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Picture Naming: An Investigation of the Nature of Categorical Priming

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Although there are numerous theories of the structure of semantic memory, a notion central to many of these theories is that of semantic category membership. The present studies represent an investigation of the effects of a semantic category relation between prime and target in a picture-naming task. Because picture naming is presumed to require access to semantic memory, category priming effects were anticipated even when associative and phonetic effects were eliminated. This expectation was verified in Experiment 1. Experiments 2 and 3 were attempts to specify the nature and locus of this categorical priming effect. In particular, it was suggested that one locus would be an entry-level memory system for pictures. Results suggest that this system plays little role in categorical priming of picture naming. Rather, a better explanation would be one based on processing within semantic memory. The possibility of lexical memory acting as an additional locus is also considered.

Since first reported in the early 1970s (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1975), priming paradigms have been used to investigate a number of issues in cognitive psychology. In the more standard technique, two stimuli are presented sequentially. The initial, or prime stimulus is presented to create a particular context. A response may or may not be required. A second or target stimulus is then presented to which the subject must make a timed response. Empirically, the question being asked is whether the context created by the prime affects the speed of target processing.

In the present article the basic experimental question is whether categorical relations facilitate responding to picture targets. The theoretical questions focus on both the nature of the memory structures responsible for the priming and where in the processing sequence the effects become manifest. Questions of this type have, of course, been treated much more extensively for word processing than for picture processing. Nonetheless, a number of parallels may exist. As such, a general synopsis of the word-processing literature serves as the starting point for the present discussion.

The classic explanation of word-priming effects has been couched in terms of Collins and Loftus's (1975) network model. According to this model, there are two networks, a semantic network and a lexical network. Nodes in the semantic network represent familiar concepts, with nodes for semantically related concepts connected by labeled, relational links. In this way all conceptual (e.g., categorical) information about a familiar concept can be represented in the network. Nodes in the lexical network represent concepts' names. These nodes are linked to nodes for phonetically/orthographically similar names in lexical memory and the appropriate concept node(s) in semantic memory. Potentially, they could also be linked to the lexical node(s) for the name(s) of associatively related concepts (Fodor, 1983; Lupker & Williams, 1986). In general, this network has come to be thought of as the entry-level system that words access prior to accessing semantic memory.

Priming results from a spreading activation process within these systems. Word primes gain access to the appropriate nodes, first in lexical memory, and then in semantic memory. Activation then spreads out from these nodes to nearby nodes, raising their activation levels. If target processing requires access to one of these activated nodes, the processing is facilitated.

To some extent, the processing level that is facilitated by this activation must be somewhat task dependent. However, an argument can be made that at least part of the facilitation can be localized at the level of accessing lexical memory. This argument is based on a couple of findings. First, the fact that the size of the priming effect varies as a function of stimulus clarity (Becker & Killion, 1977; Meyer et al., 1975) suggests, via additive-factors' logic (Sternberg, 1969), that prime-target relatedness and target clarity affect a common process. Because clarity should not affect the higher level memorial processing that takes place after lexical memory has been accessed, the obvious common process would be one involved in accessing lexical memory.

The second finding is that a task such as word naming can be facilitated by an associatively related prime. The common assumption is that word naming involves only minimal processing after lexical memory has been accessed. As such, the

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process of accessing lexical memory would be the more logical locus for this type of priming effect.

With regard to the word-naming task, a question recently investigated concerns the extent to which activity in semantic memory can produce activation in lexical memory and, hence, priming (Fodor, 1983; Forster, 1979; Lupker, 1984; Seidenberg, Waters, Sanders, & Langer, 1984). Specifically, Lupker (1984) investigated whether categorical relation can produce priming in a word-naming task. Categorical relations seem to play a major role in many theories of the structure of semantic memory (Collins & Loftus, 1975; Collins & Quillian, 1969; Glass & Holyoak, 1975; Holyoak & Glass, 1975; Rosch, 1975; Smith & Medin, 1971; Smith, Shoben, & Rips, 1974). For example, from the standpoint of Collins and Loftus's network theory, there seem to be myriad links, direct and indirect, between nodes for categorically related concepts in semantic memory. As such, there would be ample opportunity for a prime to activate the semantic node of a categorically related target. The question is, would the activation then spread to the target's node in lexical memory to facilitate lexical access?

Categorically related pairs were drawn from six categories: animals, body parts, clothing, furniture, kitchen utensils, and vehicles. Because phonetic/orthographic relations are coded in lexical memory and some associative relations may be as well (Fodor, 1983), relations based on either of these dimensions were excluded. The results indicated that priming effects with categorically related pairs were virtually nonexistent. The conclusion seems to be that whatever activation is produced in semantic memory by categorical relations, that activation does not spread back to lexical memory to prime lexical access.

The basic questions addressed here concern these same issues with respect to picture naming. That is, can picture naming be primed by categorical relations, and if so, what is the mechanism?

There appear, in fact, to be a couple of possible mechanisms. The first mechanism would be one that acts through activation of nodes in semantic memory. There is now extensive agreement (Nelson, Reed, & McEvoy, 1977; Potter, So, von Eckardt, & Feldman, 1984; Smith & Magee, 1980; Snodgrass, 1984) that pictures do not allow direct access to their name codes in lexical memory but must first be processed semantically. If the semantic node for a picture target has been activated by a categorically related prime, this semantic processing may be facilitated. Alternatively, a number of models have been proposed recently in which there is a processing level for pictures roughly paralleling the lexical memory system for words (Kroll & Potter, 1984; Seymour, 1973; Snodgrass, 1984). That is, it is an entry-level system for pictures that is accessed prior to accessing semantic memory. Accessing this system presumably involves some sort of graphic/featural analysis of pictures. As such, although certain types of relations (e.g., verbal associations) are unlikely to be represented at this level, categorical relations, which are to some extent based on featural similarity, might be represented here. If so, or if activation feeds back from the representations in semantic memory, access to this system could be facilitated just as access to lexical memory seems to be for words. In either case, a priming effect would result.

