The role of category information in word identification: A parallel decision model

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Four experiments consider the role of semantic category information in word identification using a serial classification reaction time paradigm. Experimental variables were manipulated by varying the semantic properties of blocks of trials and the target search instructions. Experiments 1, 2, and 3 investigated the facilitation on target word recognition of manipulating the categorical homogeneity of the nontarget words. An homogeneous nontarget set facilitated the classification of unrelated target words. This category contrast effect was obtained in all conditions, although its magnitude depended upon target search instructions. Experiment 3 also investigated whether word identification was inhibited if subjects were prevented from utilizing the category information to distinguish target from nontarget words. Target and nontarget word identification was slower under such conditions. Experiment 4 demonstrated that both the category contrast and category interference effects were dependent upon the use of short response-stimulus intervals to define a functional semantic background. This suggests the category effects are perceptual in nature. Current models of word recognition cannot easily explain the findings. A committee decision model is outlined to accommodate the data; the model proposes that visual analysis, identification, and categorization proceed in parallel.

This paper is concerned with the role of categorical information processing in the identification of visually presented words. More specifically, it is addressed to the question of whether or not word identification is a necessary and prior stage in semantic categorization. If it could be shown that higher order information relating to a word's semantic category is available to the decision machinery before complete or explicit identification has occurred, this would falsify those classes of word recognition models that propose that word categorization is dependent upon its prior identification.

If some category-level processing of words occurs before word identification is completed, a number of experimental hypotheses should be confirmed. First, when category information cannot logically be utilized in the decision processes (e.g., when the category information does not discriminate between alternative response choices in a word classification task), discriminatory decisions should take longer and be more error prone (a category interference effect). Second, the more discriminatory the semantic category information, in relation to the decisions being made, the greater should be the facilitatory effect of category-level processing on word recognition (a category contrast effect). Pre-

vious attempts to demonstrate categorical facilitation of word recognition have concentrated on associative or semantic priming. Meyer, Schvaneveldt, and Ruddy (e.g., 1975), for example, have shown that lexical decision times to the second of two words is shorter when the first is a semantic associate of the second. The hypothesized category contrast effect is logically distinct from this inasmuch as it posits that categorical facilitation is nonassociative in origin. The semantic difference between different categories, not the semantic similarity of words from the same category, would be responsible for any facilitation observed in word recognition. Third, if category-level processing occurs prior to specific word identification, decisions that require processing only to the word identity level should be influenced by the category interference and contrast effects.

A number of investigators have shown that if stimulus categories are well learned (e.g., letters and digits), a categorical difference between the target items being searched for and all the other items constituting the background or nontarget set facilitates processing (see Fletcher, 1981a, for a review). It has also been suggested (Fletcher, 1981a; Taylor, 1978) that identification and categorization can be considered separable and independent processes, both of which are functional in perception and decision making. Alphanumeric category effects, however, cannot unambiguously be attributed to conceptual category differences. Word recognition experiments offer one vehicle for excluding physical feature explanations that may be applied to alphanumeric effects: it seems unlikely that words from any specific semantic category could share common physical

The work was done while the author was at the Department of Experimental Psychology, Oxford University, supported by the Medical Research Council. The contribution of P. M. A. Rabbitt was invaluable. The particularly helpful comments of an anonymous reviewer are also acknowledged. Experiment 3 of this paper was presented to the Experimental Psychology Society in April 1976. The work formed a substantial component of a paper presented at the annual conference of the British Psychological Society, April 1982.

features adequate to discriminate them from words of different categories.

It is a truism to say that semantic variables differentiate between words. The categorical relationship between words is one distinguishing variable. The taxonomic structure of word-unit representations in semantic memory has attracted a large amount of investigation (e.g., Collins & Loftus, 1975). Current models of word recognition, however, assume that semantic categorical information is derived postidentification, that is, that it plays no part in the perceptual information processing. Some models (e.g., Becker, 1980; Rumelhart, 1977; Rumelhart & McClelland, *in press*) posit semantic mechanisms that facilitate the perceptual identification of words, but these require the prior activation of the semantic information derived via contextual constraints [e.g., by semantic priming of lexical decisions (Meyer et al., 1975) or sentence context primes (Schubert & Eimas, 1977)].

Semantic category information may play a central role in word recognition even when identification is not specifically primed by prior contextual factors. This is particularly important when one considers alternative conceptualizations from the serial stage models that have played a dominant role in the representation of stimulus processing. McClelland's (1979) cascade model, for example, explicitly characterizes the outputs of each subprocess as being continuous rather than discrete. It becomes sensible to talk of stimuli as being more or less identified, or more or less categorized at any point in time. Higher order information can be extracted from the stimulus before the processing at lower levels is complete. Thus, information about a word's semantic category may, logically, be able to facilitate processing even though the identification or categorization processes have not terminated.

This paper is concerned with the functional value of category processing in word recognition. In particular, it investigates the relationship between word identification and semantic categorization in decision processes involved in the recognition of words that are not primed by the prior presentation of semantic associates (as, for example, in Meyer et al., 1975; see Henderson, 1982, for a full discussion of associative priming). Specifically the experimental manipulations provide a test for the presence, and some of the parameters, of the hypothesized category interference and category contrast effects.

A number of experimental studies have investigated the "early category processing" view. The results do not provide a clear picture of the role of categorical information in the word recognition process. Karlin and Bower (1976), for example, obtained only modest category interference effects under conditions that maximized the likelihood of subjects utilizing categorical information. Subjects searched for specified target words in arrays of words from the same category as the target

(within category search), or in arrays that contained words of a single category different from the target category (between category search). They found that with a single specified target word, RT varied with display size but was unaffected by the semantic relationship between the target and nontarget items. With multiple target sets (in which the target could be one of three or six words), however, the slope was flatter in the between-category condition, suggesting that memory load affects whether subjects process the category of the words and that identification is normally the prior terminating process.

Karlin and Bowers' (1976) failure to obtain the category interference effect with a single target word does undermine the view that category information is normally available prior to identification. However, several methodological points should be noted. Subjects were afforded every opportunity to learn and use critical physical cues to discriminate between the stimulus words without even having to identify them as word units. The target-background semantic relationship remained constant for large blocks of trials; words were printed in lowercase print, and word length was not held constant. When the physical cues between target and background items are controlled, the category interference effect obtains with a single target word in a visual search paradigm (Henderson & Chard, 1978).

Schaeffer and Wallace (1970) also report a category interference effect using a serial word comparison task. They observed that semantic similarity interfered with the judgment that two words had different meanings (i.e., identities). No semantic interference was found when subjects had only to respond on the basis of superordinate meaning. This is consistent with the suggestion that high-level semantic (category) information is available and instrumental in identity-level decisions.

