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Nature of Priming Effects on Categorization

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Alternative models for explaining priming effects on categorization are described, and their predictions concerning the relative advantage of frequent versus recent priming as a function of interstimulus delay are contrasted. Subjects were asked to categorize an ambiguous stimulus description that could be characterized in either a positive or a negative manner. Prior to its presentation, subjects were unobtrusively exposed to both positive and negative primes related to the description. For half of the subjects, the positive primes appeared more frequently, but the negative prime appeared most recently; for the remaining subjects, the negative primes appeared more frequently, but the positive prime appeared most recently. Between the final prime and stimulus presentation, there was a delay of either 15 s or 120 s. Subjects tended to categorize the stimulus description in terms of the recently primed construct after the brief interstimulus delay, but they tended to categorize the description in terms of the frequently primed construct after the long interstimulus delay. These results are consistent with a proposed *synapse* model of priming effects. Other possible models that make different assumptions about the level of activation, the decay function, and their ability to account for the findings are discussed.

Priming effects on the subsequent identification of stimuli have been examined extensively in recent years. In the cognitive literature, most research on priming effects has involved presenting subjects with a word or group of words (the *prime*), followed quickly by a target letter string that subjects must name or classify (e.g., as a word vs. a nonword). These studies found that naming or classifying the target is facilitated when the prime is semantically related to or associated with the target (e.g., Forbach, Stanners, & Hochhaus, 1974; Meyer, Schvaneveldt, & Ruddy, 1975; Neely, 1977; Warren, 1977). In the social cognitive literature, most research on priming effects has involved presenting subjects with a word or group of words as part of one study, followed a few minutes later by a separate, unrelated study in which subjects read a behavioral description of a target person and formed an impression of him or her. These studies found that subjects tend to characterize the target person information in terms of the construct that had been previously primed (e.g., Bargh & Pietromonaco, 1982; Higgins, Rholes, & Jones, 1977; Rholes & Pryor, 1982; Srull & Wyer, 1979). In addition to these effects of recent priming on subsequent stimulus identification, there is also evidence that frequent priming increases the impact of priming on subsequent processing (e.g., Hayes-Roth, 1977; Reder, 1983; Srull & Wyer, 1979, 1980). Thus, it has been well established that both recent and frequent priming influence the identification of subsequent stimuli. But what mechanism underlies such priming effects? What is the relation between recent and frequent priming, and how do their relative effects change over time? The purpose of this study was to address these questions.

With respect to the effects of priming on categorization, it is known that the priming of an applicable construct increases the likelihood that it will be used to process a subsequent stimulus, that the likelihood of utilization increases as the frequency of priming increases, and that the likelihood of utilization decreases as the temporal delay between priming and stimulus presentation increases (Higgins & King, 1981; Wyer & Srull, 1981). At present, two types of models (or, more appropriately, metaphors) have been proposed in the literature to explain such

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Table 1
Possible Assumptions of Excitation Transmission Models of Priming Effects for Level of Activation and Decay Function Parameters

	Possible assumption	
Parameter	Alternative 1	Alternative 2
Level of activation	Binary	Continuous (postthreshold)
Decay function		
Between constructs	Uniform	Nonuniform
Within constructs	Constant	Nonconstant
Source of variability	Level of activation	Length of activation (e.g., frequency)

priming effects: mechanistic models, where the explanation is in terms of the arrangement and the working of component parts, and excitation transmission models, where the explanation is in terms of the heightening and the dissipation of excitation or energy levels.

The clearest example of a mechanistic model that has been specifically used to interpret priming effects on categorization is Wyer and Srull's (1980) "storage bin" model. They proposed that the constructs in each bin are stored in layers in the order in which they were previously activated. When stimulus information is interpreted, the relevant bin is searched from the top down so that constructs at the top are more likely to be retrieved and utilized. Thus, when several constructs are potentially applicable for stimulus processing, the most recently activated construct is most likely to be used. A construct will remain at the top of the bin for a substantial period as long as other constructs in the bin are not activated during the interval. Typically though, other constructs in the bin are more likely to be activated as the delay between priming and stimulus presentation increases. Thus, as the delay period increases, the primed construct is less likely to remain on top and so is less likely to be utilized in subsequent processing. When a construct is frequently activated, however, it is more likely to have been recently used, and thus it is more likely to remain on top to be utilized subsequently. In this model, therefore, the effect of frequent activation is reinterpreted in terms of its relation to recent activation. A very similar conceptualization of priming effects also has been proposed by Forbach et al. (1974).