Currently, there are a number of reports in the literature suggesting that categorical relations do prime picture naming (Carr, McCauley, Sperber, & Parmelee, 1982; Henderson, Pollatsek, & Rayner, 1987; Huttenlocher & Kubicek, 1983; McCauley, Parmelee, Sperber, & Carr, 1980; Purcell, Stewart, & Stanovich, 1983; Sperber, McCauley, Ragain, & Weil, 1979). However, as with much of the early research on word priming, these studies were addressing the issue of "semantic" priming and, as such, no attempt was made to distinguish the operative aspect of the prime-target relations. In particular, many of these effects may be due not to meaning similarity at the semantic level but to the effects of verbal association.

There are, of course, a few exceptions to this generalization. For example, McCauley, Weil, and Sperber (1976) attempted to manipulate the two variables of categorical and associative relatedness directly in a picture-naming experiment with young children. To accomplish this, university students provided ratings of prime-target pairs along these two dimensions, and stimulus sets were selected in which the two dimensions were factorially varied. The results support the notion that both factors produce priming, at least for second graders. This conclusion must be tempered, however, because there is no way to determine to what extent the university students' association ratings were appropriate to the population (second graders) showing the priming effect.

A second exception is found in a set of studies by Irwin and Lupker (1983). In their studies, categorical relations were investigated with the related trials consisting of random pairings of categorically related primes and targets. Thus, although no attempt was made to control associative relations, the occurrences of such prime-target pairings were somewhat rare. In all three studies a small positive priming effect was observed; however, none of these effects reached significance. As such, the question of the existence of a categorical priming effect appears to need closer examination.

The picture primes and targets in Experiment 1 represented the identical concepts used in the word-priming studies (Experiments 1–3) by Lupker (1984). Items were drawn from only six common and familiar categories, and prime-target pairs were not related phonetically/orthographically or through verbal association (as measured by Postman and Keppel's, 1970, norms). This procedure of controlling associative relations is, of course, less than perfect in that it cannot be guaranteed that none of the prime-target pairs were associatively related for any of the subjects. However, it is doubtful such a guarantee could ever be given when using stimuli that are related conceptually.

Also, as in Lupker (1984), subjects in all three experiments reported here were required to name the prime before the target appeared. As is now well documented (Henik, Friedrich, & Kellogg, 1983; Irwin & Lupker, 1983; Smith, Theodor, & Franklin, 1983), the nature of prime processing can affect the size of the priming effect. Hence, by requiring subjects to name each prime the hope was that at least some measure of consistency in prime processing could be achieved. The major drawback to this technique is obvious. The stimulus onset asynchronies (SOA) are all approximately 1 s, and thus, any rapidly decaying activation produced by the primes may not be detected.

Experiment 1

Method

Subjects. The subjects were 24 University of Western Ontario undergraduates (8 men and 16 women) who received course credit for participating in this experiment. All were native English speakers.

Stimulus materials, design, and equipment. The 72 items used by Lupker (1984) were also used in this study. These items represented 12 common instances from six familiar categories: animals, body parts, clothing, furniture, kitchen utensils, and vehicles. In selecting these items for the 1984 study, care had been taken to make sure that no item was a member of any of the other categories. Line drawings (pictures) of each of the items were collected from a variety of sources, and each was glued on a 23.0 × 25.6 cm stimulus card. With one exception, these pictures were identical to the ones used by Irwin and Lupker (1983). A complete list of the 72 concepts is presented in Appendix A.

The 72 items were arbitrarily divided into three sets, each set consisting of 4 items from each category. For a given subject, one set was used as primes, one set as related targets, and the other set as unrelated targets. Thus, each prime was seen twice by each subject, once on a related trial and once on an unrelated trial, whereas each target was seen only once. To complete the counterbalancing, subjects were assigned to one of six groups, depending on which of the three sets became primes and which of the remaining two sets became related targets.

The stimulus pairings for each subject were created by shuffling the target pictures and then pairing each target with an appropriate prime. In this way, each subject received a unique set of prime-target pairs. Care was taken to make sure that associated primes and targets were not created for either the related or unrelated conditions. In addition, care was taken to make sure that target items were not preceded by a same-category item in the previous trial in an attempt to minimize intertrial effects. Finally, in order to avoid phonetic priming, prime and target names were not permitted either to begin with the same phoneme or to rhyme. Given these constraints, the assignment of primes to targets was as random as possible.

A Ralph Gerbrands Company (Model 1-3B - 1C) three-field tachistoscope was used to present the stimuli. Viewing distance was 77 cm, and viewing was binocular. A Hunter Klockcounter (Model 120) timer was used to time the subjects' responses. An Electro - Voice Inc. (Model 621) microphone, connected to a Lafayette Instruments Company voice-activated relay (Model 19010) controlled the prime stimulus field and stopped the timer at the initiation of the subjects' responses.

Procedure. Subjects were tested individually. As subjects arrived to participate in the experiment they were assigned to one of the six groups. They were told they would be seeing a series of picture pairs and that their job would be to name each picture as it appeared, responding as rapidly as possible without making errors. Prior to the beginning of the experiment each subject was shown index cards containing only the pictures that would subsequently appear as primes. Subjects were asked to name each to assure that they knew the concept that each prime represented. If subjects did not refer to a picture by the intended name, they were informed of this and requested to use the intended name during the experiment.

Each subject received 2 practice trials using stimuli not appearing in the experiment proper, followed by 48 experimental trials. Each trial began with a 750 ms presentation of a fixation field consisting of a bull's-eye. Immediately thereafter the prime appeared. The prime remained in view until the subject named it. (Reaction time to the prime was not recorded, although subjects were not informed of this.) Following a 250-ms interstimulus interval (ISI), the target appeared and remained in view for 750 ms regardless of the latency of the naming response. The next trial followed a brief (approximately 5 s) interval during which the experimenter recorded the naming latency to the target and reset the equipment. Errors were recorded and those pairs were placed at the end of the trial block for re-presentation. If an error was made to the second presentation of a stimulus pair, the pair was not repeated. The entire session lasted approximately 25 min.

Results

Errors. A trial was scored an error if (a) the subject stuttered or misnamed the target, (b) the naming latency was longer than 1,600 ms, (c) the response was too soft to stop the timer, or (d) the subject either misnamed the prime or was still pronouncing it when the target arrived, which thus stopped the timer prematurely. With respect to criterion a, scoring was strict and only actual synonyms were allowed.

