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Rhyme Priming of Pictures and Words: A Lexical Activation Account

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Orthographically/phonologically related primes have typically been found to facilitate processing of target words. This phenomenon is usually explained in terms of spreading activation between nodes for orthographically/phonologically similar words in lexical memory. The phenomenon was explored in a series of studies involving the manipulations of prime and target type (word or picture) and prime and target task (naming or categorization). Generally, the results support the lexical activation explanation. Named primes, which activate lexical memory, facilitate processing in all target tasks involving lexical access (word and picture naming and word categorization), independent of prime type. Categorized primes show the expected Prime Type × Relatedness interaction with word primes, which activate lexical memory, producing much more facilitation than picture primes. Finally, unlike in semantic priming studies, increased depth of processing of a word prime decreased the size of the priming effects. Apparently, initial activation levels in lexical memory are not maintained when semantic processing of the prime is required.

One of the major issues being addressed by cognitive psychologists is how context affects the processing of new information. Especially fruitful in this regard has been the priming paradigm first reported by Meyer and Schvaneveldt (1971). In a typical priming task, two stimuli are presented sequentially. The first, or prime, stimulus establishes a particular context. Empirically, the question is whether this context affects processing of the second, or target, stimulus.

The ability of an appropriate semantic context to facilitate target processing is probably one of the best established findings in cognitive psychology (e.g., Fischler, 1977; Meyer & Schvaneveldt, 1971; Neely, 1977; Sperber, McCauley, Ragain, & Weil, 1979). The question addressed in the present article concerns the effect of the orthographic/phonological context created by the prime. Specifically, the question is how do the effects of an orthographic/phonological context vary as a function of both the type of prime and target stimuli and the nature of prime and target processing.

In the initial investigation of orthographic/phonological context effects, Meyer, Schvaneveldt, and Ruddy (1974) reported a small and nonsignificant facilitation when prime and target words were orthographically and phonologically similar (e.g., rhyming pairs like BRIBE–TRIBE) while pairs which were only orthographically similar (e.g., nonrhyming pairs like COUCH–TOUCH) showed significantly longer reaction times than unrelated pairs. More recently, however, a number of investigators (e.g., Hanson & Fowler, 1987; Hillinger, 1980; Shulman, Hornak, & Sanders, 1978) have demonstrated not only significant priming with Meyer et al.'s rhyming pairs but also a significant priming effect with Meyer et al.'s nonrhyming pairs if the nonwords used are unpronounceable. (See also Bentin, Bargai, and Katz, 1984, for a similar result using Hebrew words.) Particularly relevant to the present studies is Hillinger's (1980) demonstration of priming from rhyming pairs in a lexical decision task with successive presentation of prime and target. Further, the size of the priming effect was the same in Hillinger's studies regardless of whether the prime and target were spelled similarly (e.g., PITCH–DITCH) or not (e.g., EIGHT–MATE).

Results such as these can be explained in terms of a spreading activation process within an orthographically/phonologically based lexical memory system (e.g., Collins & Loftus, 1975), which serves as the entry-level memory system for words. For our purposes, *lexical memory* is regarded as containing both higher level, lexical units corresponding to words (the *lexical level*) as well as lower level, sublexical (graphemic and phonemic) units which feed into the word units (the *sublexical level*). In this way, units for orthographically/phonologically similar words are connected through the lower level units that they share. In addition, direct connections between word units for orthographically/phonologically similar words are also possible.

Whenever a word is processed, this processing involves the activation of appropriate lexical and sublexical units. This activation then begins to spread to other lexical units either through the common sublexical units or along the direct connections. The result is that the lexical units for orthographically/phonologically similar words become partially activated. Thus, access to these units and, hence, any subsequent lexical or semantic processing should be facilitated whenever

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an orthographic/phonological relation exists between prime and target in a typical priming paradigm.

According to the model, the spread of activation begins automatically. Allocation of attentional resources may, however, be essential either to maintain activation levels in related word units or to provide activation to the word units that are not automatically activated (Neely, 1977; Posner & Snyder, 1975). Thus, the claim is not being made that any effects observed here are due solely to automatic processing and, hence, are unaffected by expectations. In fact, no such claim could be legitimately made, given the prime-target onset asynchronies used in the present studies. Instead, the issue being examined here is to what extent this type of model can provide a realistic description of the effects of lexical activation in word and picture processing.

What the model does not explain, of course, is Meyer et al.'s (1974) finding of significant inhibition for nonrhyming, orthographically similar word pairs, as well as the null results obtained in a couple of other studies (Forster & Davis, 1984; Martin & Jensen, 1988; Slowiaczek & Pisoni, 1986). In addition, however, a number of reports of inhibition from orthographically similar primes have recently appeared in the literature (Colombo, 1985, 1986; Henderson, Wallis, & Knight, 1984). Colombo (1986) has attempted to explain these types of results within the framework of McClelland and Rumelhart's (1981) word recognition model. This model has a structure much like that discussed earlier, but it also incorporates the notion of inhibition. The set of graphemic units that are activated when a word is processed feeds into multiple lexical units. Thus, at the lexical level a competition situation between units is created. In order for the correct word to be recognized, units for orthographically similar words must have their activation inhibited. Therefore, if a word appropriate to one of these inhibited units is subsequently presented, its initial activation level will actually be below that for unrelated words, producing a longer response time.

Although both Colombo's explanation and the basic spreading activation explanation discussed earlier are intuitively reasonable and can account for a set of the data, each is faced with the problem of explaining the existence of entirely opposite results. At the very least, the one point that can be made here is that orthographic/phonological priming is a much less robust and reliable phenomenon than semantic priming. What further complicates the interpretation problem is that the target task in all of the studies reported above was lexical decision. That is, in recent years a strong argument has been made that the lexical decision task involves substantial postlexical processing (Balota & Chumbley, 1984; Forster, 1981; Lupker, 1984; Norris, 1986; Seidenberg, Waters, Sanders, & Langer, 1984; West & Stanovich, 1982). For example, Forster (1981) has suggested that subjects may evaluate the congruency of prime and target before responding. An incongruency, such as would arise for unrelated pairs, would inhibit a positive response, producing a related–unrelated difference. Thus, the possibility certainly exists that all of these effects, both facilitory and inhibitory, may be due not to lexical processing but to postlexical, decision processing.

Potentially, a better paradigm for investigating this issue is the perceptual identification task used by Humphreys and colleagues (Evett & Humphreys, 1981; Humphreys, Evett, & Taylor, 1982; Humphreys, Evett, Quinlan, & Besner, 1987). In this paradigm, a masked target is presented to a subject. The subject's job is simply to report the target, a task that appears to involve little, if any, postlexical processing. In addition, in an effort to prevent guessing biases from influencing target report, the primes were also masked to a level that they were essentially never reported. Thus, the argument is that whatever effects the prime might be having are due to lexical or sublexical activation rather than guessing biases operating at a postlexical level.