Priming effects on categorization also have been interpreted in terms of various forms of excitation transmission (see Higgins & King, 1981; Marcel & Forrin, 1974; Reder, 1983; Warren, 1972; Wyer & Carlston, 1979). These models have generally included the following basic postulates: (a) The priming of a construct increases its excitation level; (b) a construct's excitation level must reach a certain, minimal threshold for that construct to be used in stimulus processing; (c) the more frequently a construct is primed, the more likely it is that this minimal threshold will be maintained; and (d) the excitation level of a construct decreases over time, and thus the longer the period since the final priming, the less likely it is that the minimal threshold will be maintained. There is no excitation transmission model, however, that is as specific as Wyer and Srull's (1980) storage bin model with respect to the parameters that underlie recency, frequency, and temporal delay effects of priming on categorization. To be more specific, an excitation transmission model must make some assumptions with respect to two parameters: *level of activation* and *decay function.* As shown in Table 1, there are a number of possible assumptions that could be made. For level of activation, there are two basic alternatives. One could assume either that activation level is binary (i.e., all or none) or that activation level is continuous, such that constructs can build up different levels of activation above the minimal threshold of activation (e.g., Wyer & Carlston, 1979).

There are a greater number of possible assumptions that one could make with respect to decay function. First, with respect to a between-constructs comparison, one could assume either that the decay function is the same for all activated constructs (i.e., a *uniform* decay function) or that the decay function varies for different activated constructs as a function of their level or length of activation (i.e., *nonuniform* decay functions). Second, with respect to a within-constructs comparison, decay functions could involve either a constant amount (a linear function) or a constant rate (a nonlinear function) of decay per unit time (i.e., *constant* decay) or they could involve varying amounts or rates of decay per unit time as a function of level or length of activation (i.e., *nonconstant* decay). A uniform and constant decay function for primed constructs has been suggested by Marcel and Forrin (1974). A nonuniform and nonconstant decay function that varies as a function of level of activation is consistent with Wyer and Carlston's (1979) suggestion that residual excitation decreases more rapidly initially than later on, as long as one assumes higher decay rates for higher levels of activation. Another possibility, and our preferred alternative, is a nonuniform decay function that varies as a function of how often or how long a construct has been primed, where the rate of decay decreases as the length of priming increases.

There are various possible excitation transmission models that could be constructed by combining different assumptions with respect to the level of activation and the decay function. Let us consider two possibilities that reflect two common energy transmission systems: the *battery* model and the *synapse* model. In the battery model, the level of activation is assumed to be continuous, and the decay function is assumed to vary as a function of level of activation (i.e., nonuniform and nonconstant). This model would be consistent with Wyer and Carlston's (1979) general discussion of the parameters of priming effects. In this model, a construct is like a standard automotive battery that is charged by priming: The more the battery is primed, the higher is its level of activation or charge, and the higher the level of activation or charge, the higher the likelihood of subsequent utilization. Because the level of activation decreases over time, the likelihood of using the construct decreases as the amount of time between final priming and stimulus presentation increases. Frequency effects in this model are explained by assuming that the more frequently a construct is primed, the higher is its level of activation or charge.

The synapse model proposes that a construct functions like the synapses of vertebrates (see Kandel, 1976). Thus, the level of activation is assumed to be binary (i.e., all or none), and the decay function is assumed to vary as a function of the length of priming (i.e., nonuniform). In this model, stimulation of a construct through priming increases its action potential to a fixed, maximum level of elevation, which then slowly dissipates over time. Thus, as the delay between construct stimulation and stimulus presentation increases, the likelihood of utilizing the construct for subsequent stimulus processing decreases. In addition, the synapse model holds that, just as for synapses (e.g., Lloyd, 1949), the more frequently or longer a construct has been stimulated, the slower its action potential dissipates. (The decay function would be nonconstant as well.) Therefore, it follows that the more frequently a construct is primed, the more likely its action potential will remain sufficiently high to give it an advantage in subsequent processing.