In the error analysis, only trials falling into Categories a and b (i.e., those categories that represent an error in target processing) were included. There were 91 errors on related trials (15.8%) and 103 errors on unrelated trials (17.9%), a difference that was not significant, $t(23) = 1.16$, *ns.* On 64 trials (28 in the related condition, 36 in the unrelated condition) an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these missing cells filled by either the subject's mean per relatedness condition or the subject's mean per semantic category per relatedness condition. The results were virtually identical. For the data reported throughout the article, the second replacement technique was used.

Mean reaction times. Target reaction times were submitted to a 2 (relatedness) × 6 (groups) ANOVA. Subjects is nested within groups, whereas items is nested within both relatedness and groups. As a means of establishing generalizability over both subjects and items, two F values were calculated, one for a subjects' analysis and one for an items' analysis.

Mean latencies were 758 ms in the related condition and 784 ms in the unrelated condition. This effect was significant in the subjects' analysis, $F(1, 18) = 5.92$, $p < .03$, and marginally significant in the items' analysis, $F(1, 276) = 3.17$, $.10 > p > .05$. Neither the groups effect nor the Relatedness × Groups interaction approached significance.

As a result of the somewhat strict criteria for a correct response and the fact that the target stimuli were seen only once by any subject, the error rates in Experiment 1 were a bit higher than is typical. As noted, the stimulus pairs in which an error was made were presented again at the end of the trial block. As such, reaction times to those targets may be contaminated by repetition effects. To see whether mixing data from these two types of trials altered the results, only trials involving a correct response to the initial presentation of a pair were considered. The results were virtually the same. Mean latencies were 745 ms on related trials and 768 ms on unrelated trials.

Discussion

The results of Experiment 1 indicate that, although the effect was not a large one, categorical relatedness, in the absence of an associative relationship, facilitates picture naming. The question next becomes what is the mechanism for this effect? One possible locus, as noted earlier, would be the entry-level system for pictures (Kroll & Potter, 1984; Snodgrass, 1984). This system could act much as lexical memory presumably does for words. That is, various nodes in the system could be activated in a spreading-activation fashion. If subsequent access to one of those nodes is required in target processing, some aspect of the access process may be facilitated, producing the priming. This activation could either be driven by activation in semantic memory, or it could come from categorical relationships themselves being represented in this system.

A second level that could serve as a locus would be semantic memory. After an entry-level representation has been accessed, the next step in picture naming would be to access semantic memory. This process could be primed, again, because of the relevant nodes being activated. In addition, if any other processing must go on at the semantic level prior to picture naming, it also could be facilitated because of node activation.

At present there is evidence to support both of these positions. The strongest evidence supporting entry-level priming comes from studies demonstrating more priming of picture naming with picture primes than with word primes (e.g., Carr et al., 1982) and studies demonstrating an interaction of relatedness and stimulus clarity in picture naming (Sperber et al., 1979). If semantic memory is thought of as an amodal system, the picture–word difference is presumably based elsewhere. The most logical place for it would be in a system involved in processing pictures but not words, such as the entry-level system under discussion. This point is reinforced by the interaction of relatedness and clarity. The logic here is the same as with words. If a variable interacts with clarity, that variable most likely affects the processes involved in accessing an entry-level representation. Finally, an additional piece of evidence is Pollatsek, Rayner, and Collins's (1984) demonstration that picture naming can be primed by peripherally presented primes that are featurally, but not semantically, similar to the target.

Evidence supporting the second hypothesis, that priming occurs at the semantic level, comes from studies demonstrating semantic priming of semantically based tasks, especially when words are used as primes. For example, Irwin and Lupker (1983) demonstrated that categorical relations between word primes and picture targets produce priming when the target task is to produce a category name (e.g., animal). Because of its amodal nature, semantic memory is the most logical locus for this effect.

Beyond accessing an entry-level system and then semantic memory, the picture-naming process requires lexical memory to be accessed in order to retrieve a picture's name. Access to this system could be facilitated if (a) categorical relations are represented at this level or (b) the activation from categorical relations in semantic memory feeds back to lexical memory. Neither of these possibilities appears likely, based on the fact that categorical relations do not seem to prime word naming, a task that is primarily lexically based. Additional evidence against lexically based priming is provided by Huttenlocher and Kubicek's (1983) and Henderson et al.'s (1987) demonstrations that word (name) frequency and semantic relatedness do not interact in a picture-naming task. Because word frequency appears to affect some aspect of lexical processing, additive-factors' logic suggests that semantic relatedness does not. In any case, the possibility of a lexical locus for picture priming is examined again in the General Discussion section.

Experiment 2

The purpose of Experiment 2 was to examine the hypothesis that at least part of the categorical priming effect observed in Experiment 1 is localized at the entry-level system. Recently Kroll and Potter (1984) produced a task that seems to focus primarily on this processing level. In this task, referred to as the object-decision task, subjects are presented with a series of line drawings, and their job is to decide whether each is a picture of a real object or not. Logically, in order to respond accurately, subjects must determine whether the picture represents a concept in memory (Kolers & Brison, 1984). Thus, access to at least an entry-level representation is required. However, although it is an arguable point that we will return to, no further processing would seem to be necessary. As such, if categorical primes speed responding in this task, a logical explanation would be that access to this system is one of the processes facilitated by categorical relations.

On the basis of some previously reported results in the object-decision task (Potter & Kroll, 1978), as well as Sperber et al.'s interaction of clarity and relatedness, Huttenlocher and Kubicek (1983) suggested, in fact, that whatever process(es) is/are involved in both the object-decision task and the naming task represent(s) the sole locus of priming in picture naming. That is, Huttenlocher and Kubicek discovered that the size of the priming effect they observed in their picture-naming task was essentially the same as that reported by Potter and Kroll. Again using additive factors'-type logic, the lack of an interaction between response type and relatedness suggests that the full effects of priming are manifest in the process(es) these tasks have in common. Thus, the memory-access operations involved in the object-decision task were potentially implicated as the locus of the relatedness effect in picture naming.