There are a number of studies that support the contention that preidentification category processing facilitates word identification. Two experimental effects are of relevance. First, target word search is facilitated if the nontarget items form a semantically homogeneous set from a different category to the target, relative to the case in which the nontarget words are categorically heterogeneous (Henderson & Chard, 1978). Second, it has been shown that successful prime-word identification is not necessary for the associative priming effect to occur in lexical decision tasks (Fischler & Goodman, 1978). Allport (1977) reports that when a target word was presented together with an unexpected distractor word displaced parafoveally, semantic association between the words facilitated reportability of the targets, even though no subjects reported being aware of the distractors.

Perhaps the most intriguing experiments suggesting that semantic priming proceeds independently of explicit identification of the prime and that nonspecific category-level information can facilitate word recognition come

from Marcel (in press; Marcel & Patterson, 1977). He reports that the size of the semantic priming effect is unaffected by a pattern mask presented after the priming word, which reduces its detectability to a chance performance level (by critically reducing the stimulus onset asynchrony). Moreover, repeating a specific word-mask combination up to 20 times increases the associative priming effect but does not alter reportability of the premask word. The most remarkable finding, however, is that if a single word or a blank card is pattern masked and the duration of the field preceding the mask is gradually reduced, subjects who were reporting only stimulus presence/absence or were making graphic similarity judgments at a chance level were nonetheless able to make semantic judgments about the word at a better than chance level. This suggests that access to semantic information did not require conscious knowledge about the identity of a word.

None of these studies unambiguously demonstrate that preidentification category information facilitates word recognition. Henderson and Chard's (1978) non-associative category facilitation effect (i.e., the superior performance in the semantically homogeneous conditions) can be reinterpreted as an associative priming effect. Their visual search technique does not allow one to tell whether target word identification benefited from the category contrast between target and background words or whether it was due entirely to faster nontarget processing resulting from associative priming. In fact, their failure to obtain a slope or intercept difference between the homogeneous and heterogeneous nontarget conditions when display size was varied suggests the absence of such a category effect on target identification. The priming studies do suggest that semantic facilitation can occur without primes being consciously identified. However, they do not demonstrate that the primes have not been unconsciously identified. Given that the prime and test words are from the same category, the facilitation may be caused by a lowering of the response threshold of the test word. This could be due to persisting activation of some of the processing pathways common to both words (Meyer et al., 1975) or to some other mechanism that operates on the decision mechanisms to reduce stimulus entropy and therefore response choice (Schvaneveldt & McDonald, 1981).

The experiments below consider whether any category processing occurs prior to word identification in conditions that do not categorically prime word recognition. Category processing can be demonstrated in two ways. First, if subjects cannot logically utilize category-level information to facilitate word identification, identification should take longer even with single-word displays and with single specified target words. Second, presenting target words in a background of categorically homogeneous words, unrelated to the targets, may facilitate target identification if the categorical difference between the target and nontargets increases the

informational value of category-level processing in word recognition.

The experiments required subjects to perform a simple two-choice classification task in which the words were presented singly and successively and the semantic relationship between the specified target words and the nontarget words was varied as a property of blocks of trials. Single successive presentation allows one to time the response to each stimulus. This provides not only target/nontarget RT comparisons, but also comparisons across conditions within each response class.

In Experiment 1, the target set was constant across conditions, although the semantic homogeneity of the nontarget words was varied. In one condition, all the nontarget words were from one semantic category, different from the target category. In the other, they were chosen from many different semantic categories. It was hypothesized that the categorical contrast between the targets and the nontarget words would result in processing facilitation in the semantically homogeneous condition and produce faster target word identification (any nontarget facilitation may be due to associative priming).

Such a category effect would be predicted by a model in which identification and categorization were considered parallel processes with multiple-response read-off from both processes. In the semantically homogeneous condition, the target words would be categorically distinct from the nontargets and the category-level information clearly discriminatory. Furthermore, this category contrast effect should increase as the number of preceding semantically homogeneous words is increased. No such facilitation is possible when nontarget words are semantically heterogeneous.

Experiment 2 extends the inquiry of the first experiment by varying the nature of the target search across the two nontarget conditions to determine how this affects the identification of target and nontarget words. It also considers whether explicit word identification is faster than explicit semantic categorization.

Experiment 3 included a condition in which the single target word and the nontargets were from a single semantic category. Thus, subjects were prevented from using any category information to discriminate target from nontarget words. If categorical analysis does proceed before identification is complete and usually facilitates identification, removing any category-level distinctiveness should result in slower nontarget and target response latencies.

Experiment 4 investigated whether or not the semantic effects observed in the previous experiments were sensitive to the temporal dependencies between successive words. Since stimulus repetition effects in serial choice RT tasks are usually interpreted as being perceptual in nature (see Fletcher, 1981b), this would support the view that it is the encoding stage or perceptual interrogation of the stimulus words that is affected by the semantic manipulations.

EXPERIMENT 1

Method

Subjects. Five male and five female students from the Oxford Department of Psychology's subject panel served as paid volunteer subjects in a single 60-min session. They were aged 18-25 years.

Design and Materials. The experiment was a totally within-conditions design. The subjects' task was to search through a list of serially presented words for exemplars of a predefined target category, responding to each word with a keypress. There were two conditions, a run of each being presented 15 times.

The nature of the nontarget words constituted the difference between the conditions: (1) In the contrast condition, all the nontarget words were exemplars of a single semantic category, different from the target category. (2) In the random condition, the nontarget words were chosen, on a random basis, from the whole population of nouns, excluding those of the target category. All the words were from the Battig and Montague (1969) category norms. An attempt was made to control for word length and commonness of occurrence between the conditions. The majority were four to seven letters long, with a response frequency of not less than 9 in the category norms. Care was taken to match the two conditions for word frequency by cross-consulting Kučera and Francis (1967).

A session consisted of 15 blocks, each containing one run of the two conditions. In a block, the target category was held constant, although the actual target exemplars were different in the two conditions. The target exemplars in one condition for the first five subjects were used as the target exemplars in the other condition for the remaining subjects.

A run consisted of a maximum of 36 words, of which 34 were nontargets (17 words presented twice) and 2 were different target words. Since the nontarget words in the contrast condition were chosen from one of five different semantic categories (parts of the body, four-footed animals, countries, bird names, chemical elements), each word was in a contrast list three times, although the word lists were changed for each presentation of the nontarget category. The same presentation constraints were used in the random condition. Thus, all nontarget words were sampled equally frequently. Each target word occurred only once in a session. They were chosen from five different semantic categories (flower names, musical instruments, fruits, male first names, furniture items).

A Digital Equipment Corporation (DEC) LINC-8 computer was programmed to provide the two task conditions in a two-choice serial classification RT paradigm. The computer also generated, from a preprogrammed pseudorandom sequence, the order in which the blocks were presented and the order of presentation of the words within a run. These were randomized for each subject.