The major difference among these models concerns the effect of frequent priming on subsequent stimulus processing as the delay between final priming and stimulus presentation increases. This difference among the models can be highlighted by considering what each would predict if people were asked to judge stimulus person information that could be categorized either positively or negatively (e.g., an ambiguous, independent/aloof behavioral description) and prior to this had one of the applicable constructs frequently primed (e.g., independent) and the other construct primed only once but most recently (e.g., aloof). According to the storage bin model, the recent construct would predominate over the frequent construct, as long as it was the last applicable construct to be activated, regardless of the delay between final priming and stimulus presentation.

According to the battery model, whichever construct has the higher level of activation immediately after final priming would predominate, regardless of the delay between final priming and stimulus presentation. This would typically be the frequent construct because its greater priming would give it a higher level of activation, unless the period between its last priming and the priming of the recent construct was so long that its activation level fell below the level attained by a single priming of the recent construct.

In any case, whichever construct predominated after a brief delay would also predominate after a long delay, given the assumption of the battery model that the rate of decay varies as a function of level of activation. That is, when the construct with the higher activation level at Time 1 (e.g., at the end of the brief delay) eventually decays to the level that the competing construct was at Time 1, then it will follow the same decay function as did the competing construct since Time 1, but the competing construct will always be further along this decay function. Thus, although the absolute difference between activation levels of these constructs may decrease over time, their relative positions will not change.

Only the synapse model predicts a possible reversal of which construct predominates as a function of the delay between final priming and stimulus presentation. Given that the frequent and recent constructs have the same maximal level of action potential when they begin to dissipate and that the frequent construct begins to dissipate sooner than the recent construct, the recent construct should predominate immediately after final priming. However, because the frequent construct is hypothesized to have a slower rate of dissipation than the recent construct, the frequent construct should predominate when there is a long delay between final priming and stimulus presentation. The present study was designed to test these alternative predictions.

Method

Design

Subjects were randomly assigned to 1 of 12 experimental conditions formed by completely crossing the three factors of interest. Three different ambiguous stimulus descriptions were employed in order to examine the generalizability of effects across different trait dimensions. The stimulus descriptions exemplified the following trait dimensions: independent/aloof, adventurous/reckless, and persistent/stubborn. These pairs were constructed so that the members of each pair differed in social desirability but referred to highly similar behavior. A second factor was whether the positively valenced or the negatively valenced member of each pair would appear more frequently during the priming task. In the positive frequency/negative recency condition, the desirable trait from each pair appeared more frequently, and the undesirable trait appeared most recently during priming. In the negative frequency/positive recency condition, the undesirable trait appeared more frequently, and the desirable trait appeared most recently. The third factor was the amount of delay a subject encountered between the final priming and presentation of the stimulus description: either 15 s or 120 s. During this delay, the subject engaged in a mediating task designed to clear working memory. Thus, the experiment employed a 3 × 2 × 2 (Type of Stimulus Description × Type of Priming × Postpriming Delay) between-subjects factorial design.

Subjects

Sixty-three male and female undergraduates enrolled in the introductory psychology course at New York University participated in the experiment in return for course credit. All subjects were run individually and were fluent in English. Five subjects were randomly assigned to each of the 12 experimental conditions. During debriefing, 3 subjects indicated at least some awareness of a relation between the priming task and the stimulus-description labeling task, and so these subjects were replaced in the design.

Apparatus and Materials

The experimental room was equipped with two chairs and a table on which a Zenith model ZVM121 cathode-ray tube (CRT) screen and response box were placed. The subject was seated in front of the CRT display, and the response box was placed within easy reach. The experimenter sat behind and out of sight of the subject. The CRT display was under program control of an Apple II microcomputer located in a separate control room. The response box, which was directly connected to the computer as an input device, contained a button that, when pressed at appropriate times by the subject, caused the computer program controlling the experiment to proceed with the next phase of the experiment. With the exception of the experimental consent form, which explained the three tasks to the subject prior to the start of the experiment, all instructions were presented on the CRT display.

Procedure

Before the subject was shown into the experimental room, his or her experimental condition was randomly determined and was entered into the computer by the experimenter. The computer program used this code to present the appropriate stimulus materials (described later) to the subject. After being seated in front of the CRT screen in the experimental room, subjects were asked to sign a consent form that fully described the procedures of the study in which they were about to participate. Through the consent form, subjects were informed that the experiment concerned the relation between language skills and the ways in which people mentally manipulate symbols, such as numbers. To foster subjects' continued belief in the stated rationale for the experiment, the experimenter carried a clipboard and wrote down subjects' verbal responses during the course of the experimental sessions.