In agreement with most of the results reported above, these studies do suggest a facilitation of target processing following a related prime. However, these results are also somewhat less than straightforward. In particular, Evett and Humphreys (1981) appear to have demonstrated that orthographic similarity alone is responsible for the priming because nonrhyming pairs (e.g., COUCH–TOUCH) produced just as much priming as rhyming pairs (e.g., FILE–TILE) and, further, because nonword primes that have no specific correct pronunciation (STAFE for the target STATE) produced as much priming as equivalent word primes (e.g., WHILE for the target WHITE). On the other hand, Humphreys, Evett, and Taylor (1982) demonstrated significant priming from homophones (e.g., MAID–MADE) but no real effect of orthographic similarity (e.g., MARK–MADE). Finally, Humphreys et al. (1987) have reported that getting priming effects in a perceptual identification task may be crucially dependent on the prime being masked. Unmasked primes produce virtually no priming.

In Experiment 1 an attempt was made to gain converging evidence on these issues by considering a different and, potentially, more suitable target task, that is, naming. Although access to lexical memory is presumably required in order to produce a correct name for a target, postaccess processes—specifically, the retrieval of the name code, (potentially) its assembly and its production—should play a much smaller role than the postaccess, decision processes involved in the lexical decision task. Further, the retrieval and assembly of a name code are also "lexical processes" in that they are accomplished on the basis of information stored in the lexical memory system (or systems—see Morton, 1979). The same may very well not be true for the lexical decision task that seems susceptible to a number of nonlexical factors (Seidenberg et al., 1984). In fact, Seidenberg et al. have argued that naming is the best task to use when investigating lexical memory.

The target task in Experiment 1 was, therefore, naming. In addition, in order to gain some control over the nature of prime processing, subjects in Experiment 1 were also asked to name the primes overtly. Having a degree of control over prime processing was also felt to be essential. That is, at least in semantic priming experiments, the depth of prime processing can have a large effect on the amount of priming observed (Henik, Friedrich, & Kellogg, 1983; Smith, 1979; Smith, Theodor, & Franklin, 1983). Humphreys et al.'s (1987) results seem to suggest a similar conclusion for orthographic/phonological priming. The specific prime task selected, naming, should direct prime processing to the lexical level, hopefully allowing a closer look at whatever spreading activation/inhibition processes go on at this level.

Half of the subjects in Experiment 1 named targets following word primes. The other half of the subjects named targets following picture primes. Naming pictures is, of course, a somewhat different process than naming words. To begin with, the generally accepted argument is that pictures initially allow access to semantic memory and only subsequently to lexical memory (Nelson, Reed, & McEvoy, 1977; Potter, So, von Eckardt, & Feldman, 1984; Smith & Magee, 1980; Snodgrass, 1984). Nonetheless, by requiring a naming response to the picture primes, subjects should have to access lexical memory in order to retrieve the picture's name. Thus, this access should also start any spreading activation process that goes on within lexical memory. However, the lexical processing for pictures (i.e., name retrieval) should involve only phonological information and not orthographic information. Thus, if the two prime types produced differential priming effects, the most obvious explanation would be the additional orthographic processing required for word primes.

The other manipulation in Experiment 1 involved the nature of the target stimuli. Half the subjects were asked to name word targets while half were asked to name picture targets. Again, because picture naming requires access to lexical memory in order to retrieve the name code, naming target pictures should also tap whatever activation has been produced by the prime. Thus, if there is a spread of activation within lexical memory as hypothesized, picture naming should also be facilitated. However, because naming picture targets is, presumably, not orthographically based, there is no reason to expect any differential priming effects from the two prime types when considering picture targets.

In fact, there is at least one study in the literature indicating that orthographically/phonologically similar word primes do facilitate picture naming (McEvoy, 1988). In addition, there are a number of other studies suggesting the existence of these effects when a slightly different paradigm is used (Lupker, 1982; Posnansky & Rayner, 1977, 1978; Rayner & Posnansky, 1978). In these studies an interference paradigm was used in which the "prime" word and the "target" picture were presented together, the word written across the picture. The most relevant comparisons—naming times for pictures with orthographically/phonologically similar words versus naming times for those same pictures with unrelated words—show, in all cases, a difference in favor of the orthographically/phonologically similar conditions. In addition, Lupker's (1982) results suggested that there was an effect of orthographic similarity beyond that of phonological similarity.

It is impossible, of course, to tell whether the effects in the interference paradigm represent facilitation of lexical processing or simply less interference, perhaps at the response-output level. Within this paradigm, the question of orthographic/phonological priming might be better evaluated by comparing naming times in the related word conditions with naming times for pictures alone. Unfortunately, these comparisons yield somewhat mixed results. Lupker (1982) and Posnansky and Rayner (1978) found faster naming times with pictures alone while Rayner and Posnansky (1978) found slightly, but not significantly, faster naming times with the orthographically/phonologically similar words. In any case, the results of Experiment 1 should allow a more straightforward evaluation of both the question of orthographic/phonological effects and how they may vary as a function of prime type.

Finally, the specific orthographic/phonological relation investigated in the present studies was rhyming. This relation was used because it seemed to represent essentially the maximum in both orthographic and phonological similarity short of the prime's and target's being identical. Hence, lexical units for these pairs should be closely linked in lexical memory, providing the maximum potential for observing priming effects. Because rhyming was the only orthographic/phonological relation investigated here, all subsequent references to the present studies will refer to a *rhyming* rather than an *orthographic/phonological* relation.

Experiment 1

Method

Subjects

The subjects were 32 University of Western Ontario undergraduates (12 males and 20 females) who received course credit for participating in this experiment. All were native English speakers and had normal or corrected-to-normal vision.

Stimulus Materials, Design, and Equipment

Sixty-four pairs of items were used in this and all subsequent experiments. Selected pairs had to satisfy four constraints. First, each pair had to rhyme (e.g., FROG–LOG). Second, each item had to be a concrete, pictureable object. Third, care was taken to ensure that items in a pair were not members of the same semantic category (e.g., DOG–FROG). Fourth, so that the same stimuli could be used in subsequent experiments, the pairs were to fit into one of four categories. In Category A, 20 pairs were created so that all primes were objects which occurred naturally (real objects) and all targets were not (artificial objects). Category B consisted of 12 pairs of artificial objects, while Category C consisted of 12 pairs of real objects. In Category D, 20 pairs were created in such a way that all primes were artificial and all targets were real. A complete list of the items is presented in the Appendix.

Line drawings ("pictures") of each of the 128 items were collected from a variety of sources, and each was glued in the middle of a 23.0 × 25.6-cm card. Similar cards were prepared with the names of the items printed in the middle of the card (in upper case).

Sixty-four pairs of nonrhyming items were created from the original rhyming pairs. This was accomplished by arbitrarily dividing each of the four category lists in half, forming eight subsections. Pairs of items within each subsection were then randomly rearranged to create the nonrhyming pairs. Care was taken to ensure that the new pairs were not related semantically, phonologically, or orthographically.

Each item was presented once to each subject. Order of presentation of the 64 primes was the same for all 32 subjects. This order was randomly determined. Half of the primes were paired with their related targets, and half were paired with their unrelated targets.

Which primes were paired with related targets varied from subject to subject. Specifically, by changing the subsection in each category that appeared with related primes, eight different sets of related and unrelated pairs were created. Each target was paired with a related prime in exactly half of these sets and with an unrelated prime in the other half. Each set was presented to one subject in each Prime Type × Target Type condition.

Producing the correct naming response to the prime was crucial in the present study. Thus, each picture prime was duplicated on a 12 × 14.5-cm piece of paper. The appropriate name was printed below each picture in upper case. The picture primes were then stapled together to form a booklet. As described below, each subject receiving picture primes viewed the booklet before the experiment.

