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ABSTRACT

Recognizing a word in a meaningful text involves processes that combine information from many different sources, and both bottom-up processes (such as feature extraction and letter recognition) and top-down processes (contextual information) are thought to interact when skilled readers recognize words. Two similar experiments investigated word recognition latencies of adult readers who read single words that were manipulated by repetition and/or degradation, and the effects of context were observed. Subjects for the first experiment were 40 introductory psychology students, while those for the second experiment were 60 different students. Findings indicated that repeated words were recognized faster than nonrepeated words, but were not any less affected by semantic context. The two degradation manipulations (inserting asterisks between a word's letters and masking a word) slowed word recognition as compared to a clear presentation. However, only the masking manipulation produced contextual inhibition, and the magnitude of context effects did not always vary monotonically with the word recognition latencies in the neutral condition. A version of the interactive-compensatory model of skilled reading is the most compatible explanation of the results of these experiments, because that model contends that slowed word recognition is not always accompanied by contextual compensation and that adult readers depend on their decoding processes when the processes are slowed, unless the data are inadequate for such analysis. (SKC)

CENTER FOR THE STUDY OF READING

Technical Report No. 411

LIMITED ROLE OF CONTEXTUAL INFORMATION IN ADULT WORD RECOGNITION

Aydin Y. Durgunoğlu

University of Illinois at Urbana-Champaign

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University of Illinois at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

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Abstract

Recognition latencies of single words were manipulated by repetition and/or degradation and the effects of context were observed in a pronunciation task. Repeated words were recognized faster than nonrepeated words, and yet were not any less affected by semantic context. The two degradation manipulations, namely, inserting asterisks between a word's letters and masking a word, slowed word recognition as compared to a clear presentation. However, only the masking manipulation produced contextual inhibition. The magnitude of context effects did not always vary monotonically with the word recognition latencies in the neutral condition. The implications of these findings for the time-locked and strategy versions of Stanovich and West's (1983) interactive compensatory model of reading were discussed.

LIMITED ROLE OF CONTEXTUAL INFORMATION IN ADULT WORD RECOGNITION

Recognizing a word in a meaningful text involves processes that combine information from many different sources. Bottom-up processes such as feature extraction and letter recognition are based on the physical analyses of the presented (target) word. Top-down processes, on the other hand, can operate before the target word is presented. The target word is anticipated from the context such that the target word is recognized faster if it matches the anticipated word. According to interactive models of reading (Perfetti & Lesgold, 1977; Rumelhart, 1977; Stanovich & West, 1979; Stanovich, 1980), information from both top-down and bottom-up processes is simultaneously present during reading, and word recognition is based on a synthesis of information provided by these several sources. In their interactive model of reading, Stanovich and West (1979, 1981) additionally propose that top-down processes can compensate for deficiencies in bottom-up processes (see also Perfetti, 1985). This concept of compensation leads to the prediction that when word recognition is slowed due to reader or stimulus deficiencies, contextual factors become more important.

Stanovich and West describe context effects in word recognition in terms of a two-process theory (Neely, 1977; Posner & Snyder, 1975). According to their model, context may have two kinds of effects on word recognition via the operation of two mechanisms: (a) a fast-acting, automatic spread of activation that facilitates the processing of related/associated words without inhibiting the processing of unrelated words, and (b) a slower, conscious, capacity-demanding process that produces facilitation in the processing of contextually appropriate words, but inhibition for contextually inappropriate words. In tests of this model, facilitation or inhibition is determined by comparing reaction times (RTs) in a particular contextual condition with RTs in a neutral baseline. If the RTs in the condition of interest are faster than the RTs in the baseline condition, then facilitation is said to have occurred. Likewise, when RTs are slower than those in the baseline condition, inhibition is said to have occurred.

Word recognition by skilled readers on nondegraded text is assumed to be very rapid and to finish before the expectancies derived from the context can exert their influence. Since only the fast-acting automatic spread of activation could be operating under these conditions there should be facilitation from related contexts, but no inhibition from unrelated contexts. However, when target word recognition is impaired due to reader or stimulus deficiencies (e.g., inexperienced reader or degraded stimuli), then both automatic and attentional context effects should be observed. This implies that for skilled readers and with non-degraded material the context will only produce facilitation, whereas both facilitation and inhibition will be observed with less skilled readers or with degraded stimuli. Consequently, increased inhibition is the signature of stronger contextual influence. These predictions have been confirmed in many experiments (Stanovich & West, 1979; 1981; 1983; West & Stanovich, 1978; 1982).