The subject pressed the response button to begin the experiment. Each subject was informed that he or she would perform a series of tasks three times. Unbeknownst to the subject, the first two series were practice trials intended to familiarize the subject with the task procedures. Only the third and final task series contained the critical priming manipulation and person-description labeling task. There was no relation at all between the priming and labeling tasks during the first two practice sequences, which further disguised the relation between the two tasks in the experimental series that followed. The experimenter ensured that all tasks were being performed properly prior to the start of the third, critical series of tasks.

Priming task. The first task consisted of 20 trials in which groups of four words were presented on the screen. The subject was instructed to use three of the words to make a grammatically correct and meaningful sentence. The groups of words were selected so as to make this possible on every trial. Each set of words remained on the screen for 3 s, after which the screen went blank for a pause of 1 s. During this time, the subject formed a sentence and stated it out loud. (Pretesting had determined this to be sufficient time to perform this task, and no subject experienced any difficulty with this time constraint.)

In the two practice task series, all words presented were carefully chosen to be neutral in their implications for personality: No trait adjectives or other words were used that could be used to describe someone's personality. Examples of these practice, four-word groups are "write the mail letter," and "heavy it green is." In the experimental task series, the frequent trait word or one of three synonyms appeared as one of the four words in the 3rd, 7th, 12th, and 15th trials. The recent trait word was presented in the 20th and final trial. Examples of these critical four-word groups are "you unconventional are quiet," and "children older bold become." The trait word always appeared as one of the first three words (reading from left to right) in the four-word group. This was so that subjects would not fail to read a priming adjective due to constructing a sentence from the first three words. The synonyms used for each trait word were as follows:

Adventurous: bold, courageous, brave
Reckless: careless, foolhardy, rash
Persistent: determined, persevering, steadfast
Stubborn: unreasonable, obstinate, headstrong
Independent: free, unconventional, individualistic
Aloof: unneighborly, distant, unsociable

Interference task. After the final word group had been presented, the display immediately presented the instructions for the interference task, the second task in the series. The subject was instructed to count backwards as fast as he or she could, beginning with a given number and by a certain unit. The beginning number and the unit size were given in the instructions each time. The subject counted backwards from 368 by 3s in the first series, from 467 by 6s in the second series, and from 853 by 7s in the final series. Different and relatively large starting numbers and counting units were utilized in order to eliminate as much as possible any prior experience with counting backward or any practice effects carrying over from an earlier task series. This helped ensure that the interference task would completely clear memory each time. This procedure has been shown repeatedly to accomplish this objective in past studies (e.g., Brown, 1958; Peterson & Peterson, 1959; Reitman, 1974). The subject continued to count backward until the screen display instructed him or her to stop. In the short-delay condition, the interval was 15 s after the instructions to begin counting had been presented; in the long-delay condition, the interval was 120 s.

We chose these two delay lengths based on the following reasoning. Each of the alternative models would predict that the greatest advantage for the recently primed construct would occur with the shortest possible delay before stimulus presentation. With our procedure, the shortest possible delay was 15 s, as subjects had to read the number from which to count backward, had to read the counting unit, and then had to engage in the task for at least a modicum of time so that our cover story regarding various symbol-manipulation tasks would be taken seriously. Determination of the long delay length was more problematic. There is evidence that priming can last quite a long time with multiple priming of the same construct, apparently as long as 24 hr for 35 or more primes (Srull & Wyer, 1980). But when different constructs are being primed simultaneously and only a few times each, a situation that more closely resembles the present procedure, there is no evidence of priming effects lasting much longer than 10 min (cf. Forbach et al., 1974). We expected that this "effect window" would be attenuated further under the present procedure due to (a) the interference task (as it is meant to inhibit rehearsal), (b) the fact that alternative constructs for the same stimulus were primed (possibly speeding decay through mutual inhibition), and (c) the relatively low amount of priming (a maximum of 4 primes, compared with Srull & Wyer, 1980, who required 24 primes to obtain strong priming effects with a 1-hr delay). Therefore, a long delay of 2 min was implemented in order to provide a period that was both long enough for frequency effects to occur and was within the boundary conditions of priming effects given our procedure. It should also be noted that the counting-backward task becomes less effective in maintaining subjects' attention after about 3 min, so that our 2-min delay made sense for practical considerations as well.