A Ralph Gerbrands Co. (Model 1-3B-1C) three-field tachistoscope was used to present the stimuli. A Hunter Klockounter (Model 120) timer was used to time the subjects' responses. An Electro-Voice, Inc. (Model 621) microphone was positioned approximately 7 cm away from the subject's mouth. The microphone was connected to a Lafayette Instruments (Model 19010) voice-activated relay that controlled the prime–stimulus field and stopped the timer at the initiation of the subject's vocal response to the target.

Procedure

Subjects were tested individually. Eight of the subjects were assigned to each cell of the Prime Type × Target Type matrix. Each subject was informed of the type of prime and type of target they would be seeing. They were told that they would be seeing a set of stimulus pairs and that their job would be to respond to each with the appropriate name as rapidly and accurately as possible. Those subjects receiving picture primes were shown the booklet containing the prime pictures. They were instructed to look through it to familiarize themselves with the pictures and their appropriate labels and to use these labels in the experiment. Each subject then received two practice trials. If the experimenter was satisfied that the subject understood the instructions, the 64 experimental trials then commenced. If not, the two practice trials were repeated before the experiment began.

Each trial began with a 750-ms presentation of a fixation field consisting of a bullseye. The prime followed immediately and remained in view until the subject named it. After a 250-ms interstimulus interval, 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 10-s) interval during which the experimenter recorded the naming latency to the target and reset the equipment. Errors were recorded, and those pairs for which an error was made in responding to either the prime or the target were placed at the end of the set of trials for re-presentation. If an error was made to the second presentation of a pair, the pair was not repeated. The entire session took approximately 25 min.

Results

Word Target Trials

Errors. A trial was scored as 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, thus, stopping the timer prematurely. In the analysis, only trials falling into Categories (a) and (b), those categories that represent an error in target processing, were included.

A 2 (relatedness) × 2 (prime type) analysis of variance (ANOVA) was completed for the error data. There was a total of 68 errors on word target trials (6.6%). Of these, 38 were classified as target errors. Fifteen of these (2.9%) were in the related condition, while 23 (4.5%) were in the unrelated condition, a difference that was not significant, $F(1, 14) = 1.04$, *ns*. However, a significant effect of prime type was obtained, $F(1, 14) = 7.18$, $p < .025$, because of the higher number of errors with picture primes (29–5.7%) than with word primes (9–1.8%). These two factors did not interact, $F(1, 14) = 0.59$, *ns*. On 12 trials, all involving picture primes, an error was made to the second presentation of a stimulus pair (6 related pairs, 6 unrelated pairs). Latency analyses were carried out with these missing cells filled by the subject's mean response time for the other items in the same relatedness by category condition.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. Subjects is nested only within prime type. Because the same target items appeared in different conditions for each different subject, error variance due to items contributed to the expected mean squares for the conventional subject and Subject × Relatedness error terms. Thus, although only the conventional F value was calculated for each effect in this and all subsequent analyses, the effects should generalize over items.

Mean reaction times for word targets are shown in the upper portion of Table 1. The relatedness effect was significant, $F(1, 14) = 10.12$, $p < .01$, as was the prime type effect, $F(1, 14) = 5.64$, $p < .05$, with related targets and targets following picture primes producing shorter latencies. These two factors did not interact, $F(1, 14) = 0.33$, *ns*.

Picture Target Trials

Errors. Error criteria were the same as for word targets. Again, only errors falling into Categories (a) and (b) were included in the error analysis.

A 2 (relatedness) × 2 (prime type) ANOVA was completed for the error data. There was a total of 85 errors on picture target trials (8.3%). Of these, 59 were classified as target errors, 27 (5.3%) on related trials and 32 (6.2%) on unrelated trials. Neither this difference, the prime type effect (28 errors on word prime trials, 31 errors on picture prime trials), nor the interaction were significant (all Fs < 1.00). On 4 word prime trials (2 related) and 15 picture prime trials (5 related), an error was made to the second presentation of a stimulus pair. These cells were filled in the same way as on word target trials.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are the same as for word targets.

Mean reaction times for picture targets are also shown in the upper portion of Table 1. Although the relatedness effect was again significant, $F(1, 14) = 63.84$, $p < .001$, neither the prime type effect nor the interaction approached significance (both Fs < 1.00).

Table 1
Mean Reaction Times (RTs, in Milliseconds) and Target Error Percentages (EPs) in Experiments 1, 2, 3, and 4

Prime	Target	Related *RT*	Related *EP*	Unrelated *RT*	Unrelated *EP*	Relatedness effect
Experiment 1 (Name prime–name target)						
word	word	516	1.6	527	2.0	+11
picture	word	463	4.3	479	7.0	+16
word	picture	676	5.9	820	5.1	+144
picture	picture	695	4.7	835	7.3	+140
Experiment 2 (Name prime–categorize target)						
word	word	818	4.3	836	5.1	+18
picture	word	963	5.3	989	4.7	+26
word	picture	769	7.0	759	4.7	−10
picture	picture	952	8.2	957	9.2	+5
Experiment 3 (Categorize prime–name target)						
word	word	553	1.3	565	1.6	+12
picture	word	585	0.8	580	1.3	−5
word	picture	798	5.3	880	4.5	+82
picture	picture	832	7.2	867	5.5	+34
Experiment 4 (Categorize prime–categorize target)						
word	word	676	4.9	672	4.1	−4
picture	word	751	3.7	742	3.9	−9
word	picture	662	4.3	662	4.3	0
picture	picture	648	2.0	646	2.0	−2

Discussion

Two important generalizations are to be drawn from the results of Experiment 1. The first is that the naming of both words and pictures was facilitated by the presentation of a rhyming prime. In no condition was there any evidence of inhibition. This result is consistent with most of the results from the lexical decision task (specific exceptions being Colombo, 1985, 1986, and Henderson et al., 1984) and with most of the results in the perceptual identification task. Thus, at least initially, the results can be taken as support for the simple model postulating a spread of activation, either direct or indirect, between units for rhyming words in lexical memory.

The second generalization is that named picture primes did not produce less facilitation than named word primes for either type of target. Word primes would presumably be much more likely than picture primes to activate units at the sublexical–graphemic level. Thus, the possibility existed, at least for word targets which share these processing units, that this activation could have contributed to the overall priming effect. The lack of a prime type difference for either target type suggests that such was not the case. Apparently, the extra activation created by word primes either does not affect the processing of orthographically similar words or dies away too rapidly to be detected in the present task. Given that masked primes do facilitate the processing of orthographically similar targets in a low-level task like perceptual identification while more extensively processed unmasked primes do not (Humphreys et al., 1987), at present, the latter explanation seems more likely.

One other effect was significant in the present experiment, the prime type effect for word targets. Subjects named these targets more slowly but more accurately following word primes, effects which did not interact with relatedness. At present, the most likely explanation of these effects seems to be one based on a speed–accuracy trade-off. The group receiving word primes was simply more cautious in their responding than the group receiving picture primes. A difference of this sort was not found for the two groups receiving picture targets.