The words were composed of uppercase letters from the standard DEC 6 by 4 matrix character set (examples of which can be seen in Fletcher & Rabbitt, 1978) averaging 2.5 mm in width and 3 mm in height. They appeared singly in the center of a 20 x 15 cm cathode-ray tube display (coated in P11 phosphor that decays to 10% in 80 microsec). The words were viewed from a distance of 50 cm through a viewing tube with a forehead rest. Subjects responded to each word by pressing one of two keys inset in a desk beneath their two forefingers. As soon as either key was pressed, the current word was removed from the screen and the next word in the pseudorandom sequence appeared after a fixed response-stimulus interval of 300 msec.

Procedure. The subject was allowed to dark adapt for approximately 10 min, during which the nature of the task was described and four practice runs were given.

At the beginning of each block, subjects were verbally told the target category. They were instructed to search through the words and to classify them as either targets or nontargets by

pressing the appropriately labeled response key. The run was terminated after the second target item had been presented. Each run was preceded by a "READY" signal, which also acted as a fixation point, and ended with an "END OF RUN" display. Subjects were asked to work as fast as possible without making any errors. It was emphasized that there were very few target words.

The subjects were not given any information about the nature of the background items they would experience in any run. Thus it would take them several trials before they could discover whether the nontargets were categorically homogeneous or not.

Results and Discussion

The mean correct RTs to target and nontarget words in each condition were analyzed. Error responses and those immediately following them were excluded. The results are given in Table 1.

The data were subjected to a four-way ANOVA (subjects treated as a random factor). The ANOVA revealed that RTs became faster as practice progressed [the session was split into 3 by 5 blocks, $F(2,9) = 23.1$, $p < .005$]. Response latencies to target items were some 155 msec longer than to nontarget words [$F(1,9) = 11.3$, $p < .01$]. In view of the unequal response probabilities of these response types, little of significance can be interpreted from this difference. The conditions factor (contrast vs. random) was also highly significant [$F(1,9) = 15.9$, $p < .005$]. RTs were some 30 msec shorter in the contrast condition compared to the random condition. More important, however, there was no interaction between response type (target and nontarget) and conditions ($F > 1$). No interaction approached significance.

Thus, the time to recognize a target word as an exemplar of the target category and the time to classify the nontarget words was affected by the semantic homogeneity of the nontarget words. Words are accepted as targets faster and rejected as nontargets faster if the nontarget items are drawn from one other semantic category than if they are drawn from the population of nouns.

Table 1
Mean Correct Reaction Times (in Milliseconds) to Target and Nontarget Words in Conditions Same, Contrast, and Random in Experiments 1, 3, and 4

Condition	Same		Contrast		Random	
	Mean	SD	Mean	SD	Mean	SD
Experiment 1						
Targets			611	110	647	100
Nontargets			462	104	486	104
Experiment 3						
Targets	502	59	458	51	473	69
Nontargets	426	94	406	90	409	90
Experiment 4						
Targets	535	107	541	94	530	96
Nontargets	479	92	481	92	486	93

It has been suggested that such facilitation is due to the "categorical contrast" that could occur in the contrast but not the random condition. A direct test of this hypothesis is possible. If target latency is facilitated by category contrast, the greater the number of items from a single category preceding the target word, the greater should be the facilitation. In each run, there were two presentations of exemplars from the target category. Table 2 presents the mean RTs to the first and second occurrences of the target words for both conditions, together with the mean position in the runs of each target word.

It can be seen from Table 2 that mean run position of the target words was controlled across the two conditions. Two points should be noted. First, target RTs are faster in the contrast condition for both the first and second presentations. Second, the RT for the second target word is significantly shorter than the first in the contrast condition (36 msec), but not in the random condition (5 msec). The more semantically homogeneous the nontarget words, the greater the category contrast. Both of these points are substantiated by a three-way ANOVA. The conditions factor was significant [$F(1,9) = 49.5$, $p < .0005$], as was the target occurrence factor (first or second) [$F(1,9) = 13.9$, $p < .005$] and the interaction between them [$F(1,9) = 6.2$, $p < .05$].

Each nontarget word was presented twice in both conditions. On successive trials, therefore, the same nontarget word could be repeated. In choice RT tasks, identical repetition transitions result in smaller RTs to the repeated stimulus. Repetition of semantic information also produces shorter response latencies (Rabbitt & Vyas, 1973). We have seen that nontarget semantic homogeneity can facilitate target word classification. If this facilitation is a result of the earlier availability of category information relative to identity information in the contrast condition, the repetition of a specific nontarget word (i.e., the repetition of both identity and category) should have a smaller facilitation on RTs in the contrast condition. The effect on RT of repeating words was calculated for both conditions.

In the contrast condition, this repetition effect is some 32 msec, compared to 55 msec for the random condition. A t test on the size of the repetition effect in the two conditions proved significant [$t(9) = 5.17$,

$p < .01$]. Thus repeating a word facilitated RT to a greater degree in the random condition, in which, *ex hypothesi*, more identity-level information is processed in each decision.

An analysis of the data was performed to check that there were no differences in RT to each of the target and nontarget semantic categories. In the contrast condition, no nontarget category was associated with faster RTs than any other ($F < 1$). No target category produced significantly different response latencies, nor was there an interaction with condition (contrast vs. random) ($F < 1$), although, as we have already seen, target RTs were generally smaller in the contrast condition.

Errors accounted for only 1.1% of all responses. Almost all these, however, were incorrect rejections of target items. An ANOVA on these errors showed a significant difference between the conditions, there being twice as many errors in the random condition [$F(1,9) = 6.64$, $p < .05$].

EXPERIMENT 2

Experiment 1 demonstrated that semantic homogeneity of the nontarget set can facilitate target word recognition. The mechanisms responsible for the category contrast effect, however, require elaboration. One possible explanation is based on the assumption that categorization and identification are parallel independent processes with substantial overlap in the distribution of the processes (Fletcher, 1981a; Taylor, 1978). If the decision required by the task can be made on the basis of either of the terminating processes, conditions that favor category processing will result in faster decisions. The contrast condition may have been one in which increasing emphasis could be placed on the categorical analysis of the words.