Labeling task. In the third task of each series, which began immediately after the conclusion of the second task, the subject was given a brief, ambiguous description to read. In the first two task series, the description was of an animal, and the subject was instructed to write down the name of the type of animal, as quickly as she or he could. In the third series, an ambiguous description of a person was presented that had been demonstrated previously to elicit with approximately equal frequency both members of the adjective pair involved (Higgins et al., 1977). The subject was told to write down the one word that best described the person. The descriptions presented to the subject in each adjective-pair condition were as follows:

Adventurous/Reckless: He has risked injury, and even death, a number of times. Now he is in search of new excitement. He is thinking, perhaps, he will do some skydiving or maybe cross the Atlantic in a sailboat.

Persistent/Stubborn: Once he makes up his mind to do something, it is as good as done no matter how long it might take or how difficult the going might be. Only rarely does he change his mind even when it might well have been better if he had.

Table 2
Mean Categorization of the Stimulus Information

Type of priming	Postpriming delay: Brief	Long
Positive frequency/negative recency	3.1	3.4
Negative frequency/positive recency	4.8	2.9

Note. The higher the score, the closer a categorization was in meaning to the positive alternative construct.

Independent/Aloof: Other than business engagements, his contacts with people are rather limited. He feels he doesn't really need to rely on anyone.

In all three versions of this task, the subject immediately pressed the response button after writing down the one-word label.

At the conclusion of the third series of tasks, all subjects were informed that it would be helpful to the experimenter to know if they felt that their performance on any of the tasks had been influenced by any of the other tasks. As an example of what was meant, the experimenter suggested that the sentence-forming task or the counting-backward task might have influenced their performance on the labeling task that followed. Only 3 subjects responded to this line of questioning by reporting that the words in the sentence-forming task were related to the description presented in the third task, but even these subjects did not guess the hypothesis being tested in the study. These subjects were replaced in the design, and their responses were not included in any of the analyses. The remaining subjects did not report noticing the trait words in the sentence-forming task and did not feel that any of the words in that task had influenced the label they used in the third task. As a check on their memory for the priming words, all subjects were next asked to write down all of the sentences they had formed in the sentence-formation task. The experimental procedures and purpose then were explained fully to each subject, and he or she was thanked for participating in the study.

Results and Discussion

As discussed earlier, alternative models of priming effects make different predictions concerning the relative advantage of recent versus frequent priming on subsequent categorization of stimulus information as a function of the delay between final priming and stimulus presentation. The storage bin model predicts an advantage of the recent construct after both delay periods. The battery model predicts that whichever construct has the advantage after a brief delay will also have the advantage after a long delay. The synapse model predicts that the recent construct will have the advantage after a brief delay, but the frequent construct will have the advantage after a long delay. To test these alternative predictions, subjects' categorizations of the stimulus information were first scored by two independent coders (blind to experimental condition) with respect to their similarity in meaning to either the positive or the negative alternative construct that could be used to characterize the stimulus information. The categorizations were scored on a 6-point scale ranging from *same as negative alternative construct* (1) to *same as positive alternative construct* (6). The agreement between the coders was very high, $r = .94$, and so the coders' scores for each categorization were averaged together to yield the final scores. A Type of Priming (positive frequency/negative recency; negative frequency/positive recency) × Postpriming Delay (brief; long) × Type of Stimulus Description (adventurous/reckless; persistent/stubborn; independent/aloof) between-subjects analysis of variance (ANOVA) then was performed on these scores. As shown in Table 2, subjects' categorizations of the stimulus information reflected the recent construct more than the frequent construct after the brief delay but reflected the frequent construct more than the recent construct after the long delay, $F(1, 48) = 4.84$, $p < .05$.