In their experiments, Stanovich and West have manipulated word recognition latencies by comparing children and adults and by comparing easy (i.e., short and high frequency) and difficult (i.e., long and low frequency) words. The assumption is that young children, who are less skilled readers, are slower to pronounce words compared to adults. Likewise, adult readers are slower to pronounce difficult words compared to easy words. Hence, one can observe contextual effects when word recognition is rapid and when it is slower by comparing different reader and item groups. However, one would prefer a manipulation of word recognition latency that does not involve comparing readers of different skills and/or stimuli of different frequencies. The reason is that less skilled readers may show impaired word recognition compared to skilled readers, but less skilled readers may also use strategies that are different from strategies of skilled readers. Also, with words of different frequencies it is very difficult to control factors such as length, imageability, relatedness to context, predictability from context and familiarity (Gernsbacher, 1984; Jastrzembski, 1981).

One variable that seems to affect the latency of word identification in skilled readers is what Jacoby and his colleagues call perceptual fluency (Jacoby, 1983; Jacoby & Dallas, 1981; Jacoby & Witherspoon, 1982). Jacoby has used a repetition paradigm to examine perceptual fluency in word recognition. The basic paradigm involves presenting a set of words to be read ("studied") in the first phase of the experiment. During the second phase, these "old" words and some nonstudied (new) words are presented very briefly and are followed by a mask. A subject's task is to identify the words. The general finding is that studied words are identified more accurately than new words. This facilitation is called repetition priming (or perceptual enhancement by Jacoby).

Jacoby (1983) has also shown that the type of analysis done on a word during its first presentation changes the magnitude of repetition priming. He manipulated how people studied a word prior to a perceptual identification test. During the study phase, a target word such as 'cold' was read in one of the three context conditions (Jacoby, 1983, Experiment 4): no context (xxx), antonym context (e.g., hot) or unrelated context (e.g., down). He found that the extent of prior visual analysis on a word determined the probability of its later perceptual identification (see also Winnick & Daniel, 1970). Compared to nonstudied words, all three study conditions produced repetition priming, but the unrelated condition produced repetition priming significantly larger than the other two conditions. This result indicates that when the context is uninformative, there is more physical analysis, which in turn leads to better perceptual identification.

Given its effects in word identification, repetition is a good variable to manipulate so as to exmine context effects on words with different recognition latencies. Context effects may be compared across repeated and nonrepeated words instead of readers of different skills and/or stimuli of different frequencies so as to keep item and reader characteristics constant. The word recognition of a repeated word improves, but the length, frequency, imageability, relatedness to the context and so forth of the repeated word remains the same. Hence, in the following experiments the repetition paradigm was used to manipulate word recognition latencies.

Stanovich and West's interactive compensatory model predicts that because repeated words have faster recognition latencies, performance on them should be less affected by context than should performance on nonrepeated words, thus producing an interaction of context effects and repetition status. However, several lexical decision experiments show that semantic priming and repetition effects are additive (den Heyer, Goring, & Dannebring, 1985; Durgunoglu, 1986; Wilding, 1986). Likewise, in a pronunciation experiment with children, Stanovich and West (1981, Exp. 2) found comparable semantic priming effects for practiced and unpracticed words.[1] These additive effects of semantic priming and repetition are problematic for Stanovich and West's interactive compensatory model. The two experiments below will examine this problem more closely.

Experiment 1

The original version of the interactive-compensatory model cannot explain the additivity of repetition and priming effects, but this additivity has only been shown with a lexical decision task (den Heyer et al., 1985; Durgunoglu, 1986; Wilding, 1986). One problem is that the lexical decision task has been shown to involve decision mechanisms that are not necessarily part of the normal reading process (Balota & Chumbley, 1984). Therefore, the first goal of this experiment was to determine if the additivity of repetition and semantic priming effects still holds when a pronunciation task is used. Previous research has shown the pronunciation task to be less affected by post-lexical processes than the lexical decision task. Thus, even though repetition and associative priming effects are speculated to be operating at different stages of word recognition, if both effects are in part pre-lexical, as seems likely, the changes in task should not affect the additive effects of repetition and semantic priming observed in lexical decision experiments. If, on the other hand, post-lexical processes in the lexical decision task are overshadowing the interaction of repetition and semantic priming effects, then the interaction should be detected with a pronunciation task.

The second goal of this experiment was to try to replicate Jacoby's finding of different repetition effects as a function of the encoding conditions during the first presentation. In two lexical decision experiments (Durgunoglu, 1986), Jacoby's finding of stronger repetition effects after studying a word in an unrelated context compared to a related context, was not replicated. However, with a pronunciation task the differential effects of prior encoding conditions on the magnitude of the repetition effect may be observed.