Finally, although no attempt was made to evaluate it, there was a large difference in the amount of facilitation for picture compared with word targets. In naming tasks, a difference of this sort is to be expected. Words allow essentially automatic access to lexical memory and retrieval of their name codes. Hence, naming times are quite short, and little facilitation is possible. For pictures, access to lexical memory is a much more indirect and time-consuming process. Thus, activation within lexical memory, spread either automatically or by controlled processing, can provide much more of a benefit. To the extent that controlled processing actually was involved, the priming effect may represent not only facilitation of related targets but inhibition of unrelated targets. Given the basic questions addressed by these data (is there priming and does it vary as a function of prime type?), no attempt was made to decompose the priming effects into facilitation and inhibition through the inclusion of a neutral condition.

Experiment 2

Although the results of Experiment 1 can be easily explained in terms of a lexical activation account, additional/alternative explanations are also possible. First of all, the larger priming effect with picture targets could be due to activation at the level of semantic memory. If spreading activation within lexical memory spills over into semantic memory, processing at the semantic level could also be facilitated. Picture targets, which access semantic memory prior to being named, would benefit, whereas word targets would not. Thus, the possibility exists that part of the reason for the larger priming effect for picture targets was that those targets had an additional locus of facilitation.

The second alternative explanation arises from the lack of a prime type effect, especially for word targets. This result suggests that only phonological, and not orthographic, relations were important for producing priming in Experiment 1. Although phonological relations are assumed to be represented, to some extent, at both the lexical and sublexical levels, these systems are assumed to be primarily orthographically based. Thus, a result such as this suggests that, for some reason, the phonological structures were more active than the orthographic structures in the present context. The most likely reason (in line with the earlier discussion of the effects of masked versus unmasked primes) is that activation at the graphemic level may simply have a very short time course and may die off very quickly once lexical access for the prime has been completed. Alternatively, the lack of a prime type effect could suggest that the priming effects were not input effects. For example, producing a name requires the retrieval of the name code, (potentially) the assembly of its components (e.g., Dell, 1986), and its actual production. Because all of these processes are phonologically based, in theory, any of them could be facilitated by a phonologically similar prime (Balota & Chumbley, 1985; McCann & Besner, 1987). Thus, one or more of these processes could have been responsible for at least part of the facilitation observed in Experiment 1.

The purpose of Experiment 2 was to evaluate these possibilities. As in Experiment 1, subjects were required to name the prime; thus, lexical memory should be activated by both word and picture primes. The target task, however, was now a categorization task in which subjects had to determine whether the target represented a natural or an artificial object. The reason for selecting this specific task was that it was one that clearly requires retrieval of information from semantic rather than lexical memory. Thus, according to the lexical activation account, there are quite different implications for word versus picture targets, as described below. The lexical decision task was specifically not selected for this study because, as noted previously, it is unclear which system, lexical or semantic, is primarily involved in making a lexical decision.

For picture targets, the use of the categorization task should allow subjects to respond without accessing lexical memory. Thus, if all of the priming in Experiment 1 was due to activation within lexical memory, the semantic processing necessary to respond in Experiment 2 should not be facilitated. On the other hand, if some of the priming in Experiment 1 was due to activation in lexical memory spreading over into semantic memory and facilitating the early semantic processing of pictures, this same type of process should occur in Experiment 2. Hence, a priming effect should emerge.

The story for word targets is somewhat different. For words, lexical memory is viewed as the entry-level system that words must access prior to accessing semantic memory. The priming effects in Experiment 1 were conceptualized as being due to a facilitation of this lexical access in any task involving word targets. Thus, even tasks such as that in Experiment 2, where the focus is on semantic memory, should show priming effects. On the other hand, the target task used in Experiment 2 bypasses the retrieval, assembly, and production of the word's name. Thus, if the priming effects in the naming task of Experiment 1 were localized in one or more of these processes, one would not expect priming effects in the categorization task of Experiment 2.

Method

Subjects

The subjects were 64 University of Western Ontario undergraduates (21 males and 43 females) who received either course credit or $4 for participating in this experiment. All were native English speakers and had normal or corrected-to-normal vision.

Stimulus Materials, Design, and Equipment

The stimuli and design were the same as in Experiment 1. For the target task, a board with two telegraph keys was placed on the table in front of the subjects. The right key was labeled *real* and the left key was labeled *manmade.* Depression of either key stopped the timer. Otherwise, the equipment was the same as in Experiment 1.

Procedure

With one exception, the procedure was identical to that of Experiment 1. The exception was that subjects were told to make a "reality" decision about the target after naming the prime. They were instructed to depress the right key if the target represented a real object and the left key if the target represented a manmade object. Examples of items from these categories were orally presented to each subject by the experimenter. Subsequent instructions and procedures were the same as in Experiment 1. In particular, the subjects receiving picture primes were shown the booklet containing the prime pictures and asked to familiarize themselves with the pictures' labels. Because twice as many subjects participated in Experiment 2 than in Experiment 1, two subjects in each of the prime type by target type conditions received the identical set of prime–target pairs.

Results

Word Target Trials

Errors. A trial was scored as an error if (a) the subject responded incorrectly to the target, (b) target response latency was longer than 2,100 ms or (c) the subject responded incorrectly to the prime. (The latency ceiling in the target categorization experiments, 2 and 4, was higher than in the target naming experiments, 1 and 3. The reason for the difference is that it quickly became apparent that a 1,600-ms ceiling would produce an inordinate number of errors, especially in the picture–target conditions in Experiment 2.) As in the previous error analyses, only those errors representing an error in target processing, Categories (a) and (b), were considered.

A 2 (relatedness) × 2 (prime type) ANOVA was completed for the error data. There was a total of 152 errors on word target trials (7.3%). Of these, 99 were classified as target errors. Forty-nine of these were in the related condition (4.8%), and 50 were in the unrelated condition (4.9%), an obviously nonsignificant difference ($F < 1.00$). Also nonsignificant were the prime type effect (48 errors with word primes, 51 with picture primes) and interaction (both Fs < 1.00). On 3 word prime trials (2 related) and 8 picture prime trials (4 related), an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these missing cells filled in as in Experiment 1.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are as in Experiment 1.

Mean reaction times for word targets are shown in the middle portion of Table 1. The relatedness effect was again significant, $F(1, 30) = 5.39$, $p < .05$, as was the prime type effect, $F(1, 30) = 9.50$, $p < .005$), with related targets and targets following word primes producing shorter latencies. These two factors did not interact, $F(1, 30) = 0.17$, *ns.*

Picture Target Trials

Errors. Error criteria were the same as for word targets. Again only errors falling into Categories (a) and (b) were included in the error analysis.

A 2 (relatedness) × 2 (prime type) ANOVA was completed for the error data. There was a total of 192 errors on picture target trials (9.4%). Of these, 149 were target errors. Seventy-eight of these were in the related condition (7.6%) while 71 were in the unrelated condition (6.9%), a nonsignificant difference, $F(1, 30) = 0.34$, *ns*. The prime type effect (60 errors with word primes, 89 with picture primes) was, however, marginally significant, $F(1, 30) = 3.36$, $.10 > p > .05$, while the interaction was not. On 12 word prime trials (10 related), and 60 picture prime trials (35 related), an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these cells filled in as before.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are the same as before.

Mean reaction times for picture targets are also shown in the middle portion of Table 1. Neither the relatedness effect, $F(1, 30) = 0.05$, *ns*, nor the Relatedness × Prime Type interaction approached significance, $F(1, 30) = 0.44$, *ns*. However, there was a large prime type effect, $F(1, 30) = 10.36$, $p < .005$, with word primes producing substantially shorter target latencies than picture primes.