This outline framework, however, raises a number of questions in connection with the previous experimental effects. Experiment 1 produced nonassociative categorical facilitation of target word classification. Does this imply that word categorization is a faster terminating process than word identification? The literature on the processing of alphanumeric characters would suggest not. It has been consistently found that explicit identification is faster than explicit categorization (Fletcher, 1981a). This is consistent with a parallel model. The question can be tested empirically. If subjects can classify words more quickly when targets are defined by exemplar than when they are categorically defined, and if the contrast effect is present at both levels, this suggests that categorization and identification proceed in parallel. Second, from Experiment 1, it was hypothesized that the additional category information present in the contrast condition facilitated the identification of words. This was supported by the smaller repetition effect found in the contrast condition. All the decisions in that experiment, however, required explicit category-

Table 2
Effect of Target Word Run Position on Target Reaction Time (in Milliseconds) in the Contrast and Random Conditions in Experiment 1

Condition	Contrast		Random	
	RT	RP	RT	RP
First Target Word	628	15.6	650	15.5
Second Target Word	592	26.1	645	26.4

Note—RP = mean run position.

level processing of words. It may be that target and nontarget facilitation occurs only when decisions are required at category level. If the nonprimed category-level processing of a word can facilitate its identification, the category contrast effect should also be present when subjects are not asked to explicitly categorize words but merely identify specified ones. This was investigated by requiring subjects to search for categorically defined target words, exemplar-specified words, or mixed-level targets (category and exemplar level) in both the contrast and random conditions.

Third, an alternative interpretation of the category contrast effect is that in the contrast condition, subjects were classifying the target words on the basis of their exclusion from the nontarget category (i.e., by first testing whether a presented word was a member of the nontarget category). Since subjects were not informed which condition they were going to do at any one time, one might expect that as it became obvious that they were doing the contrast condition, they would increasingly adopt this exclusion strategy as the number of trials increased (see Table 2). In the contrast condition, the nontarget category is successively associatively primed, and target classification decisions may be made more quickly in such circumstances. This explanation can be ruled out if it is found that variations in the size and semantic level of the target set affect both target and nontarget classification times additively or interactively. The "respond-to-targets-by-exclusion" strategy predicts that how the target words are specified should have no effect on nontarget word processing. Moreover, if target words are classified by exclusion, the semantic level to which the target word has to be processed (i.e., identity or category) should not affect target decision times. Thus, in Experiment 2, the effects of varying the nature of the target set is investigated.

If nonassociatively primed category processing produces the contrast effect on target RTs, one would hypothesize that the greater the amount of category-level processing required in a task, the greater the potential facilitatory contrast. Therefore, if decisions require explicit categorization of the words (as in category search), as opposed to exemplar-level analysis, they should require the extraction of a greater amount of categorical information and, therefore, show a greater contrast effect. Since there are many more nontarget words than targets in a run, only target word processing should be facilitated by category contrast. Therefore, when there is greater opportunity for categorical contrast (i.e., category search), the effect should be more marked for target than nontarget RTs.

The following experiment is addressed to each of these questions.

Method

Subjects. Seven males and three females, aged 20-31 years, from the subject panel served as paid volunteers in two 45-min

sessions on consecutive days, whenever possible. None had been used in the previous experiment. Each subject was tested individually.

Design and Materials. The experiment was a 3 by 2 by 2 within-subjects factorial design. There were three target search conditions, two response classifications (target, nontarget), and two nontarget conditions (contrast, random).

As in Experiment 1, the subjects' task was to search through a list of serially presented words for exemplars of the target search set.

The three target search conditions differed in terms of how the target words were defined prior to run: (1) Category search—Subjects were asked to search for exemplars of either of two categories X or Y (e.g., "Press the target key if the presented word is an 'animal name' or a 'musical instrument'"). They were given no indication of what the specific target words were. (2) Identity search—Subjects were asked to search for two specified exemplars of the X and Y categories (e.g., "the word 'lion' or the word 'violin'"). (3) Mixed-level search—Subjects search instructions were for a specified exemplar of Category X and any exemplar of Category Y (e.g., "the word 'lion' and any 'musical instrument'").

The two nontarget conditions were as in Experiment 1 (i.e., contrast and random), except for some minor changes. First, a different set of nontarget categories was sampled in the contrast condition (four-footed animals, males first names, musical instruments, food-flavoring substances, countries, parts of the body, vegetables, parts of buildings, colors, bird names, earth formations, items of furniture, occupations, articles of clothing, towns and cities of the U.K.). The towns and cities exemplars were obtained from 100 respondents using the same method as Battig and Montague (1969). All the other words were from their category norms. Second, instead of sampling the whole population of nouns in the random condition, only the word population used in the contrast condition was sampled. All nontarget words used in the contrast condition were also used in the random condition, with the proviso that not more than one exemplar from each category could be used. Although sampling constraints similar to those employed in Experiment 1 were adopted, this manipulation ensures that any differences in RT between the two nontarget conditions are due to semantic homogeneity and not to differences in the words used (e.g., letter length, word frequency, syllable length). No exemplars of either of the target categories could occur, unless they were the target words.

The experiment consisted of 60 runs, 30 of each nontarget condition (contrast and random). There were 10 runs of each target search condition (category, identity, and mixed level) for each nontarget condition. These were divided equally between the 2 days. Since 15 nontarget categories were used, each of these categories was sampled once for each contrast condition run on each day. On each day, the particular configuration of target categories was the same for one run of a contrast and a random condition. Although the same target words were used for each subject, they were used in different target search conditions and carefully balanced across the two nontarget conditions. A run consisted of the two different target words and a maximum of 10 different nontarget words, each presented twice.

The procedure adopted was similar to that used in Experiment 1.

Results and Discussion

The mean correct RTs to the target and nontarget words in each condition are shown in Table 3.

The mixed search target conditions allow a within-conditions analysis of the relative speed of word categorization and word identification search. A three-way ANOVA (target search instructions by nontarget condi-

Table 3
Mean Correct Reaction Times (in Milliseconds) to
Target and Nontarget Words in the Contrast and
Random Conditions Under Different Target
Search Instructions (Experiment 2)

	Target Search Instructions					
	Category Level		Mixed Level		Identity Level	
	C	R	C	R	C	R
Nontarget Condition						
Target Category Component	732	875	685	756		
Target Identity Component			592	660	537	563
Nontargets	695	776	645	685	473	515

Note—C = contrast; R = random.

tion by subjects) on the target RTs revealed that category search target words took significantly longer to classify than identity search words (721 msec vs. 626 msec) [$F(1,9) = 15.8$, $p < .005$]. The semantic homogeneity of the nontargets also significantly affected target RTs [$F(1,9) = 21.1$, $p < .005$], replicating the category contrast effect of Experiment 1. Response latencies were significantly faster in the contrast condition compared to the random condition (639 msec vs. 708 msec). There was, however, no interaction between these factors ($F < 1$). Categorically defined target words showed a facilitation of 71 msec and identity-defined targets, 68 msec.

A four-way ANOVA (target search instruction by nontarget condition by response type by subjects) was performed on the mean RTs to targets and nontargets in all conditions. (Since the previous ANOVA on the target RTs of the mixed-level search condition showed no indication of an interaction between nontarget condition and target search instructions, the mean RT to the category- and identity-level target words in that condition were entered into the ANOVA.)