Method

Subjects. Forty native English speakers participated in the experiment and received partial credit for an introductory psychology course.

Materials and design. One hundred associated pairs (e.g., high LOW) selected from published norms (Deese, 1965; Palermo & Jenkins, 1964; Postman & Keppel, 1970) were used to construct the test lists. The associated pairs consisted of short, high frequency words. The first word of each pair (e.g., high) served as the prime and the second item served as the target. Fifty word targets were used to construct the lists for the first presentation (hereafter called the study list). For the second presentation (hereafter called the test list), those 50 words were used in addition to 50 nonstudied words.

In the study list, each target word (e.g., LOW) was preceded by a neutral (xxx), associated (high) or an unrelated prime. The unrelated prime was the associated prime of another word (e.g., in). However, those unrelated primes never appeared as the related primes to their corresponding target word (e.g., OUT) in that test list.

For repeated words, five priming conditions were defined as a function of the priming conditions in which a target appeared in the study and test lists. These five priming conditions are summarized in Table 1. In the semantic-neutral condition, a target word was primed by a semantically related prime in the study list and by a neutral prime in the test list. In the unrelated-neutral condition, a target word was primed by an unrelated prime in the study list and by a neutral prime in the test list. In the neutral-neutral condition, a target word was primed with a neutral prime in both study and test lists. In the netural-unrelated and neutral-semantic conditions, the targets were primed by a neutral prime in the study list and by an unrelated or a semantically related prime, respectively, in the test list.

[Insert Table 1 about here.]

Because the repeated words in a test list served as the nonrepeated words for another group of subjects, the nonrepeated words appeared in the same number of priming conditions as did the repeated words in the test list. However, for nonrepeated words the three neutral priming conditions were functionally identical because their targets had not been presented in the study list.

Procedure. Oral instructions informed subjects that they would silently read the lower case word (the prime) but read aloud the uppercase item (the target) as they appear one by one on the video monitors in front of them. They were told that sometimes the lower and uppercase words would be related, therefore paying attention to the lowercase word would help them to respond faster. No mention was made of the fact that some of the target items were repeated.

The prime remained on the screen for 300 ms, followed by a 400 ms blank screen, which yielded a stimulus onset asynchrony (SOA) of 700 ms. The target item was displayed for 1000 ms followed by a 3000 ms blank screen before the next prime was presented. There was a short break halfway during the presentation of both the study and the test lists.

Results

Because of a technical problem in one of the rooms, the average pronunciation latencies of subjects tested in that room were 380 ms longer than the subjects tested in the other room. Therefore, for the subjects tested with that voice key (n = 21), 380 ms was subtracted from the mean RTs in each condition of each subject. This will not affect the statistics, because a constant was subtracted from the mean of every condition for each subject and the conditions were all within-subjects. Analyses of variance (ANOVAs) were performed on the word data from the test list. The reaction times and error rates are summarized in Table 2. All differences referred to as reliable fall beyond the .05 level of confidence.

[Insert Table 2 about here.]

Semantic Priming and Repetition Effects

The first ANOVA involved repeated and nonrepeated words in the three priming conditions: neutral, semantically related, and unrelated. For repeated words, the neutral-neutral, neutral-semantic, and neutral-unrelated conditions were included in the analysis. The repeated words in these three priming conditions were treated identically prior to their second presentations in that they were all preceded by neutral primes during their first presentation. For the nonrepeated words, the relevant priming conditions were neutral, semantic, and unrelated.

There was a significant main effect of repetition, with repeated words yielding 8 ms faster pronunciation latencies, $F(1,39) = 7.17$, $MS_e = 525.11$. The priming main effect was also significant, $F(2,78) = 14.91$, $MS_e = 1269.72$. The interaction of repetition and semantic priming effects was nonsignificant, $F<1$.

The priming effects were determined by subtracting the RTs (and error rates) in the semantic or unrelated priming conditions from the RTs (and error rates) in the neutral priming condition. The statistical significance of these individual facilitation and inhibition effects were evaluated by computing a least significant difference (lsd). The error term for the lsd test was computed using the MS_e for the Repetition x Priming interaction. For repeated words, the semantically related primes produced a 25 ms (+0.8%) facilitation effect and the unrelated primes produced a -1 ms (+0.3%) inhibition effect. For nonrepeated words, the corresponding values were +28 ms (-0.7%) and -1 (-1.0%). There was a pattern of facilitation dominance, with only the facilitation effects being significant (lsd = 10 ms), replicating the usual pattern found with associated materials (Becker, 1980; Neely, 1976). To summarize, even with a pronunciation task the repeated words were as much affected by context as nonrepeated words, and, hence, these results are problematic for the interactive compensatory model.