An additional analysis then was carried out to compare the number of subjects in each delay condition who clearly used the recent construct to categorize the stimulus information with those who clearly used the frequent construct. First, categorizations receiving a score between 1 and 2.5 were classified as clear reflections of the negative prime; categorizations receiving a score between 4.5 and 6 were classified as clear reflections of the positive prime, and categorizations receiving a score greater than 2.5 but less than 4.5 were classified as ambiguous. We then determined, for each delay period separately, how many subjects clearly categorized the stimulus information in terms of the positive or negative frequent construct, how many subjects clearly categorized the stimulus information in terms of the positive or negative recent construct, and how many subjects categorized the stimulus information in an ambiguous manner. As shown in Table 3, after the brief delay, most subjects used the recent construct to categorize the stimulus information, whereas after the long delay, most subjects used the frequent construct to categorize the stimulus information, $\chi^2(N = 60) = 6.79$, $p < .05$, two-tailed.

These results are consistent with the prediction of the synapse model of priming effects and do not support the predictions of either the storage bin model or the battery model. It should also be noted that the same pattern of recency–frequency reversal as a function of delay was found for each of the three different stimulus descriptions. Thus, the Type of Priming × Postpriming Delay interaction was independent of type of stimulus description ($F < 1$). The probability of obtaining this exact pattern (i.e., recency greater than frequency after a brief delay and frequency greater than recency after a long delay) for all three stimulus descriptions is only .016 (i.e., $p = [½ \times ½]^3$).

Memory of the Primes and its Relation to Categorization

If subjects' categorizations of the stimulus information were influenced by the primes they remembered seeing in the priming task, then there should be a relation between their categorizations and their memory of the primes. To test this possibility, an additional Type of Priming × Postpriming Delay × Type of Stimulus Description × Memory for Frequent Primes (0 vs. 1 or more correctly recalled) × Memory for Recent Prime (0 vs. 1 correctly recalled) ANOVA was performed on the categorization data. The Type of Priming × Postpriming Delay interaction was independent of memory for frequent primes ($F < 1$), and the interaction with memory for recent prime was not significant ($p > .10$). The reversal in categorization as a function of delay and type of priming depicted in Table 2 was, if anything, even stronger among those subjects who did not remember the recent prime, so that memory for the recent prime was clearly not responsible for the interaction. In fact, an ANOVA of the categorization data for only those 28 subjects who did not remember any primes (frequent or recent) found that not only was the recency–frequency reversal still reliable despite the much smaller sample size, $F(1, 24) = 7.78$, $p = .01$, but it was even more dramatic than for the total sample (brief delay: positive frequent/negative recent, $M = 2.8$; negative frequent/positive recent, $M = 4.5$; long delay: positive frequent/negative recent, $M = 3.9$; negative frequent/positive recent, $M = 1.6$). Moreover, the correlation between use of the primed construct (as measured by the coders' 6-point scale ratings) and memory for the primes was nonsignificant for both the frequent primes ($r = .13$, $p > .25$) and the recent prime ($r = .16$, $p > .25$). Finally, it is not at all clear how a memory for primes interpretation could predict both the advantage of the recent prime after a brief delay but not the advantage of the frequent primes after a long delay, given that reliably more frequent primes were remembered than recent primes after both the brief delay (frequent, $M = .43$; recent, $M = .20$) and the long delay (frequent, $M = .47$; recent, $M = .23$; overall $t[59] = 2.59$, $p = .01$, two-tailed) and that memory for the primes was generally poor (overall, only 13% were remembered). It should be noted that although the mean numbers of frequent and recent primes remembered in the long-delay condition were greater than in the short-delay condition, these differences were small and unreliable (both $ps > .50$).

Table 3
Number of Subjects Using the Recent, Frequent, or an Ambiguous Construct to Categorize the Stimulus Information as a Function of Postpriming Delay

Type of categorization	Postpriming delay: Brief	Long
Recent construct	21 (70%)	11 (37%)
Ambiguous construct	1 (3%)	3 (10%)
Frequent construct	8 (27%)	16 (53%)

Note. Numbers in parentheses represent percentages of total subjects in each delay condition.