The effect of nontarget semantic homogeneity was highly significant, replicating the finding of Experiment 1 [$F(1,9) = 93.0$, $p < .0005$]. Nontarget RTs were 44 msec faster than target RTs [$F(1,9) = 17.5$, $p < .005$]. Words presented in the contrast condition were classified some 67 msec faster than words presented in the random condition. Moreover, nontarget homogeneity facilitated target word processing by 79 msec and nontarget processing by only 54 msec. This interaction was statistically significant [$F(1,9) = 5.74$, $p < .05$]. Thus nonassociative priming of target items was more pronounced than the associative priming of nontarget items. This may be a function of response frequency.

Target search instructions had a marked effect on RT [$F(2,18) = 89.8$, $p < .0005$]. The mean RTs for the category, mixed-level, and identity search conditions were 770 msec, 669 msec, and 522 msec, respectively. Therefore, explicit categorization takes much longer than identification, despite the semantic categorical effects on word recognition observed. This is analogous to findings observed with alphanumeric characters

(Fletcher, 1981a). Although target search and response type interacted [$F(2,18) = 6.1$, $p < .01$], the time required to classify both target and nontarget words was affected by the nature of the target search instructions. The target RTs in the category, mixed-level, and identity search conditions were 804 msec, 674 msec, and 550 msec, respectively. This supports the view advanced earlier that the category contrast effect on target word processing is not an artifact of subjects responding to target words by exclusion from the nontarget category in the contrast condition. This is further supported by the absence of a three-way interaction among the main factors ($F < 1$).

It was hypothesized that the category contrast effect should be greater in those conditions that require a greater degree of explicit categorical processing. This was confirmed by the target search by nontarget condition interaction [$F(2,18) = 6.0$, $p < .01$]. RT facilitation in the contrast condition, compared to random condition, was 112 msec for category search, 55 msec for mixed-level search, and 34 msec for identity search instructions. The category contrast effect was statistically significant under identity search instructions ($p < .01$), indicating that even when categorical processing is not logically required by the task, category-level processing facilitates word identification.

One apparently inconsistent finding is the failure to obtain an interaction between nontarget condition and target search instructions within the mixed-level search condition. The category component shows a 71-msec facilitation and the identity component a 68-msec facilitation. The interaction between the target search conditions was significant. Target RTs showed a 143-msec facilitation under category search instructions and only 26 msec under identity search instructions. These inconsistencies can be reconciled, however, if it is postulated that the categorical component of the target set in the mixed-level search condition causes subjects to extract more categorical information from words whose target identity is specified by instruction. This interpretation is supported by two findings. First, the identity component RTs in the mixed-level search conditions are much longer than the RTs to the target words specified in the identity search conditions (626 msec vs. 550 msec). Second, the category contrast effect on target RTs is much greater for the identity component under mixed-level search instructions than for the target words in the identity search condition (68 msec vs. 26 msec). This is consistent with the primary hypothesis that the category contrast is greater in conditions in which more semantic categorical information is extracted from the words.

EXPERIMENT 3

The previous experiments have shown that category information plays an important role in word recognition, even in conditions in which subjects need only

identify the words presented. The evidence is consistent with a model of word recognition that proposes that categorical analysis proceeds simultaneously with, and independently of, the identification processes. It should be noted, however, that in both experiments, the target set was never less than two specifically identified words. Under most target search conditions, the target set contained a categorically defined component. This may have encouraged subjects to adopt a "categorization strategy" and to delay their response even though they had fully identified the stimulus word. Karlin and Bower (1976), for example, only obtained semantic category effects when multiple target sets were employed. They proposed that when subjects can confine their search to a single word, insufficient categorical information is extracted from the display to affect the decision process. To ensure that the category effects observed here are not a result of similar processes, the target search in Experiment 3 was confined to a single identified word.

Experiment 3 also investigated whether category interference effects would be present using the serial trials paradigm. The parallel model predicts that decisions that can be made only on the basis of the identification processes will take longer than those that can use either identity or category information. Therefore, if subjects are prevented from utilizing the early accumulating categorical information to facilitate word identification, decisions requiring identification should take longer. Experiment 3 includes a condition in which the single target word and the nontarget words were from the same semantic category. Thus, although the nontargets are semantically homogeneous, categorical information cannot serve to discriminate the target word from the nontargets (the category interference effect). According to the parallel model, response latencies to both target and nontarget words will be longer in the same condition than in either the contrast or random conditions. It is of particular interest to see if categorical similarity between the target and nontarget words results in larger RTs than in the random condition. If so, this would suggest that some category-level processing usually occurs and facilitates word identification, even in those cases in which successive words are not semantically homogeneous or categorically primed. This would suggest that it is only when subjects cannot logically utilize the category information in word identification that they do not.

It may be that categorical processing reduces the amount of visual feature analysis required to identify a word (i.e., an encoding facilitation). This was suggested by the transition analyses of Experiment 1. It would follow, therefore, that when category-level processing does not distinguish targets from nontargets, more feature extraction will occur. This prediction was tested in the following experiment by using some nontarget words that shared a common first letter with the target

word. The greater the amount of category information used to discriminate targets from nontargets, the smaller should be the interference effect reflected in the RTs to these nontarget words.

Method

Subjects. Five female and five male students, aged 19-23 years, served as paid volunteer subjects, each tested individually in a single 70-min session. None had served in the previous experiments.

Design and Materials. The experiment was of a simple within-subjects design with three different conditions. The nature of the nontarget items, and their semantic relationship with the target words, distinguished between the three conditions: In Condition 1, the "same" condition, the nontarget words were all exemplars of a single semantic category, the same as that from which the target word was drawn. Conditions 2 and 3, the contrast and random conditions, were the same as in Experiment 1, except that the target word identity was specified.

All the target words and the nontarget words for the same and contrast conditions were taken from eight of the Battig and Montague (1969) category norms (family relations, four-footed animals, colors, kitchen utensils, parts of the body, countries, flower names, food-flavoring substances). The nontarget words in the random condition were chosen from the other 48 categories. The words were equated with the other two conditions for commonness of occurrence and word and syllabic length. They were all high-frequency exemplars of between four and seven letters in length.

A session consisted of eight blocks, each composed of a run of each condition, making a total of 24 runs. A run was made up of 11 words (1 target, 10 nontargets), each presented a maximum of three times each. As soon as all the target words had occurred, the run was ended. Each target exemplar acted as the target item in each of the three conditions. The same nontarget words were used for each of the two semantically homogeneous conditions (i.e., same and contrast). Each nontarget set in the random condition was also presented twice in order to equalize the number of times each nontarget word occurred within a session. None of the target words used in a session was ever used as nontargets.