Discussion

The most important aspect of these results is that there was a significant priming effect for word targets, but there was little evidence of a priming effect for picture targets. In fact, whereas the priming effect for picture targets decreased from the 140-ms range observed in Experiment 1 to essentially 0 ms, priming effects with word targets did not diminish at all. In addition, once again there was no Prime Type × Relatedness interaction. That is, word primes, which share both orthography and phonology with word targets, produced no more facilitation than picture primes, which share only phonology.

These results are consistent with a spreading activation account like that provided by Collins and Loftus' (1975) model and allow us to eliminate some of the alternative/additional explanations proposed earlier. In particular, the lack of a priming effect for picture targets suggests that the activation which is created by rhyming primes in lexical memory does not spill over into semantic memory (either automatically or as a result of controlled processing) to facilitate semantic processing. Thus, it appears that the locus of the priming effect for picture targets observed in Experiment 1 is no earlier than the process of accessing lexical memory from semantic memory.

The existence of a priming effect with word targets suggests that the locus of this effect is one common to both word naming and categorization. Thus, the effect does not appear to be a production effect. Under the assumption that the word naming and categorization processes diverge after lexical memory has been accessed (the next step in naming being name retrieval, the next step in categorization being accessing semantic memory), these results suggest that it is the lexical-access process that is being facilitated.

One could, of course, make the alternative assumption that name retrieval is necessary not only for producing a word's name but also for accessing semantic memory in order to make a categorization response. If so, these priming effects could be localized at this "postaccess," name-retrieval process. Although this assumption cannot be rejected out of hand, what evidence does exist suggests that it probably is incorrect. For example, primes which are masked to the point that they cannot be named, nonetheless, create a semantic context such that the processing of semantically similar words is facilitated (Carr, McCauley, Sperber, & Parmelee, 1982; Hines, Czerwinski, Sawyer, & Dyer, 1986; McCauley, Parmelee, Sperber, & Carr, 1980). The point should also be made that if it were true that name retrieval is necessary before semantic processing can begin, name retrieval really should not be viewed as a "postaccess" process but as a part of the process of completing lexical access. Thus, such an assumption would not really disturb the basic conclusion, that the priming is a "lexical-access" phenomenon.

As in Experiment 1, there was evidence of prime type effects in Experiment 2; however, unlike in Experiment 1, these effects do not appear to be due to a speed–accuracy trade-off. In particular, latencies for both target types showed a substantial advantage for word primes while the error data tended to show the same pattern. This particular effect, faster latencies following word primes, is actually somewhat pervasive in the present set of studies. It also obtained for both target types in Experiment 3, for picture targets in Experiment 1, and for word targets in Experiment 4. Although none of the effects in the other experiments were significant, the effect sizes ranged from 11 to 73 ms. In addition, although there is little indication that a result of this sort is common in previous ("semantic") priming literature, there is at least one other report of word primes producing shorter target latencies than picture primes (Vanderwort, 1984), and in none of the studies surveyed was there even a hint of an effect in the opposite direction.

If the prime type effect is a real one, it probably is due to the fact that picture processing requires slightly more resources than word processing and, thus, it may be slightly easier to begin target processing following a word prime. The tasks used in Experiment 2 may have amplified the problem. To begin with, the prime task, naming, is much more effortful with pictures than with words. In addition, the target task requires retrieval not from the lexical system, which the named prime has just accessed and activated, but from semantic memory. Thus, target processing also may be more effortful in Experiment 2 than in the other studies reported here.

Experiments 3 and 4

Experiments 1 and 2 give general support to the basic notion of a spreading activation process, either direct or indirect, within lexical memory. Activation seems to spread between locations for orthographically/phonologically similar words, facilitating lexical processing of a subsequently presented target. This support, however, has been derived under the specific circumstance where prime processing was directed to the lexical level by requiring subjects to name the prime. As Forster, Davis, Schoknecht, & Carter (1987) have argued, task variables such as this may play an important role in determining whether orthographic/phonological priming will be observed in a particular circumstance. Thus, what seems to be an important question is to what extent are these effects a function of requiring subjects to name the prime?

Experiments 3 and 4 are analogs of Experiments 1 and 2; however, prime processing will now be directed away from lexical memory by requiring the subjects to make a categorization response to the prime. For word primes, this task represents a deeper level of prime processing than in Experiments 1 and 2. In the semantic priming literature, the typical result of inducing deeper prime processing is a larger priming effect (Henik et al., 1983; Irwin & Lupker, 1983; Smith, 1979; Smith et al., 1983; see also Kaye & Brown, 1985). The basic explanation for these effects is that the deeper processing creates higher levels of activation in both semantic and lexical memory, with the higher levels of activation then producing larger facilitation. The situation in the present experiments is, of course, slightly different. The priming is due to a rhyming rather than a semantic relation. Thus, only the activation generated within lexical memory should be relevant to the amount of priming observed. In addition, what this particular change really represents is a change from a task that should maximally stimulate lexical memory to one in which attention is actually directed away from lexical memory. Thus, although the word primes presumably must access lexical memory prior to being categorized, the activation and facilitation they create may actually be less than in the "shallower" naming task.

For picture primes the story is slightly different. Categorizing pictures represents a shallower level of processing than naming. As such, from a levels-of-processing standpoint, less activation and, hence, less priming should be produced. In fact, the question is whether categorized picture primes will produce any priming at all. If, as suggested by the results of the previous experiments, the priming observed is purely a lexical phenomenon, categorized picture primes should produce priming only if (a) the semantic processing necessary to categorize a picture activates the picture's lexical location and (b) this activation then spreads to the locations of rhyming names. At present, most evidence suggests that such is not the case.

Babbitt's (1983) results using a color–word interference task would probably be those most relevant to this issue. In Babbitt's task, a picture was initially presented followed by a word whose ink color was to be named. Babbitt's results were that when the word named the picture, color-naming latency was affected only in conditions where lexical processing (specifically, accessing the lexical location and retrieving the picture's name) would be helpful. In conditions where lexical processing of the picture would not help performance, a match between word and picture had no effect.

What makes it somewhat difficult to generalize from Babbitt's results to the present situation is the fact the stimulus onset asynchrony (SOA) between picture and color word in his study was a full 2 s. This length of time would certainly have been sufficient for any automatic activation to decay (Neely, 1977), especially when maintaining this activation could harm color naming. The use of a shorter SOA, as well as a prime task which directs processing to semantic memory, should allow a better examination of the question of whether processing pictures semantically activates lexical memory.

Method

Subjects

The subjects in both experiments were University of Western Ontario undergraduates who received course credit or $4 for appearing in the experiment. There was a total of 80 subjects (18 males and 62 females) in Experiment 3 and 64 subjects (16 males and 48 females) in Experiment 4. All Prime Type × Target Type conditions had 16 subjects except the two word target conditions in Experiment 3, which had 24. (In these two conditions 3 subjects received each set of prime–target pairs.) All subjects were native English speakers and had normal or corrected-to-normal vision.

Stimulus Materials, Design, and Equipment

The stimuli, design, and equipment were the same as in the previous experiments.