General Discussion and Conclusions

The results of this study indicate that when alternative constructs for characterizing an ambiguous stimulus are both made accessible by being either frequently or most recently primed, people will categorize the stimulus in terms of the most recently primed construct if the stimulus appears almost immediately after final priming, but they will categorize the stimulus in terms of the frequently primed construct if there is sufficient delay between final priming and stimulus presentation. This finding of a recency–frequency reversal over time is consistent with the synapse model of priming effects. This model proposes that there is a fixed, maximum level of action potential or accessibility that a construct reaches after being primed, that the level of action potential slowly dissipates over time, and that the rate of dissipation is slower the more frequently the construct has been primed (i.e., binary level of activation and nonuniform decay function that varies with length of activation). Thus, when there is a delay between the final priming of the frequent construct and the priming of the recent construct, the frequent construct will necessarily be at a lower level of action potential than the recent construct immediately after the recent construct is primed. But after a sufficient delay, the frequent construct will be at a higher level of action potential than the recent construct, given its slower rate of dissipation. The results do not support either the storage bin model (where frequency effects are interpreted in terms of recency effects) or the battery model (where the decay function varies with level of activation) of priming effects because both models predict that whichever construct has the advantage after a brief delay will also have the advantage after a long delay.

Although the results of the present study are consistent with the synapse model and are not consistent with the battery model, these are not the only two possible kinds of excitation transmission models. In fact, it is evident in Table 1 that alternative, possible models could be constructed from other combinations of assumptions with respect to level of activation and decay function. Could any of these alternative possible models account for our findings? First, one could combine a binary level of activation and a uniform decay function. This model (whether a constant or a nonconstant decay function is assumed) would predict that the recent construct would predominate over the frequent construct at both delay periods because they begin at the same level of activation, but the frequent construct starts to decay sooner. This kind of model, then, could not account for our findings. Thus, if one assumes that level of activation is binary, then one must also assume a nonuniform decay function that varies with the length of activation (as in the synapse model) in order to account for the results. Second, one could combine a continuous level of activation and a uniform, constant decay function (see Marcel & Forrin, 1974). This model (whether a constant rate or a constant amount of decay is assumed) would predict that whichever construct predominates at the brief delay would also predominate at the long delay, because their relative positions could not change if they decay at the same rate or the same amount per unit time (although the difference between them may decrease over time). Thus, this model also cannot account for our findings.

There are two additional possible models that can account for our results. The first would involve combining a continuous level of activation and a nonuniform decay function that varies with length of activation. This model would be a synapse model without the constraint of assuming a binary level of activation and might be called a *cell* or *cell assembly* model (see Hebb, 1949). The present study was not designed to distinguish between these two alternatives, but the synapse model at this point has the advantage of simplicity. The remaining alternative model differs more radically from the synapse model. This model combines a continuous level of activation and a uniform, nonconstant decay function, and like the battery model, would also be consistent with Wyer and Carlston's (1979) general discussion of the parameters of priming effects. If the frequent construct began at a higher level of activation, the decay function did not vary systematically with level of activation, and the rate of decay decreased over time, then the recent construct could predominate at the brief delay, and the frequent construct could predominate at the long delay.

The design of the present study does not permit a test between the synapse model and these two competing alternatives. The common difference between the alternatives and the synapse model is their assumption of a continuous level of activation, as opposed to the binary level of activation assumed by the synapse model. Assumptions concerning level of activation were not critically examined in the present study but will be in future studies. One possibility would be to vary both the frequency of the frequent construct (e.g., 2, 4, or 6 primes) and the delay between the final priming of the frequent construct and the priming of the recent construct (5 s, 30 s, 1 min, 2 min), with stimulus presentation occurring soon after the recent prime. With respect to the predominance of the frequent construct, the synapse model would predict little advantage of increased frequency at the shortest delay period (given the assumption of a binary level of activation) but would predict an increasing advantage of frequency with increasing interprime delay (at least until the decay functions reached asymptote). In contrast, the alternative models would predict a clear advantage of increased frequency at the shortest delay period (given the assumption of a continuous level of activation), and for the uniform, nonconstant alnative model at least, the advantage of increased frequency would remain constant or would decrease over time.

In addition to these alternative, excitation transmission models, there is another type of model that needs to be considered as a possible explanation of our results. There is evidence in the memory literature that recent items in a list are recalled better than earlier items after little or no delay, whereas earlier items are recalled better than recent items after a long delay (see Glanzer, 1972). There is also evidence that massed repetitions are superior to spaced repetitions after short retention intervals, whereas spaced repetitions are superior to massed repetitions after long retention intervals (see Bjork, 1970). In the present study, the priming of the frequent construct involved earlier and spaced repetitions relative to the priming of the recent construct. This suggests that our results possibly could be interpreted in terms of memory for the priming events and that the effect of the frequent priming might have been due simply to its primacy. Such an explanation would be qualitatively different from those we have considered thus far. The storage bin and excitation transmission models all involve assumptions about how priming influences some feature of the primed construct that is stored in conceptual or semantic memory (i.e., the arrangement of its component parts or its excitation level). In contrast, this *memory for primes* model involves assumptions about the acquisition, retention, and retrieval of traces of the priming events themselves in episodic memory (see Tulving, 1972; Wickelgren, 1973).