In the final block, two of the nontarget words in each run shared a common first letter with the specified target item.

The presentation orders of the blocks and of the conditions within the blocks were systematically balanced as far as possible to remove any order effects. The order of word presentation within a run was random.

Procedure. The procedure was similar to that in Experiment 1, except that prior to each run the target word was specifically identified (e.g., "The target word is 'LION'").

Results and Discussion

The mean correct RTs to target and nontarget words in each of the three conditions are given in Table 1. Errors and responses immediately following errors were not included in any analyses.

A three-way ANOVA, with subjects treated as a random factor by response type (target, nontarget) by condition (same, contrast, random), was performed on the RT data. The conditions factor was highly significant [$F(2,18) = 45.5$, $p < .0005$]. Tukey's *a* test for confounded means produced critical values of 8.8 msec ($p < .05$) and 11.5 msec ($p < .01$). The RTs to words in the "same" condition were larger than those in either the contrast or the random condition, although the

latter did not (quite) differ significantly (the means were 464.2 msec, 432.3 msec, and 440.9 msec, respectively). Thus, denying subjects the opportunity to utilize categorical information to facilitate word identification slowed response latencies to target and nontarget words by almost 30 msec.

Although there was no overall difference between the contrast and random conditions, the interaction of response type by condition was significant [$F(2,18) = 5.9$, $p < .025$]. A post hoc Tukey a test for unconfounded means produced critical values of 14.7 and 18.5 msec ($p < .05$ and $.01$). These can be used to compare the RTs of Experiment 3 in Table 1. Target and nontarget RTs in the "same" condition were larger than those in either the contrast or the random condition. The interference effect was greater for target RTs than for nontarget RTs (56 msec vs. 20 msec). It can be seen that although there was no difference in nontarget RT between the contrast and random conditions, nontarget semantic homogeneity significantly facilitated target RT. A separate ANOVA on the target RTs of the contrast and random conditions strengthened this conclusion [$F(1,9) = 21.4$, $p < .005$]. This confirms the findings of the two previous experiments and suggests that the category contrast effect occurs even when the target set is confined to a single specified word. Moreover, it confirms that the mechanisms responsible for target RT facilitation (nonassociative category priming) are distinct from those responsible for nontarget facilitation (associative priming?). In this experiment, nontarget homogeneity was found to have an effect on target word identification without facilitating nontarget word processing.

Nontarget response latencies were significantly faster than target RTs [$F(1,9) = 30.7$, $p < .0005$].

It is worth pointing out that the difference in RT between the "same" condition and the other two conditions was present when only the first nontarget trial in each run was analyzed. The means of the first nontarget RTs in each run for conditions same, contrast, and random were 717 msec, 658 msec, and 656 msec, respectively. An ANOVA confirmed that response latencies were slower in the "same" condition [$F(2,18) = 4.5$, $p < .05$]. The small, but significant, F ratio was due to the very variable RTs obtained to the first word in each run. This finding rules out any explanation of the slow identification times that suggests that response interference develops as the run progresses.

Table 4 presents the data for those trials in which two nontarget words within a run shared a common first letter with the target word. Each score was calculated by subtracting mean latencies to the critical nontarget words from the mean latencies to all the other nontarget items within that run. A two-way ANOVA of subjects (randomized) by conditions (same, contrast, random) on these difference RTs showed significant differences between the conditions [$F(2,18)$

Table 4
Difference Reaction Times (in Milliseconds) to
Nontarget Words Which Shared a Common
First Letter With the Target Word

Experiment	Condition		
	Same	Contrast	Random
3	-42	-18	+ 5
4	-26	-38	-26

Note—Each score is the mean RT to the critical nontarget words subtracted from the mean RT to the other nontarget words within the same run.

= 13, $p < .001$]. A Newman-Keul's test with a q of 2 gave critical values of 19 msec and 27 msec ($p < .05$ and $.01$, respectively). From Table 4, it can be seen that sharing a common first letter with the target word slowed nontarget response latency considerably (42 msec) in the "same" condition. The interference was significantly greater than that obtained in the contrast condition, which in turn was greater than that observed in the random condition. Having a first letter in common with the target word did not appear to affect nontarget RT in the random condition.

It was hypothesized that the categorical analysis of a word can facilitate its identification by reducing the information that must be extracted from lower level analyzers. Therefore, when subjects cannot utilize category information to discriminate targets from nontargets, the effect of physical confusibility should be most marked. This has been shown to be the case, at least for nontarget word processing in the "same" condition. However, although there were no differences found between the other two conditions in nontarget RTs, it does appear that physical similarity had a differential effect in these conditions. The greater interference observed in the contrast condition can be explained by proposing that some visual feature analysis of these critical nontarget words incorrectly primes the target response (see Fletcher & Rabbitt, 1978, p. 425). We have observed that target word processing is facilitated by a semantically homogeneous background and hypothesized that this category contrast effect facilitates lower level feature analyzers. In the case of physically similar nontargets, the categorical analysis (and other featural analysis) is incompatible with target word classification and the decision is, therefore, delayed. Since no category contrast occurs in the random condition, one would expect less response interference.

As in the previous two experiments, there were virtually no errors made on nontarget trials, and no comparison of their relative frequencies across conditions could be made. For the seven subjects who did make errors, incorrect rejections of target words (4.5% of all target responses) did show a conditions effect. Sixty-four percent of the errors occurred in the random condition, 27% in the contrast, and 9% in the same

condition. Four of these subjects made no errors in conditions same or contrast. A Wilcoxon matched-pairs signed-ranks test indicated that there were significantly more errors in the random condition than in either of the other two conditions ($p < .05$).

EXPERIMENT 4

In the previous experiments, category effects have been manipulated by varying specific properties of blocks of serially presented trials. The results have been compared with those obtained using visual search paradigms (e.g., Henderson & Chard, 1978), in which an experimental manipulation can be effected in a single multiple-stimulus array. It is important, therefore, to establish whether the temporal relationship between the trials in a run affects the perception of the stimulus words. The previous experiments have utilized a response-stimulus (R-S) interval of 300 msec, which proved sufficiently short to define a functional semantic "background" or context against which target word perception could be contrasted. In the following experiment, the R-S interval was increased to 2,000 msec. The literature suggests that this may provide a boundary condition in which the processing of any word trial should remain unaffected by the processing of the previous word trial (Bertelson, 1961; Fletcher & Rabbitt, 1978; Hale, 1967; Posner, Boies, Eichelman, & Taylor, 1969). Increasing the R-S interval has been shown to significantly slow high-level repetition effects (Fletcher, 1981b; Marcel & Forrin, 1974; Meyer, Schvaneveldt, & Ruddy, Note 1). It has been suggested that at short R-S intervals, it may not be necessary to explicitly identify each stimulus presented in order to make the appropriate response; the successive stimuli can be compared at some higher order level before explicit identification has occurred (see Fletcher, 1981b).