Comparisons such as those that Huttenlocher and Kubicek made (i.e., across time and stimuli) are, of course, shaky at best, a point the authors readily acknowledge. However, even more problematic for this comparison is that the natures of the tasks were quite different in the two studies. In Huttenlocher and Kubicek's experiment, primes and targets were presented sequentially with the subject only being required to respond to the target. In Potter and Kroll's study the two stimuli were presented together with a positive response required only if both were pictures of real objects. Although there is, as yet, little evidence on this issue, it would seem that in the simultaneous-presentation, object-decision task there would be a much greater likelihood for more semantically based processing to occur. For example, some sort of congruency evaluation, similar to that described by Forster (1981) and others when considering the lexical-decision task, may be involved much more with simultaneous stimuli than in the normal sequential task when responding is based on the target alone. If so, a comparison of the priming in the simultaneous object-decision task with that in the picture-naming task, with its own specific semantically based processing, reveals little.

The task used in Experiment 2 was a sequential object-decision task. To aid in comparison to the priming observed in Experiment 1, the same pictures and methodology were used. The set of nonobjects was drawn from the set used by Kroll and Potter (1984). These nonobjects were created especially for the object-decision task in that they appear to have all the gestalt properties of pictures of real objects. As such, subjects should not be able to respond accurately on the basis of gross figural differences between the objects and the nonobjects. Instead, correct responding should be based on the subjects' success (or lack of it) at finding a conceptual representation for the drawing in memory.

Method

Subjects. The subjects were 24 University of Western Ontario undergraduates (2 men and 22 women) who received course credit for participating in this experiment. All were native English speakers.

Stimulus materials, design, and equipment. The only difference in materials and design between Experiments 1 and 2 was that Experiment 2 contained 24 additional stimulus pairs. These pairs were constructed by creating a third set of the 24 prime items used for a given subject and pairing each with a nonobject selected from Kroll and Potter's set. As such, there were now 72 trials per subject.

The tachistoscope, timer, microphone, and voice-activated relay were the same as those used in previous experiments. In addition, because target responding was now manual, a board with two telegraph keys was placed in front of subject. Depressing either key stopped the timer.

Procedure. The procedure was almost identical to that of Experiment 1. The only difference was that the target response was now a button press. Subjects were instructed to press the right key with their right index finger when the picture of a real object was presented and to press the left key with their left index finger when the picture of a nonobject was presented.

Results

Errors. A trial was considered an error if (a) the subject pressed the wrong button, (b) the latency was longer than 1,600 ms, (c) the subject made an anticipatory response, defined as one shorter than 200 ms, (d) the subjects misnamed the prime, or (e) there was an equipment malfunction. Again, only errors that would represent an error in target processing were included in the analysis.

There were a total of 32 target errors (Categories a and b) to pictures of objects (2.8%). Of these, 16 were on related trials (2.8%) and 16 were on unrelated trials (2.8%), an obviously nonsignificant difference. On 9 trials (4 in the related condition and 5 in the unrelated condition) an error was made to the second presentation of a stimulus pair. As in Experiment 1, the latency analysis was carried out with these missing cells filled in by the subject's mean latency per semantic category per relatedness condition.

Mean reaction times. Target latencies for trials involving pictures of objects were submitted to a 2 (relatedness) × 6 (groups) ANOVA. Subjects is nested within groups, whereas items is nested within both relatedness and groups. As in Experiment 1, F values for both subjects and items were calculated.

The key issue is whether a categorical relation facilitates responding in this task. Mean latencies were 636 ms on related trials and 635 ms on unrelated trials, an obviously nonsignificant difference (both Fs < 1.00). The only effect reaching significance was the groups effect in the items' analysis, $F(5, 276) = 9.75$, $p < .001$. This effect, which was not significant in the subjects' analysis, $F(5, 18) = .62$, *ns*, was simply due to the counterbalancing procedure. That is, different groups of subjects saw different sets of object pictures. As such, the mean group reaction times on positive trials ranged from 594 ms to 688 ms.

Although the data for negative trials were not analyzed, it should be noted that both mean latency (736 ms) and error rate (5.6%) were larger than on positive trials. This particular result is similar to that obtained by Kroll and Potter (1984) in their simultaneous object-decision task as well as the results typically obtained in lexical-decision tasks (e.g., Meyer & Schvaneveldt, 1971).

Discussion

The purpose of Experiment 2 was to evaluate the effects of categorical relatedness on the early stages of picture processing. It is conceivable that an entry-level system (Kroll & Potter, 1984; Snodgrass, 1984) could be responsible for some or all of the priming observed in picture naming. The total lack of a priming effect in Experiment 2 provides little support for such a conclusion. Alternatively, a higher level (e.g., semantic) system would be implicated as the major locus of the categorical priming effect observed in Experiment 1.

The total lack of an effect in Experiment 2 might, in and of itself, seem somewhat surprising. There is certainly evidence that priming can emerge in this task (Kroll & Potter, 1984; Kroll & Venugopal, 1984; Potter & Kroll, 1978). However, the actual task used in each of these cases was slightly different from that used in Experiment 2. Potter and Kroll (1978) and Kroll and Potter (1984) used a task involving the simultaneous presentation of picture pairs with a response being required to the pair. Kroll and Venugopal (1984) presented targets singly. However, in their study, primes were not single pictures or words but incomplete sentences for which the picture may or may not represent a viable completion. The processing demands of these tasks may be quite different from those encountered in Experiment 2. In particular, these tasks would seem to encourage some sort of congruency evaluation, which is what Forster (1981) argued occurs for words in the lexical-decision task. Targets that are incongruent either with each other (simultaneous-presentation tasks) or with the sentence context would tend to inhibit a positive response. Congruent targets would not, producing a "priming" effect.

The present task, which involves a separate response to both prime and target would tend to discourage this type of processing, although responding to the prime may not be crucial. Similar results have been obtained in a study identical to Experiment 2 except that the prime was simply viewed for 750 msec with a 250 ms ISI. On the other hand, J. F. Kroll (personal communication, June 2, 1986) demonstrated small but reliable priming effects in a sequential presentation task with brief prime presentations, a situation closer to the simultaneous-presentation paradigm. As such, the claim is not being made that it is not possible to obtain priming effects in this task. Nor is it being claimed that the entry-level system can never act as a locus of priming. The claim is simply that categorical relations, in the absence of associative relations, do not produce priming in an object-decision task when sequential processing is enforced.