Procedure

The basic procedure was the same as before. Subjects responded to both prime and target. In both experiments subjects responded to the prime by depressing the right key if it represented a real object and the left if it represented a manmade object. Examples of items from these categories were orally presented to the subject by the experimenter. Again, subjects receiving picture primes were shown the booklet containing the prime pictures and asked to familiarize themselves with the pictures' labels. The target tasks were naming in Experiment 3 and the natural–artificial categorization task in Experiment 4.

Results: Experiment 3 (Categorize Prime–Name Target)

Word Target Trials

Errors. A trial was scored as an error if (a) the subjects stuttered or responded incorrectly, (b) target naming latency was longer than 1,600 ms, or (c) the subject responded incorrectly to the prime. As in the previous error analyses, only those errors representing an error in target processing, Categories (a) and (b), were considered.

A 2 (relatedness) × 2 (prime type) ANOVA was completed on the error data. There was a total of 84 errors on word target trials (2.7%). Of these, 39 were classified as target errors. Seventeen of these were in the related condition (1.1%), and 22 were in the unrelated condition (1.4%), a nonsignificant difference, $F(1, 46) = 1.18$, *ns*. Also nonsignificant were the prime type effect (22 errors with word primes, 17 with picture primes) and the interaction (both $F\text{s} < 1.00$). On 6 trials an error was made to the second presentation of a stimulus pair (3 in the related picture prime condition, 1 in each of the other conditions). Latency analyses were carried out with those cells filled in as before.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are as before.

Mean reaction times for word targets are shown in the middle portion of Table 1. Neither the relatedness effect, $F(1, 46) = 0.95$, *ns*, nor the prime type effect, $F(1, 46) = 1.75$,

$p > .15$, were significant. However, there was a significant Prime Type × Relatedness interaction, $F(1, 46) = 4.17$, $p < .05$. This effect was due to a significant relatedness effect in the word prime condition, $t(23) = 2.42$, $p < .025$ one-tailed, but not in the picture prime condition.

Picture Target Trials

Errors. Error criteria were the same as for word trials. Again, only errors falling into Categories (a) and (b) were included in the error analysis.

A 2 (relatedness) × 2 (prime type) ANOVA was completed on the error data. There was a total of 160 errors on picture target trials (7.8%). Of these, 115 were classified as target errors. Sixty-four of these were on related trials (6.25%), and 51 were on unrelated trials (5.0%) a nonsignificant difference, $F(1, 30) = 1.74$, $p > .15$. Also nonsignificant were the prime type effect (65 errors with picture primes and 50 errors with word primes) and the interaction (both Fs < 1.00). On 9 word prime trials (5 related) and 13 picture prime trials (4 related), an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these cells filled in as before.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are as before.

Mean reaction times for picture targets are also contained in the middle portion of Table 1. Although the prime type effect was not significant ($F < 1.00$), both the relatedness effect $F(1, 30) = 37.03$, $p < .001$, and the Relatedness × Prime Type interaction were significant, $F(1, 30) = 6.03$, $p < .025$. The interaction was due to a significantly smaller relatedness effect with picture primes. An analysis of the picture prime condition, however, does show a significant advantage for the related targets, $t(15) = 2.25$, $p < .05$, two-tailed.

Results: Experiment 4 (Categorize Prime–Categorize Target)

Word Target Trials

Errors. A trial was considered an error if (a) the subject responded incorrectly to the target, (b) target response latency was longer than 2,100 ms, or (c) the subject responded incorrectly to the prime. As in previous error analyses only those errors representing an error in target processing, Categories (a) and (b), were considered.

A 2 (relatedness) × 2 (prime type) ANOVA was completed for the error data. There was a total of 108 errors on word target trials (5.3%). Of these, 85 were classified as target errors, 44 in the related condition (4.3%) and 41 in the unrelated condition (4.0%). Neither this effect, the prime type effect (46 errors with word primes, 39 with picture primes), nor the interaction were significant (all Fs < 1.00). On 8 trials (1 related word prime trial, 5 related picture prime trials and 2 unrelated picture prime trials), an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these missing cells filled in as before.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are as before.

Mean reaction times for word targets are shown in the lower portion of Table 1. Although neither the relatedness effect nor the interaction were significant (both Fs < 1.00), the prime type effect was marginally significant, $F(1, 30) = 3.01$, $.10 > p > .05$. This was due to slightly faster target latencies following word primes ($M = 674$) than following pictures primes ($M = 747$).

Picture Target Trials

Errors. Error criteria were the same as for word targets. Again, only errors falling into Categories (a) and (b) were included in the error analysis.

A 2 (relatedness) × 2 (prime type) ANOVA was completed for the error data. There was total of 92 errors on picture target trials (4.5%). Of these, 64 were classified as target errors, 32 in the related condition (3.1%), and 32 in the unrelated condition (3.1%). Neither this effect nor the interaction approached significance (both Fs < 1.00). However, there was a significant effect of prime type, with word prime trials producing more errors (44—4.3%) than picture prime trials (20—2.0%), $F(1, 30) = 10.38$, $p < .005$. On 6 trials (2 related word prime trials and 4 unrelated picture prime trials), an error was made to the second presentation of a stimulus pair. Latency analyses were carried out with these cells filled in as before.

Mean reaction times. Target latencies were submitted to a 2 (relatedness) × 2 (prime type) ANOVA. The nestings and analyses are the same as before.

Mean reaction times for picture targets are also shown in the lower portion of Table 1. Neither the prime type effect, the relatedness effect, nor the interaction were significant (all Fs < 1.00).

Discussion

The results of Experiments 3 and 4 allow for two general conclusions. The first is that categorized picture primes have much less effect on naming rhyming targets than categorized word primes (Experiment 3). The second is that categorized primes do not prime the categorization of rhyming targets (Experiment 4). The implications of these are discussed in turn.

For word primes, the prime task used in Experiment 3 (categorization) represented a deeper level of processing than the prime task used in Experiments 1 and 2 and a deeper level of processing than the same task using picture primes. For the named word targets in Experiment 3, categorized word primes produced essentially the same level of priming as the named word primes in the previous two experiments. Categorized picture primes produced no evidence of priming for these same targets. For the picture targets, word primes produced a priming effect (82 ms) which was somewhat diminished from that observed in Experiment 1 (144 ms) although it was significantly larger than the effect produced by picture primes (32 ms). The word prime advantage for both target types does indicate that depth of prime processing may be of some relevance here. Nonetheless, the comparison to Experiments 1 and 2 also shows that increasing the depth of processing of the word prime does not *increase* the size of the priming effect (in contrast to what occurs with semantic priming) (e.g., Irwin & Lupker, 1983; Smith et al., 1983). Instead, these data support the more general conclusion that priming is maximal when the prime task is lexically based, as in Experiment 1, and that by directing prime processing away from lexical memory the priming effect starts to diminish.

If this conclusion is correct, an obvious question is why was there no difference between the size of the priming effect in the word prime–word target condition in Experiment 3 and that in Experiment 1? Two possibilities suggest themselves. First, the size of the priming effect observed in Experiment 1 was small, only 10–15 ms. In the analogous conditions with picture targets, the dropoff from changing the prime task was only approximately 43% (144 ms–82 ms). It is unlikely that a similar size dropoff for word targets could be picked up empirically. (It should also be noted that we did have some trouble getting this effect in Experiment 3 to settle down. We had to test three times as many subjects as in Experiment 1.) A second possible reason why no real difference was observed may be that after prime categorization had been completed, subjects in the word prime–word target condition may have been able to direct full attention back to lexical memory in preparation for target processing. With picture targets, which require semantic processing before being named, a complete switch of attention back to lexical memory may be counterproductive. As such, it may be easier to maintain original activation levels in lexical memory for word targets than for picture targets.