Two opposing classes of hypotheses suggest differential effects of increasing the R-S interval for the nontarget semantic homogeneity and category interference effects observed in Experiment 3.

The first emphasizes that both effects have their locus at a very early perceptual stage and assumes that the extraction of semantic category information relies on the internal persistence of a previously processed word and its comparison with the current stimulus word. Thus, the category effects will be present only when a dynamic comparison of successive stimuli (i.e., presented or processed serially) can occur; only then is the early category-level processing revealed. Increasing the R-S interval would, therefore, remove both the category contrast and the category interference effects.

The second hypothesis emphasizes the role of category information on the response decision mechanisms. It proposes that category information is always extracted in word identification and is not contingent

upon contextual factors or the dynamics of multi-stimulus processing. Since subjects cannot logically utilize category information to facilitate decision making when target and nontarget words are from the same category, the effect of category interference should be independent of R-S interval. There is some support for this prediction. Schaeffer and Wallace (1970) observed that although semantic similarity interfered with the judgment that two words have different meanings, this effect did not interact with R-S interval (10 msec and 3,010 msec). The category contrast effect, on the other hand, may be affected by increasing the R-S interval because it is necessarily dependent upon the persistence of categorical information across intertrial intervals.

Method

Subjects. Nine males and three females, aged 18-34 years, from the subject panel, were run individually in a single session. They were paid at an hourly rate. None had participated in the previous experiment.

Design, Materials, and Procedure. The design, materials, and procedure were exactly as those in the previous experiment, except that the R-S interval was 2,000 msec instead of 300 msec.

Results and Discussion

Mean RTs in each condition for target and nontarget trials are shown in Table 1. Error responses immediately following errors and RTs larger than 2.5 standard deviations from the mean were excluded from the analyses.

A three-way ANOVA (random subject term) was performed on the mean RTs for each subject. Neither the main conditions factor (same, contrast, random) nor its interaction with response type (target, nontarget) approached significance [$F_s(2,22) < 1$]. This is apparent from Table 1. This result clearly demonstrates that both the category contrast and category interference effects are sensitive to the R-S interval between successive stimuli. Both effects appear to be dependent upon temporal relations between sequentially presented stimuli and support the conclusion that they are dependent upon perceptual factors.

The failure to obtain a category interference effect is somewhat surprising in the light of Schaeffer and Wallace's (1970) data, which clearly showed that "different" judgments were slowed by semantic relatedness between the word pairs, even at long interstimulus intervals (3,010 msec). One reason for this discrepancy may be that in Schaeffer and Wallace's experiment, both the words of the stimulus pair to be semantically compared were changed on each trial. In the method used here, the target word was kept constant for many trials. To check whether category interference effects were present on each trial in which both component concepts of the decision were "novel," the nontarget RTs of the first, second, third, and fourth trials of each run were compared across the conditions. The mean RTs are shown in Table 5.

Table 5
Mean Reaction Times (in Milliseconds) for the First
Four Nontarget Trials in Each Run for Conditions
Same, Contrast, and Random in Experiment 4

Condition	Nontarget Trial Number			
	1	2	3	4
Same	770	523	499	474
Contrast	678	505	497	487
Random	709	509	485	475

It can be seen from Table 5 that the first nontarget trials in condition same produced longer response latencies than the other two conditions (92 msec and 61 msec compared to the contrast and random conditions, respectively). A two-way ANOVA (subjects term randomized) confirmed this. The conditions term was highly significant [$F(2,22) = 7.9$, $p < .0005$]. Newman-Keuls post hoc tests resulted in critical values of 48 and 65 msec ($p < .05$ and $.01$) for q_2 and 59 and 76 msec for q_3 . The response latencies in the contrast and random conditions did not, therefore, differ significantly.

A similar comparison of Trials 2, 3, and 4 across conditions did not produce any differences approaching significance.

The effect on nontarget latencies of sharing a common first letter with the target word are presented in Table 4. An ANOVA comparing the three conditions confirmed that the conditions were not differentially affected by this letter sharing ($F < 1$). It should be noted, however, that each mean is different from zero, which suggests that the letters of the nontarget words were instrumental in the decision making in each of the conditions.

GENERAL DISCUSSION

The results of the experiments clearly demonstrate that the categorical membership of a word can markedly affect the speed of response classification. Word identification can be facilitated or interfered with depending upon the nature of decision required, the semantic homogeneity of the background words, and the semantic relationship between the target and nontarget words. Moreover, each of these effects have been observed in a task requiring separate decisions to singly presented words when the semantic variables are varied across a number or a block of trials.

The experiments have demonstrated the following: (1) A semantically homogeneous nontarget set facilitates the classification of unrelated target words (the category contrast effect). The degree of this nonassociative facilitation increased with the number of nontarget trials preceding target word presentation. (2) A semantically homogeneous nontarget set produces faster response latencies to nontarget words compared to when the nontarget set is semantically heterogeneous (i.e., the

smaller the actual area of memory sampled from the faster the RTs). (3) The larger the potential target set and the greater the number of categories represented in the target set, the larger is the category contrast effect and the larger is the effect of nontarget homogeneity on nontarget RTs. (4) When category information does not discriminate target from nontarget words, RT to both targets and nontargets is inhibited (the category interference effect). (5) Explicit identity-level classification instructions generally result in much faster target and nontarget word response latencies than do category-level classification instructions. (6) Both the category contrast effect and the category interference effect were obtained when target search was confined to a single word. (7) When conditions make it difficult for subjects to successively compare their representation of the previous word with their representation of the current word (i.e., using a 2,000-msec R-S interval), the category contrast and category interference effects do not persist. (8) When subjects cannot make use of the categorical information of the presented words (i.e., in condition same, Experiment 3), the nontarget words that share a common first letter with the specified target take longer to reject compared to other conditions. Moreover, repeating identical words on successive trials facilitates RT to a greater degree when the nontarget set is categorically heterogeneous than when it is categorically homogeneous (Experiment 1). Thus, the use of category information appears to reduce the amount of physical featural information.

A Theoretical Interpretation: The Parallel Committee Decision Model

The experimental evidence has generally been interpreted as supporting a model of word recognition in which some category-level processing occurs before the word identification process is complete. It appears that the early categorical information can facilitate the decision processes even when the task requires subjects only to perform an identity-level match or mismatch. Under normal circumstances, identification has been found to be a faster terminating process than categorization. One way of interpreting the data, therefore, is to consider word identification and categorization as parallel processes that are continually feeding information into some central decision processor (CDP). This CDP makes the appropriate response when sufficient confirmatory evidence has been accumulated. Information must be passed to the CDP before, as well as after, it becomes available for perceptual report or conscious awareness.