The results of the present study, however, do not support this alternative type of model. The critical assumption underlying this explanation is that the more primes of a construct that are recalled, the more likely it is that the construct will be used to categorize the stimulus. And, following this assumption, one would expect that the stimulus would tend to be categorized in terms of whichever construct had more of its primes recalled. But more primes were recalled for the frequent construct than for the recent construct after both the long delay and the brief delay. Based on that finding, the memory for primes model should predict that the frequent construct would predominate (i.e., would be used to categorize the stimulus) after both delay periods. More generally, there was no evidence in our study for any relation between memory for primes and categorization of the stimulus. Thus, just as recency and frequency effects in impression formation are independent of memory for the specific traits contained in the original stimulus list (see Anderson & Hubert, 1963; Dreben, Fiske, & Hastie, 1979), the effects of recent and frequent priming on categorization appear to be independent of memory for the priming events themselves. Indeed, as described earlier, the size of the recency–frequency reversal over time was increased considerably when the data of subjects who recalled one or more primes were excluded from the analysis. This suggests that recall of the primes in episodic memory, if anything, interfered with the effects of priming the competing constructs in conceptual memory.

The recall results also indicated that memory for the primes was quite poor. Higgins et al. (1977) also found that verbal priming significantly affected subjects' subsequent categorizations of stimulus descriptions even though their recall of the priming words themselves was relatively low. Bargh and Pietromonaco (1982), in fact, obtained priming effects on categorization even though their subjects were never aware of the presence of the priming words, much less had any memory of them. This phenomenon can be understood in terms of Tulving's (1972) distinction between *semantic* memory, where general construct information is stored, and *episodic* memory, where particular experiences of specific events are stored. Priming can increase the accessibility of constructs stored in conceptual memory, thus increasing the likelihood of their utilization in subsequent stimulus processing, without the actual experience of exposure to the prime (i.e., the priming event itself) being retained in episodic memory. In fact, it is this property of priming that makes it an especially useful technique for investigating the impact of construct accessibility on stimulus processing, because it makes it possible to manipulate the accessibility of different constructs without the risk of producing experimental demand effects. (see Higgins & Chaires, 1980, for other arguments against a demand effect interpretation of priming effects.)

Our discussion thus far has focused on how the results from the present study can be accounted for by various models. Of course, the alternative models proposed must account for the results of previous studies as well. We began this article with a description of the general effects of priming on categorization that have been documented, and we discussed how each of the alternative priming models could explain these results. There are other results, however, that need to be accounted for. In particular, there is Srull and Wyer's (1979) finding that frequency effects (i.e., stronger priming effects on categorization with more frequent priming) decreased as the delay between priming and stimulus presentation increased (i.e., from no delay to 1-hr delay to 24-hr delay). How would our proposed synapse model account for this finding? Srull and Wyer (1979) employed the unrelated studies paradigm, which requires the subject to move to a different experimental room and begin what he or she believes to be a different experiment. As a consequence, their no delay condition actually involved at least a 5-min delay between final priming and stimulus presentation, which is longer than our long-delay condition, where the predominance of the frequent construct over the recent construct was found. Given the high priming frequency used in Srull and Wyer's (1979) study (6, 12, 24, and 48 primes), it is quite possible that the effect of different priming frequencies on reducing the rate of decay (as would be predicted by the synapse model) might have been maximal at this delay period. After an hour delay, however, the decay function of each priming frequency would likely approach asymptote, which would reduce the frequency effect. Thus, given the actual delay periods involved in the Srull and Wyer (1979) study, the synapse model can account for the decreasing effect of frequency with increasing delay.

To conclude, the results of the present study demonstrate that even though subjects had two competing constructs primed prior to presentation of the same stimulus information, different subjects categorized the stimulus information differently, depending on which construct was frequently versus recently primed and depending on how soon after final priming the stimulus information appeared. Thus, momentary, and even accidental, contextual factors can have a considerable influence on how people categorize stimulus information.

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