The step from claiming that categorical relations do not produce priming when sequential processing is enforced to the conclusion that the priming observed in Experiment 1 is not an entry-level phenomenon obviously involves making assumptions about the nature of processing in the object-decision task. In particular, the assumption was being made that access to the entry-level system was necessary, but little additional processing was needed. If correct, the conclusion that the entry-level system is not a locus of priming follows from the negative results. If incorrect, the conclusion may be premature and would require additional support.

This assumption is essentially the same assumption that was once made about processing in the lexical-decision task. In fact, in the lexical-decision task, the assumption was wrong because it underestimated the amount of processing involved in making a correct response. If the same is true here (i.e., some higher level processing is involved) the conclusion would still be appropriate. That is, the lack of priming would still indicate that the entry-level system, as well as some slightly higher level processing, was not responsible for the effects observed in Experiment 1. On the other hand, if the assumption is incorrect because even the entry-level system is not involved in this task, the lack of an effect would have no implications for the hypothesis under investigation. Theoretically, something like this could occur if, for example, object pictures could have been easily distinguished from nonobject pictures on some physical dimension. Although the nonobject data (a substantially longer mean latency and a slightly higher error rate) suggest that such was not the case, at present not enough is known about the object-decision task to feel totally confident. As such, the potential role of the entry-level system in categorical priming needs a second evaluation.

Experiment 3

As noted earlier, there is other evidence supporting the notion that priming of picture naming is partially based in a picture-specific, entry-level memory system. In particular, Carr et al. (1982) and Sperber et al. (1979) demonstrated that larger priming effects are obtained in a picture-naming task with picture primes than with word primes. Such a result would implicate the entry-level system unless the nature of the higher-level, semantic processing turned out to be different for picture primes than for word primes. This is the main issue investigated in Experiment 3.

As noted by Carr et al. (1982), one important difference between picture primes and word primes might be their specificity of meaning. For example, if a subject sees the word HAND, a number of meanings, and hence, a number of directions for semantic processing, may arise. That is, although HAND may refer to a part of the body, it could also refer to applause, help, the act of passing something to someone, and so forth. Such is not the case with the picture of a hand. With a picture, the intended meaning is clear. As such, the neighboring conceptual nodes that are activated by the picture of a hand are probably somewhat different and, perhaps, somewhat more restricted than those activated by the word HAND. The result may be more activation and, hence, more priming for a particular related target by a picture prime.

In order to evaluate this hypothesis, Experiment 3 consisted of a norming study, followed by a priming study comparing prime types. The point of the norming study was to select a set of prime-target pairs for which differential prime processing does not seem to be a problem. That is, these would be pairs for which, according to subjective ratings, the strength of the relation between a picture target and a picture prime was the same as the strength of the relation between that same picture target and the corresponding word prime. If such a set could be selected, the hypothesis suggests that the standard picture-prime advantage would disappear. This result would also support the conclusion from Experiment 2 that picture priming in a naming task is not a result of activation at the entry level for pictures.

The norming task itself was set up to provide, as close as possible, a parallel to the normal experimental setup in a priming task. Subjects were first asked to examine a prime (either a picture or a word). They were then asked to examine the target picture. Finally, they were instructed to rate how likely this particular prime would be to make them think of this particular target in an experimental setting. By creating this parallel, it was hoped that the concept-activation process in the norming task would mirror that in the priming task as closely as possible.

The norming study was carried out with only the related pairs. Alternatively, the study could have been set up to include unrelated pairs as well. The concern was that the inclusion of unrelated pairs would, in effect, push all the ratings for the related pairs to the top half (or top third) of the rating scale. If so, this ceiling effect would have reduced the discriminability among the related pairs, which would essentially negate the usefulness of the norming procedure.

Support for the main hypothesis hinges on the elimination of an established effect. As such, it was felt that a larger baseline effect was needed so that floor effects did not obscure any prime-type differences. To this end, candidate prime-target pairs were selected to be frequent verbal associates of one another, according to Postman and Keppel (1970), in addition to being members of the same semantic category. The result should be priming effects much larger than those found in Experiment 1.

In an effort to get converging evidence on the potential role of the entry-level system in the categorical priming of pictures, a second manipulation was introduced. Another set of prime-target pairs was also included. These pairs were verbal associates as well; however, they were not members of the same semantic category. As such, these pairs differ from the categorical associates on an important dimension. That is, because access to the entry-level system presumably involves some sort of featural analysis of pictures, this system would be an obvious locus for encoding categorical relations. However, it is much less likely that the relations between noncategorical associates, which show virtually no physical or featural similarity, would be encoded at this level. Rather, these relations would presumably be encoded somewhat higher in the system.

This presumed difference between categorical and noncategorical associates allows for two interesting comparisons. First, a direct comparison can be made between priming effects for the two types of associates in the picture-prime condition. If these two sets of stimuli can be equated on rated strength of the relation, this comparison will indicate whether categorical relations convey any special advantages. If so, the most likely locus of this effect would be the entry-level system. Second, relatedness effects as a function of prime type can be examined for noncategorical associates. A picture-prime advantage here should not be due to entry-level effects but to differential activation at higher levels. This result would indicate that the norming task did not completely achieve its goal. More important, the size of this difference provides a baseline against which any categorical associates data can be compared. Convincing evidence for the contribution of the entry-level system only follows if the Prime Type × Relatedness interaction was larger with categorical associates than with noncategorical associates.

The norming study also involved the noncategorical associates. Its goal was to select four types of prime-target pairs with essentially equivalent relatedness ratings (i.e., categorical vs. noncategorical associates with both word and picture primes).

Norming Study

Method

Subjects. The subjects were 333 University of Western Ontario undergraduates who received course credit for their participation. Of these, 163 rated stimulus pairs with word primes, whereas 170 rated stimulus pairs with pictures primes.

Stimulus materials and equipment. Forty associated prime-target pairs, selected from Postman and Keppel's (1970) norms, were initially included. Half of the pairs involved two members of the same semantic category and half did not. These pairs were randomly divided into eight sets of five for purposes of creating rating booklets. Each booklet had eight pages of items with each page containing one set of five pairs. The left-hand column on each page contained the prime stimuli, either pictures or words. The modality or the prime stimuli did not vary throughout a booklet. The middle column contained the appropriate target stimuli (always pictures). The right column contained 7-cm lines with crosshatches on both ends and in the middle. Under the crosshatch at the left end of each line the words *very unlikely* were written, with the words *very likely* written under the crosshatch at the right end of the line. Although the order of the five pairs on each page did not vary, the order of the eight pages did. Five different random orders of the eight pages were used for booklets containing each prime type. Each booklet also had a cover page containing the instructions for carrying out the ratings.