The precise nature of the underlying model cannot be specified on the basis of the present data. Nonetheless, the evidence is consistent with an enlarged version of Rabbitt's "parallel process committee decision" model (Rabbitt & Rodgers, 1977; Rabbitt & Vyas, 1981). The model was originally developed to explain how people

Figure 1. The parallel committee decision model.

can detect and correct perceptual and response-based errors in visual search and serial choice RT tasks. Essentially, this author's new model (illustrated in Figure 1) proposes that on the presentation of a word, a number of different and independent processes or "committees" (A, B, and C) begin simultaneous interrogation of the stimulus for information at various "levels" of analysis. Each process level accumulates evidence in order to determine whether the stimulus contains information consistent with its function. Each process level or committee has a number of committee members or parallel processes devoted exclusively to the work of that committee. The parallel processes that constitute the work of the committees have different termination times. Some reach their decision before others. Moreover, the different committees or levels have tasks of different levels of complexity that take different lengths of time to complete. The committee work is completed when a "vote" is taken. This decision is taken by each committee before all the processes have terminated. The committee decision is represented by time Y in Figure 1. Committee processing continues until the last member votes, at Time Z.

Word recognition is supposed to be the result of the CDP incorporating the evidence of all the committees. Word recognition occurs when enough committee members from all process levels vote in its favor. Thus, word recognition need not be based on the votes of any one committee (Time Y might be said to represent the optimum point of time/information accrual for each process level), but on the deciding votes of them all. The identification of any word, for example, would occur before Y_i (Process B), if members from other processes (A and C) cast their vote before Y_i . These votes can be utilized by the CDP even though they are

not members of B's committee, whose brief is to identify the stimulus word. Therefore, word identification is facilitated when the early terminating votes of members of other committees (which, overall, may take longer to reach their specialist decision) can be incorporated in the overall decision process.

A model of this kind can be used to interpret the present findings. First, it suggests that although identification may be a faster terminating process overall than categorization ($Y_i < Y_c$), category information can still affect word identification because some Process C members vote before Process B has reached its committee decision. Second, less analysis of visual features of words would be required if one or more category members vote before Process A makes its decision (i.e., if X_c , the earliest terminating category process, occurs before Y_v). Third, when the information from any committee is not informative (e.g., when category information will not distinguish target from nontarget words), their votes cannot be used by the CDP in the overall count (although capacity may have to be spent counting them). Target and nontarget decision times would be larger in the "same" condition, therefore, because the CDP will have to await the later voters of the other processes.

Fourth, if it is assumed that committee members remember decisions made in the past, having to make the same decision more than once (or process the same information) should facilitate response latencies. The semantically homogeneous nontarget set would result in faster categorization of nontarget words, either because Committee C becomes faster at casting its votes or because the CDP gives its voters evidence more importance in the overall decision (because its previous deliberations have proved discriminatory in

the past). If the locus of the categorical facilitation is at the level of the CDP, and not the committee of Process C, however, other observed effects can be interpreted. Faster target processing in the contrast condition would be predicted (even though the target word has not been semantically primed) because the category voters have more effect on the decision process in this condition. This category contrast effect would also be sensitive to the overall task demands because the greater the task demands on the CDP, the more facilitation could accrue from paying particular attention to any "proven" committee voters. Semantic homogeneity facilitates the CDP because categorical evidence per se (i.e., independent of actual category processed) is given more weight. There is no necessity to postulate passive category-specific facilitation at the level of subcommittee C.

Fifth, the semantic effects observed here have been found to be sensitive to the temporal dependencies between successive words. Since stimulus repetition effects are usually interpreted as being perceptual in nature (see Fletcher, 1981b), this would support the view that in these word experiments, it is the perceptual interrogation of the stimulus that is being affected by the semantic manipulations. However, since these processes appear to be affected by the task demands, it would appear that the perceptual, memorial, and decision mechanisms operate in an interactive fashion.

Current models of word recognition cannot easily accommodate the major results of these experiments. In the main, the interactive models (e.g., Becker, 1980; Rumelhart & McClelland, 1982) interpret the category-level facilitation of primes on subsequent word recognition in terms of prior or preactivation of associated word detectors. The models have no provisions for explaining the nonassociative category contrast effect. Moreover, category interference effects (which occur in conditions in which target and nontarget words should be primed, according to these models) must be explained by making additional assumptions that are not relevant to the descriptions about the mechanisms of the underlying model. For example, Becker's (1980) model would have to presume that the slower identity-level classification observed in condition same was a result of response-level interference caused by doing deeper level processing than is logically required by the task. This explanation is seriously questioned, however, by Henderson and Chard's (1978) finding that analogous category interference effects occur for target-present and target-absent trials in a visual search paradigm when no response is required to the background items (see also Karlin & Bower, 1976).

The parallel committee decision model is not simply a parallel "horse-race" model (as, for example, Karlin & Bower, 1976). The horse-race model proposes that each mean RT is the result of the parallel and independent processes that have a stochastic distribution of termination times over a number of trials. If any distri-

butions overlap, decisions that can be made on the basis of more processes will result in faster mean RTs. According to the committee decision model, however, information from all processes can be functional in every decision, since the CDP incorporates evidence from each process.

There are several reasons, on the basis of present evidence alone, for favoring the committee decision model. First, it appears that the mean RT difference between explicit identification and categorization ($Y_c - Y_i$ in Figure 1) is around 80-100 msec (see Table 3). The variance of the underlying distributions would have to be unreasonably large to ensure sufficient overlap required by the horse-race model to explain the size of the category effects observed. Second, the horse-race model has no provisions to explain observed task demand effects. The CDP is the mechanism in the committee model. Third, it appears that category information is used in most, if not all, decisions. The category contrast effect is present for both target words presented in a run in Experiment 1 (Table 2). The various category effects were present even though target words occurred infrequently (of course, in a session a single subject received quite a few target trials). The presence of identical repetition effects (Experiment 1) and the effect of a nontarget sharing a common first letter with the target word (Experiments 3 and 4) also cast doubt on the "distributional influence" explanations required by the horse-race model. Finally, the committee model does not assume that the various processes are "all or none" in their influence. This may explain why, for example, category information can influence word recognition even though the information is not available for direct or conscious read-off from that process.

The parallel committee decision model seems to adequately predict the observed findings without making too many assumptions or appealing to mechanisms outside the remit of the model. Perhaps one of its most important features is that it does not compartmentalize the perceptual, memorial, and decision making processes as discrete (or even separable) stages of analysis. In view of the difficulty that such compartmentalization causes for the interpretation of experimental evidence (cf. McClelland, 1979), the postulation of such models may provide the most fruitful route for further study of the word recognition process.

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(Received for publication March 17, 1982;
revision accepted February 9, 1983.)