For picture primes, the absolute level of priming observed in Experiment 3 is of some interest. Specifically, categorizing picture primes did not facilitate naming of rhyming word targets although it did provide some facilitation for picture targets. The word target results certainly support Babbitt's claim that semantic processing of pictures stimulates little, if any, activation of the lexical memory system. On the other hand, the existence of a quite reduced but, nonetheless significant, priming effect for picture targets does not appear to be consistent with the claim.

This priming effect with picture targets is the only result in the present studies suggesting an interaction between activation at the lexical and semantic levels. (In Experiment 2, for example, there was no evidence that lexical activation spreads to semantic memory to facilitate categorization of pictures.) What should be kept in mind, however, is that this specific condition (the picture prime–picture target condition in Experiment 3) seems to be quite susceptible to influences of subject strategies. Specifically, given the time-consuming nature of picture naming, the subjects in this condition may have found it beneficial to attempt to access lexical memory in order to retrieve the prime's name during or immediately after the categorization task. Thus, at least some proportion of the time, a spreading activation process in lexical memory may have begun quickly enough to facilitate picture naming on related trials. If this suggestion is correct, then, this effect would actually be a lexical effect and, thus, would not be incompatible with either Babbitt's claim or the basic lexical-activation explanation.

In Experiment 4 there was no expectation that categorization of picture targets would be facilitated by the categorization of a rhyming prime. As was argued on the basis of the results of Experiment 2, activation in lexical memory does not seem to spill over into semantic memory to facilitate semantic processing. The lack of a priming effect in the picture target conditions of Experiment 4 is consistent with this conclusion. On the basis of the results in the picture prime–word target condition of Experiment 3, it was also expected that there would be no priming in the analogous condition in Experiment 4. That is, because categorized pictures do not seem to automatically activate lexical memory, they should not be able to facilitate lexical processing of words. Thus, the major question was whether there would be a priming effect in the word prime–word target condition.

As with the analogous condition in Experiment 3, there seem to be three possibilities. First, the added depth of processing required for both prime and target could have produced an increased level of priming. Second, as in Experiment 3, the size of the priming effect could have been the same as in all other conditions where the prime is lexically processed (i.e., approximately 10–15 ms). Third, the fact that the prime task and the target task direct attention away from lexical memory could have diminished the priming effect. The results support this third possibility, that is, that word categorization is not facilitated by a rhyming word prime that has also been categorized. These results also support the notion that lexical activation produced by lexically processing the prime will die off unless a certain amount of attention is available to maintain it. When both prime and target must be categorized, subjects are apparently unable or unwilling to maintain this activation. That is, this problem is essentially the same problem that subjects had in categorizing word primes and naming picture targets in Experiment 3. There, because both prime and target processing involved semantic memory, subjects seemed to be unable to give lexical memory enough attention to prevent a decay of at least some of the lexical activation.

The overall conclusion to be drawn then from Experiments 3 and 4 is that directing prime processing away from lexical memory produces a diminishing of the size of the rhyme priming effects. This is true even for word primes in spite of the fact that the particular manipulation used actually represented a deeper level of prime processing, a manipulation that tends to increase the size of semantic priming effects. In fact, as the results in the word prime–word target condition of Experiment 4 suggest, unless sufficient attention can be directed to lexical memory, evidence of lexical activation can, in fact, disappear.

General Discussion

The present studies were carried out with two goals in mind. First, they were an attempt to gain converging evidence for the existence of rhyme priming by examining the phenomenon with a different, and potentially more appropriate, target task. Second, the studies represented an attempt to expand upon the conceptual framework of a spreading activation process in lexical memory by examining the boundary conditions of the phenomenon. The results clearly suggest that the first of these goals was accomplished. Facilitation was typically found where expected, and, in opposition to some earlier results (e.g., Colombo, 1986), there was no evidence of inhibition. Thus, the main issue to discuss here is, how do these results fit into the context of a spreading activation model?

The boundary conditions of the priming effect were investigated in three ways. First, pictures, as well as words, were used as primes and targets. The results indicate that as long as lexical processing of the pictures was enforced by requiring the subjects to name them, the basic priming effects for pictures paralleled the basic priming effects for words. Specifically, named picture primes produced the same amount of facilitation as named word primes (Experiments 1 and 2), and named picture targets were facilitated in the same conditions as named word targets (Experiments 1 and 3).

Second, the nature of the target task was changed from one which focused on lexical processing to one which focused on semantic processing. The results indicate that for words, which require access to lexical memory prior to accessing semantic memory, there is still a priming effect, whereas for pictures, which access semantic memory directly, there is not. Both of these results fit nicely into the framework of a spreading activation process within lexical memory that facilitates lexical access for rhyming targets.

The third manipulation involved changing the nature of the prime task from one that is lexically based to one that is semantically based. Here the results were slightly different than anticipated. That is, (a) categorized word primes facilitated the naming of picture targets somewhat less than named word primes did, and (b) categorized word primes did not facilitate the categorization of word targets. These effects appear to be due to a particular constraint on the nature of orthographically/phonologically driven lexical activation. Specifically, although both named and categorized word primes are assumed to start the spreading activation process, the requirement to categorize the word prime apparently draws attention away from lexical memory to semantic memory. Without this attention, the lexical activation starts to decay, and, thus, less activation is available to prime lexical access for a subsequent target. Only when the target task allowed the subject to switch full attention back to lexical memory (as when the word primes were categorized and the word targets were named in Experiment 3) was it possible to observe a full-blown priming effect.

As noted earlier, there was one other somewhat unexpected result. In Experiment 3 categorized picture primes produced a significant priming effect for naming target pictures although not for naming target words. This effect was attributed to subject strategies, specifically the strategy of consciously accessing lexical memory in order to retrieve the picture's name and start the spreading activation process. It was further argued that what made this strategy effective was that picture naming is a fairly time-consuming process. A more rapidly unfolding process, like word naming, would be somewhat more difficult to affect.

It is worth noting that this picture prime–picture target condition of Experiment 3 was the only condition in which subjects appeared to adopt a strategy of processing the prime beyond the task requirements. Such was not the case, for example, in Experiment 2 when picture targets were categorized. In theory, it might have been possible in Experiment 2 to use the spreading activation produced by the prime in lexical memory to activate locations in semantic memory for concepts with rhyming names. For example, after naming the word MOUNTAIN and thereby activating the lexical location for FOUNTAIN, it might have also been possible to activate the semantic location for FOUNTAIN, thus facilitating its categorization. This, as argued, does not appear to occur automatically. The fact that it also does not appear to happen as a result of subject strategies is probably due, to some extent, to the brevity of the prime–target onset asynchrony and to the speed of picture categorization. Whether it could occur with a longer onset asynchrony is, of course, an empirical question. One factor that is probably important is the number of rhymes a prime has. Producing facilitation for FOUNTAIN in the above example might be somewhat easier than producing an effect from a prime like HAT for which there are a large number of possible rhyming targets (e.g., *bat*, *cat*, *gnat*, *mat*, etc.).