Procedure. Subjects were tested in groups of 25 to 50 participants. Each subject received a single nine-page booklet on arrival at the experimental setting. The instructions on the front page of the booklet were then read to the subjects. The subjects were instructed that for each stimulus pair they should first consider the stimulus on the left and assume it had been presented to them by an experimenter. In this circumstance, they were to judge how likely it would be that they would think of an object like that pictured on the right. They were then to place a mark on the 7-cm line that reflected this likeliness judgment. Judgments were measured to the closest millimeter.

To aid subjects in using the rating scale, it was suggested that if the stimulus pair was, for example HOT–COLD, they would probably want to place their mark very near the right end of the line, whereas if, for example, the stimulus pair was CUP–HANGER, they would probably want to place their mark somewhere near the left end of the line. The entire procedure took between 15 and 25 min.

Results

The purpose of the norming study was to select equal size sets of prime-target pairs whose strengths of relatedness did not vary as a function of prime type or category membership. In fact, this proved to be somewhat more difficult than anticipated, because categorical pairs consistently tended to achieve higher ratings than did noncategorical pairs. Finally, it was decided to drop five pairs from each set to produce two sets of size 15. A 2 (category membership) × 2 (prime type) ANOVA was then carried out on the ratings for the 15 remaining pairs. Items, nested within category membership, was the only random factor included in this analysis.

Mean ratings on the 15 categorical associates were 50.25 for picture primes and 48.57 for words primes. For the noncategorical associates, the ratings were 47.19 for picture primes and 46.79 for word primes. Although these means were not identical, neither the category membership effect, $F(1, 28) = 3.07$, $.10 > p > .05$, the prime type effect, $F(1, 28) = 0.35$, *ns*, nor the interaction of these factors, $F(1, 28) = 0.11$, *ns*, were significant. These stimulus pairs are listed in Appendix B.

Discussion

Although the major goal of the norming study was to find four types of prime-target pairs that did not differ on rated strength of relation, the most important aspect was that the ratings did not vary as a function of prime type for either set of stimuli. In this respect the study was successful. Ratings for picture primes were only slightly (and certainly not significantly) higher than were those for word primes in both cases. As such, these pairs should allow a fair evaluation of the hypothesis under consideration.

Priming Study

Method

Subjects. The subjects were 40 University of Western Ontario undergraduates (20 men and 20 women) who received course credit for appearing in this experiment. All were native English speakers.

Stimulus materials and equipment. Line drawings (pictures) were obtained for both primes and targets for each of the 30 stimulus pairs. One 23.0 × 25.6 cm stimulus card was prepared containing each picture. For the word-prime trials, one 23.0 × 25.6 cm card was prepared with each prime word written in the middle. In addition, to aid in counterbalancing, prime words and pictures and target pictures for one of the rejected pairs in each condition were prepared (BREAD–BUTTER in the categorical associative condition, CHICKEN–SOUP in the noncategorical associative condition). Thus, there were 16 prime-target pairs in each set. However, naming latencies for the extra pairs were not included in the analysis.

To create the appropriate stimulus pairings, each set of 16 pairs was arbitrarily divided into 2 lists of 8. For each set, the targets from one list of 8 were presented with the appropriate primes to create the related trials, whereas the targets from the other list of 8 were presented with unrelated primes. As such, two groups of subjects were designated, depending on which stimulus pairs appeared in the related versus unrelated conditions. The order of stimuli within a block was randomly determined by shuffling the targets before pairing them with the relevant primes. Prime-target pairings on unrelated trials were randomly determined so that each subject received a unique set of unrelated trials. Care was taken to make sure that there was no relation of any sort between the primes and targets on unrelated trials. The tachistoscope, timer, microphone, and voice-activated relay were the same as those used previously.

Procedure. The procedure was virtually identical to that of Experiment 1. In particular, subjects first had to name the primes and, then after a 250-ms ISI, were to name the targets. There were three procedural differences. First, for half of the subjects, the primes were words. Second, each prime appeared only once in the experiment. Finally, there were only 32 trials.

Results

Errors. The error criteria in Experiment 3 were the same as in Experiment 1. As before, only trials in which the subject stuttered, misnamed the target, or had a naming latency longer than 1,600 ms were included in the error analysis. Scoring was again somewhat strict in that essentially only the experimenter-designated name for the target was accepted.

The error data are listed along with the reaction time data in Table 1. These error rates were submitted to a 2 (prime type) × 2 (relatedness) × 2 (semantic category membership) ANOVA, the final two factors being within-subjects factors. Both the relatedness effect, $F(1, 38) = 7.49$, $p < .01$, and the semantic category membership effect, $F(1, 38) = 23.36$, $p < .001$, were highly significant. The former effect indicates that there were significantly fewer errors made to targets in the related condition (11.8% vs. 17.2%). The latter effect indicates that fewer errors were made to targets in the categorical associates condition (9.3% vs. 19.7%). There was no evidence of an interaction between these factors, $F(1, 38) = 0.10$, *ns.*

Although the prime type effect was not significant, $F(1, 38) = 0.10$, *ns*, there was a marginally significant Prime Type × Relatedness interaction, $F(1, 38) = 3.03$, $.10 > p > .05$. This result indicates that in these data there was a tendency for the relatedness effect to be larger with picture primes (9.7% vs. 18.6%) than with word primes (14.0% vs. 15.6%). This effect, however, did not interact with semantic category membership, $F(1, 38) = 0.01$, *ns.* On 22 trials (13 with picture primes, 9 with word primes) an error was made to the second presentation of a stimulus pair. These were approximately evenly distributed across the experimental conditions. Those missing cells were filled in with the subject's mean for that particular experimental condition.

Mean reaction times. Target latencies were submitted to a 2 (prime type) × 2 (relatedness) × 2 (semantic category membership) × 2 (groups) ANOVA. Subjects is nested within prime type and groups, whereas items is nested within all factors. As before, F values for both subjects and items were calculated.

