Experiment 3) were modalities mixed. In the former studies robust priming effects were obtained while in the latter the effects were substantially diminished. This comparison suggests that different strategies may be being used in the two situations.

Becker (1980) has recently suggested a model of the processes involved in the lexical decision task based essentially entirely on subjects' strategies. In this conceptualization a candidate set of words is derived from the prime stimulus, and target processing initially involves a comparison of these words to the target stimulus. Facilitation is observed when a match is obtained. Otherwise, naming time is prolonged. This process is regarded as the "input" process responsible for the interaction observed by Meyer et al. (1975) and by Becker and Killion (1977).

In a situation where the subject knows the modality of the target and prime a strategy like this may be easily implemented and standard patterns of facilitation and interference would emerge. However, when trials are mixed and the modality of the target is uncertain, as in the present studies, the difficulty of executing this strategy may make it prohibitive. Thus, in mixed trial blocks the process of accessing the target's location in memory and retrieving its name would proceed essentially as if in isolation. As such, little evidence of input priming would be expected in mixed mode naming tasks. This hypothesis, in fact, receives at least token support from a closer examination of the data of Sperber et al. The comparison process as described by Becker would seemingly be a time-consuming process and, thus, one would expect picture and word naming to take longer in the blocked situation than in the mixed situation. Exactly this pattern of results was obtained with the difference being over 100 milliseconds for words and nearly 300 milliseconds for pictures in the unrelated contexts.

In any case, the point to be made is not that priming was not obtained in the present naming tasks but that for both pictures and words less priming was obtained in the naming task than in the categorization task. Taken together with the other results in the present studies the suggestion is that the order of access assumption for pictures is

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incorrect. Instead it appears that naming represents a shallower level of processing than categorizing for both words and pictures.

Appendix: Stimuli Used in Experiments 1, 2, and 3

Body parts	Kitchen utensils	Furniture
brain	pan	picture
nose	bowl	piano
eyes	blender	lamp
head	knife	table
finger	pot	dresser
hand	ladle	stool
knees	spoon	bed
thumb	eggbeater	television
leg	kettle	sofa
foot	spatula	chair
skull	toaster	desk
arm	fork	bookcase

Animals	Vehicles	Clothing
tiger	plane	mitten
squirrel	bicycle	skirt
lion	motorcycle	shoe
cat	boat	vest
moose	jeep	boot
dog	truck	dress
elephant	canoe	glove
fox	tractor	pants
horse	train	scarf
cow	car	hat
camel	bus	overalls
pig	helicopter	sock

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