Given that the results of the present experiments (as well as a number of others) basically support the spreading activation model, the obvious question to ask is why do some researchers find either null effects or inhibition? The most obvious answer is that the size (and existence) of priming effects varies as a function of the depth (and manner) of prime (and target) processing. The present data, of course, support this conclusion as does an analysis of data already in the literature. For example, in situations where a lexical decision is required to the target, priming has generally been found when a lexical decision is also being made to the prime (e.g., Hanson & Fowler, 1987; Hillinger, 1980; Shulman et al., 1978; although see Martin & Jensen, 1988). When the subject simply views the prime, the result is either inhibition (Colombo, 1986) or no effect (Forster & Davis, 1984). Apparently, a similar type of phenomenon occurs when the target task is perceptual identification. As Humphreys and colleagues have observed, although priming is typically found with masked primes, it is not with unmasked primes (Humphreys et al., 1987).

If this conclusion about depth of prime processing is correct, the next question is what is the mechanism that produces the depth effects? The answer supported by the present results is that orthographic/phonological priming will emerge to the extent that prime and target processing is directed to the lexical level. Thus, one explanation for the previous results is that by requiring a lexical decision to the prime, processing was directed to the lexical level, whereas such was not the case when subjects were simply told to view the prime. Unfortunately, there is no real way to determine exactly what subjects were doing during prime processing in any of the earlier experiments. Thus, there is no way to evaluate this explanation.

An additional complication for any attempt to interpret the orthographic/phonological priming literature is the fact that those studies that showed a priming effect (including the present studies) have typically had a much longer prime–target onset asynchrony. Although the importance of prime-target onset asychrony has yet to be convincingly demonstrated (e.g., Colombo, 1986), the pattern of activation in the early stages of prime processing may be quite different than that at later stages. For example, in line with the suggestions put forth by Humphreys, Besner, and Quinlan (1988), early in prime processing the sublexical, graphemic units will be activated and, hence, they may drive priming effects. Thus, if the onset asynchrony is short enough, it may be possible to get pure "orthographic" priming effects (e.g., Evett & Humphreys, 1981; Humphreys et al., 1987; Lupker, 1982). With only slightly longer onset asychronies, this activation may have died away, and only activation spreading within phonologically based lexical and sublexical structures may be able to produce priming. This process may take a certain period of time before the activation has reached a detectable level. Thus, in a task where the prime is viewed, either masked or unmasked, many typical onset asynchronies might produce neither an orthographic nor a phonological priming effect.

The suggestion offered here about the importance of processing focusing on the lexical level together with the notion of different time courses for orthographic and phonological activation could, then, allow an explanation of a number of the facilitory and null effects currently in the literature. Unfortunately, because this explanation is based on the concept of activation, what it cannot explain is the occurrence of inhibitory effects (e.g., Colombo, 1986; Henderson et al., 1983; Meyer et al., 1974). One possibility is that at these intermediate onset asynchronies, there actually is, as Colombo (1986) suggests, inhibition of orthographic cohorts (i.e., related targets) as a result of the prime recognition process. Although this suggestion can not be ruled out, it faces a certain difficulty explaining why there is priming in tasks in which prime and target are presented together and a lexical decision must be made to the pair (Hanson & Fowler, 1987; Shulman et al., 1978). That is, although the amount of time devoted to processing the top stimulus in these tasks is not controlled, it certainly should be longer than that which produces pure orthographic priming (the sensitivity of the priming effect to phonological relations; Meyer et al., 1974, appears to back up this notion). Nonetheless, this time should also be somewhat less than the onset asynchrony in most sequential prime-target tasks and, hence, somewhere in the range where Colombo (1986) found inhibition (i.e., 320 ms and less). Thus, the lack of inhibition here suggests that there is at least something more to the story.

For the remainder of the answer, it appears to be necessary to consider what effects the prime might be having on stages of target processing other than lexical access. For example, as Shulman et al. (1978) suggest, the lack of a rhyming relation between orthographically similar primes and targets may very well inhibit decision making if the subject tries to assign the same pronunciation to the two words. Balota and Lorch (1986) hypothesize a similar process in the semantic realm to explain why they obtained no second-order (e.g., LION–STRIPES) facilitation in a lexical decision task (see also de Groot, 1983). Another potential source of inhibition, which is more relevant to Colombo's (1986) studies and which may have its maximum effect at intermediate onset asynchronies, is that subjects may still be processing the prime when the target arrives. The result may be that a response competition (or, more generally, processing competition) situation is created in which full attention can not be given to target processing. At longer onset asynchronies (or when prime and target are presented together) the subjects may be able to clear the prime by responding in whatever implicit way they wish and, as such, alleviate the problem.

Although response competition (and, to some extent, processing competition) is a well documented phenomenon in a number of situations (e.g., color-word and picture-word interference tasks), its potential role in priming studies has received somewhat less consideration (although see Glaser & Dungelhoff, 1984, and La Heij, Van der Heijden, & Schreuder, 1985, for interesting attempts at reconciling priming and interference phenomena). The reason may be that in semantic priming tasks, competition effects may affect either the related and unrelated pairs equally, or they may even enhance the priming by harming the unrelated pairs more. Orthographically/phonologically related word pairs may be somewhat different. For example, if as McClelland and Rumelhart (1981) suggest, word recognition is a process of eliminating cohorts, an orthographically/phonologically related target may "prime the prime". The effect would be to bring the rhyming prime back to a high level of activation, thus, diverting attention from target processing on rhyming trials. Alternatively, the inhibition may take place at or near the response level. That is, normally, prime processing may create at least some tendency to want to name the prime. A rhyming target may enhance this tendency, further delaying a target response. In any case, the potential for effects such as these may be especially high in a target task like lexical decision, which appears to be influenced by a large number of contextual factors (Seidenberg et al., 1984).

As is clear (we hope) from the previous discussion, the support for the spreading activation model presented here can not really be generalized much beyond the present situation. The effects of an orthographic/phonological context are far from being well understood. Thus, although the spreading activation model does appear to provide a good basic description of the nature of the processing involved, Forster et al. (1987) were likely correct in claiming "we are left with the possibility that task variables will need to be included in any adequate theory of priming" (p. 249).

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Appendix

Stimuli in Experiments 1, 2, 3, and 4

Category A (real–artificial)
mountain–fountain
claw–saw
shell–bell
dove–glove
mouse–house
goat–boat
roots–boots
snail–nail
lake–rake
toe–bow
duck–truck
thumb–drum
head–bed
nurse–purse
hair–chair
rain–cane
stork–fork
nest–vest
star–car
rock–lock

Category B (both artificial)
light–kite
swing–ring
bag–flag
box–socks
ship–whip
bench–wrench
block–clock
chain–train
bread–sled
pie–tie
lamp–stamp
can–fan

Category C (both real)
beet–feet
pear–bear
trunk–skunk
rose–nose
egg–leg
deer–ear
parrot–carrot
wing–king
fly–eye
ant–plant
log–frog
knee–bee

Category D (artificial–real)
pail–whale
spoon–moon
towel–owl
hat–bat
horn–corn
tower–flower
noose–moose
dish–fish
tack–back
cake–snake
pan–man
mat–cat
phone–bone
gun–sun
dart–heart
jeep–sheep
wheel–seal
tire–fire
crown–clown
key–tree

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