The central issues in this experiment concern the relatedness effect and how it varies as a function of prime type and semantic category membership. The means for these comparisons are contained in Table 1. The relatedness effect was highly significant in both analyses, $F(1, 36) = 42.64$, $p < .001$, for subjects, and $F(1, 104) = 5.88$, $p < .025$, for items. However, this effect interacted with neither prime type nor semantic category membership (all $Fs < 0.11$). In particular, an approximately 60-ms relatedness effect was found in all four cells of the Prime Type × Semantic Category Membership matrix.

The only other significant main effect was that of semantic category membership, $F(1, 36) = 67.45$, $p < .001$, for subjects, $F(1, 104) = 11.45$, $p < .005$, for items. This effect was due to latencies being substantially shorter for targets in the categor-

Table 1
Mean Reaction Times (RTs in Milliseconds) for Picture Targets as a Function of Type of Associate, Prime Type, and Relatedness in Experiment 3

Prime type	Related RT	Related % Error	Unrelated RT	Unrelated % Error	Priming Effect
	Categorical associates				
Picture	731	4.7	799	13.3	68
Recalculated *M*	733		784		51
Word	709	9.3	770	10.0	61
Recalculated *M*	704		761		57
	Noncategorical associates				
Picture	829	14.7	888	24.0	59
Recalculated *M*	811		859		48
Word	774	18.7	831	21.3	57
Recalculated *M*	772		816		44

Note. Recalculated means are based only on errorless trials.

ical associates condition ($M = 752$) than in the noncategorical associates condition ($M = 831$).

The only effect involving the counterbalancing variable of groups that was significant was the Groups × Semantic Category Membership × Relatedness interaction, $F(1, 36) = 18.16$, $p < .001$, for subjects, and $F(1, 104) = 3.22$, $.10 > p > .05$, for items. This effect was due to one group showing a larger priming effect for the categorical stimuli and the other group showing a larger priming effect for the noncategorical stimuli. The effect was seemingly due to item differences. That is, the counterbalancing procedure required that the two groups have different sets of pictures in the related and unrelated conditions. As such, the size of the relatedness effect for a given group is highly dependent on the ease or difficulty of naming the stimuli making up these two conditions. In the present circumstance these differences were substantial enough to produce the observed effect.

Finally, as in Experiment 1, error rates were somewhat higher than one would like. As such, the potential for these data to be influenced by repetition effects again exists. In order to evaluate this possibility, the means in Table 1 were recalculated after eliminating all stimulus pairs with first presentation errors. These new means are also listed in Table 1. As before, there appears to be little difference in the size of the priming effects as a function of prime type or semantic category membership.

Discussion

Carr et al. (1982) and Sperber et al. (1979) reported that picture primes provide more priming than do word primes in a picture-naming task. The purpose of Experiment 3 was to examine this effect more closely in order to determine whether it might be due to categorical priming in an entry-level system. The results indicate that when rated relation strength is equated, neither prime type nor semantic category membership appear to influence the size of the priming effect. As such, these results provide little evidence for the role of an entry-level system in the categorical priming of picture naming, which supports the conclusion offered in Experiment 2.

There are potentially two aspects of the data that might be regarded as problematic for this conclusion. First, although statistically the four priming effects were equal, there was a range of 11 ms from the largest to the smallest. Furthermore, the largest effect was found in the picture-prime condition with categorical associates. However, it should also be recalled that it was not possible to totally equate the rated relationship strengths either. These small differences could easily account for the small differences in the sizes of the priming effects. In fact, the correlation between the four rated strengths and their corresponding priming effects is .991.

The other seemingly problematic piece of data for the conclusion is the marginal Prime Type × Relatedness interaction in the error data. This resulted from a larger related–unrelated difference (i.e., relatedness effect) with picture primes than with word primes. However, the point to keep in mind about this effect, in addition to the fact that it was only marginally significant, is that it was the same size for the noncategorical associates as for the categorical associates. As such, if it is a real effect, it is probably not due to entry-level activation but to slightly different activation at higher, semantic levels where the noncategorical-associative relations are represented.

General Discussion

The purpose of the present set of experiments was to verify the existence of a categorical priming effect in picture naming and to determine to what extent this priming was due to a facilitation of access to an entry-level system. In Experiment 1 it was demonstrated that categorical relations do prime picture naming in the absence of verbal association and phonetic relations. In Experiment 2 it was demonstrated that these same relations do not facilitate responding in an object-decision task, a task presumed to tap activity in the entry-level system. In Experiment 3 it was demonstrated that one of the major pieces of evidence supporting the notion of entry-level priming, the prime-type effect (Carr et al., 1982; Sperber et al., 1979), disappears when the strengths of prime-target relations at higher levels are equated. These results point to the conclusion that the entry-level system contributes little, if anything, to the categorical priming of picture naming.

Although Experiment 3 helped to reconcile Carr et al.'s results with this conclusion about the entry-level system, one other result reported by Sperber et al. appears to be problematic. In particular, Sperber et al. demonstrated that relatedness and stimulus clarity interact and, thus, according to additive-factors' logic, the two factors must affect the same process. Stimulus clarity seemingly affects how long it would take to access an entry-level memorial representation and, as such, relatedness should as well, in opposition to the stated conclusion.

On closer examination, however, the inconsistency turns out to be illusory. Although Sperber et al.'s results do demonstrate that a related context can affect initial memory access for degraded stimuli, they do not demonstrate that the same is true for clear, nondegraded stimuli. In fact, it is logical to suggest that in a situation in which access to memory is slowed, for whatever reason, subjects presumably use every clue at their disposal to identify the stimulus. For example, as Perfetti, Goldman, and Hogaboam (1979) have shown, readers who are less skilled at encoding print make more use of context than do skilled readers. Similarly, presenting degraded stimuli may cause the higher level activation produced by a related prime to be brought to bear on the memory-access process. The facilitation obtained at this level would then be added to whatever facilitation occurred in higher level processing for any and all stimuli. The result would be a larger priming effect for degraded than for nondegraded stimuli as Sperber et al. reported.

The other point to be made about Sperber et al.'s results is that an interaction like they reported does not indicate that either factor *only* affects the common process. Thus, if the above argument is correct, Sperber et al.'s results can be reconciled nicely with the notion that categorical relatedness affects higher level processes. The only way to argue that relateness does not affect higher level processes would be to show that variables affecting these processes do not interact with relatedness. Huttenlocher and Kubicek (1983) tried to make this argument from a comparison of the priming in their picture-naming task and Potter and Kroll's (1978) object-decision task. The objections to this comparison were outlined previously. Experiments 1 and 2 provide a much better basis for making this type of comparison. As a comparison of these data shows, the priming effects are much larger for picture naming than for the object-decision task. As such, to the extent that a comparison of this sort is reasonable, it provides an additive factors'-type argument for priming at higher levels.

The obvious next question would be, what is the nature of the priming at higher levels? Because categorical relations are presumably represented in semantic memory and processing at this level appears to be necessary in order to name a picture, semantic memory is an obvious locus. The mechanisms for this effect could be as described by Collins and Loftus's network model. That is, a spreading activation process could activate nodes in semantic memory, facilitating their access. Alternatively, if more processing is required at the semantic level than simply accessing a node, priming could result from a facilitation of this processing. That is, the nature of this semantic processing would presumably be somewhat similar for categorically related primes and targets. Hence, target processing would be a partial repetition of operations. Priming may result because an operation being repeated can be carried out more rapidly. This type of explanation was offered by Irwin and Lupker (1983) to account for the fact that the depth of prime processing affects the amount of priming observed in a target-categorization task.

Neither the present data nor a general consideration of the priming literature allow a strong case to be made for either explanation. However, the second explanation is purely an account of priming by means of semantic (particularly, categorical) similarity and, thus, would appear to have limited generalizability. It may, for example, be unable to account for the existence of the noncategorical-associative priming effect observed in Experiment 3. The spreading activation model, on the other hand, makes no real distinction between various types of relations in semantic memory and would, therefore, have no problem with this effect. As such, it would appear that the spreading activation explanation would be preferred on the basis of parsimony. However, the concept of spreading activation as an explanatory principle has come under attack in recent years (de Groot, 1983; Ratcliff & McKoon, 1981). McKoon and Ratcliff (1986), for example, used Gillund and Shiffrin's (1984) memory model to build a retrieval-based explanation of priming of which the Irwin and Lupker (1983) explanation appears to be a special case. To the extent that models such as McKoon and Ratcliff's (1986) turn out to be valid, an explanation of the sort offered by Irwin and Lupker would gain credibility.

The final issue to mention concerns the role of lexical memory in the picture-naming process. Because concept names are presumed to be stored in lexical memory, this system must be accessed in order to produce a picture-naming response. Results showing phonetic/orthographic priming of picture naming (Lupker & Williams, 1986) suggest that, at least under certain circumstances, activation in lexical memory can facilitate picture naming. With respect to word naming, access to lexical memory appears to be *the* process that is being facilitated by an associatively related prime. As such, a legitimate question would be whether activation in lexical memory might have contributed to the priming observed in the present studies.

With respect to categorical relations, as noted above, these relations have a limited ability to prime word naming (Lupker, 1984). Apparently, these relations are neither represented in lexical memory nor do they feed activation back from semantic memory in a way that facilitates the word-naming process. However, because access to lexical memory is somewhat different for pictures (i.e., less direct and more time-consuming), there would be more opportunity for feedback. (In a sense, the argument would be similar to the argument for why categorical relations may prime entry-level processing for degraded pictures but not for nondegraded pictures.) Furthermore, as Fodor (1983) suggested, certain strong semantic relations may be represented in lexical memory (perhaps strong associates like those used in Experiment 3). If so, those primes might activate lexical memory directly. Therefore, the possibility of a lexical basis for some of the higher level priming effects observed here, particularly in Experiment 3, cannot be ruled out. In any case, however, an important point to realize is that subjects were required to name all primes. Thus, any lexically based priming in Experiment 3 should not have favored either prime type.

The notion that there may be two loci for the priming effects observed in Experiments 1 and 3 does not affect the conclusion that the entry-level system is playing no role here. Rather, it simply illustrates the complicated nature of priming phenomena. Processing linguistic stimuli is an operation involving many stages and, hence, many potential priming loci. Multiple mechanisms may also be involved that may vary with the type of prime-target relation as well as the nature of the prime and the target tasks. For example, although the entry-level system for pictures may play no role in categorical priming of picture naming, it may be a major contributor to, say, repetition priming effects or priming effects in other types of prime and target tasks. For example, as noted, Pollatsek, Rayner, and Collins (1984) reported that featural similarity, in the absence of semantic similarity, can facilitate picture naming when prime presentations are brief and peripheral. Potentially, the entry-level system and its associated processes would be a likely locus for this effect. In any case, it appears that understanding the roles played by factors such as type of relation and target task will prove to be essential to producing an adequate explanation of the nature of context effects.

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(Appendix follows on next page)

Appendix A

Stimuli in Experiments 1 and 2

Animals	Vehicles	Clothing	Body Parts	Kitchen Utensils	Furniture
elephant	canoe	glove	ear	pan	picture
fox	tractor	pants	nose	bowl	piano
horse	train	scarf	eyes	blender	lamp
cow	car	hat	head	knife	table
camel	bus	overalls	finger	pot	dresser
pig	ship	socks	hand	spoon	stool
tiger	plane	mitten	knees	eggbeater	bed
squirrel	bicycle	skirt	thumb	kettle	television
lion	motorcycle	shoe	leg	spatula	sofa
cat	boat	vest	foot	toaster	chair
moose	jeep	boot	skull	pot	desk
dog	truck	dress	arm	fork	bookcase

Appendix B

Stimuli in Experiment 3

Categorical associates	Noncategorical associates
dog–cat	cheese–mouse
lion–tiger	ostrich–feather
fireman–policeman	rake–leaf
knife–fork	corn–field
shirt–tie	apple–tree
truck–car	shark–teeth
chair–table	harp–angel
vest–suit	harpoon–whale
doctor–nurse	carrot–rabbit
window–door	hand–glove
hammer–nail	beaver–dam
arm–leg	foot–shoe
coat–hat	ant–hill
lettuce–tomato	church–priest
nose–mouth	scarf–neck

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