Repetition Effects as a Function of the Encoding Conditions During the First Presentation

The second analysis on the word data involved a comparison of the three neutral priming conditions at test. The results are summarized in the top portion of Table 2. For repeated words, these conditions were semantic-neutral, unrelated-neutral, and neutral-neutral. In all three conditions the targets were preceded by a neutral prime during their second presentation, but they were preceded by different kinds of primes during their first presentation. For the nonrepeated words, the three neutral conditions were functionally identical.

A 2 (repetition status: repeated vs. nonrepeated) x 3 (encoding conditions during the first presentation: related, unrelated, neutral) ANOVA examined these effects. There was a significant effect of repetition, with repeated words having 13 ms faster pronunciation latencies than nonrepeated words, $F(1,39) = 12.91$, $MS_e = 763.47$. Neither the main effect of encoding conditions during the first presentation nor the interaction of repetition and encoding conditions was significant, both F's <1. Both the 18 ms repetition effect in the semantic-neutral condition and the 12 ms repetition effect in the unrelated-neutral condition were significant (lsd = 12 ms). The 9 ms repetition effect in the neutral-neutral condition did not quite reach significance.

To summarize, in this experiment there were significant repetition effects which did not differ as a function of prior encoding conditions. Unlike in Jacoby's experiments, prior study of a word in an unrelated condition did not produce larger repetition effects.

Discussion

The additivity of repetition and semantic priming effects found in this experiment indicates that the compensatory model needs to be revised to accommodate why the repeated words, which are recognized faster than nonrepeated words, are not less affected by contextual factors. The next experiment is concerned with the issue of how the interactive compensatory model can be revised to accommodate these additive effects. A factor that seems to be important in obtaining contextual compensation (as measured by larger inhibition effects) is slowed word recognition. The original version of the model (hereafter called the time-locked version) assumed word recognition latencies to be the critical determinant of whether contextual compensation will be observed. However, contrary to the time-locked version of the model, slowed word recognition may be a necessary, but not sufficient, condition for the compensatory effects of context. Indeed, Stanovich and West (1983) have already entertained this idea.

In two pronunciation experiments, Stanovich and West presented sentence contexts clearly, but degraded the target words to slow word recognition latencies by inserting asterisks between the letters of a target word (Stanovich & West, 1983, Exp. 6) and by reducing target-background contrast (Exp. 8). In these two experiments, the target words following the sentential context stem were degraded in one block and clear in another. (Only the results from the "easy" words in the first block of their experiments will be summarized because they are the most comparable to the conditions of the present experiments). Stanovich and West's data showed that in the neutral condition, both degradation manipulations slowed word recognition by 143 ms and 210 ms, respectively, for contrast reduction and asterisk manipulations. Consequently, their original time-locked model predicts an increase in the facilitation *and* inhibition scores in both degraded conditions as compared to the nondegraded conditions.

When the related context condition is considered, the time-locked version of the interactive-compensatory model was supported because the facilitation in the related condition increased with both degradation manipulations. However, the more critical observation is what happens in the unrelated conditions of the two experiments, since the facilitation in the related conditions may have increased because of the spread of activation as well as the increased utilization of expectancies. Therefore, inhibition is the major indicator of whether the expectancy mechanism is working and whether there is contextual compensation. With the contrast reduction manipulation, the predictions of the interactive compensatory model were supported as the inhibition increased from -1 ms for clear stimuli to -49 ms for reduced contrast stimuli. However, when the degradation was induced by the insertion of asterisks between the letters of a target word, the +12 ms effect in the unrelated condition for clear targets became even more positive (+34 ms). This last finding is very problematic for the time-locked version of the interactive-compensatory model. Because both degradation manipulations slowed word recognition significantly, the inhibitory effects of contextual compensation should have been observed with both manipulations.

Stanovich and West state that "Perhaps subjects only use a conscious expectancy strategy when they are in doubt as to whether purely data-driven mechanisms will be sufficient to specify the stimulus. Contrast reduction . . . may signal executive processing systems that extra resources are necessary. The asterisk manipulation may slow later stages . . . and although disrupting performance, may never leave the system in doubt as to whether the stimulus will be resolved" (p. 19). Stanovich and West propose that it is not only slowed word recognition that determines contextual compensation, but also whether or not there is a problem in the basic data-driven processing accompanying the slowed word recognition. (Hereafter this will be called the strategy version of the interactive-compensatory model).

In a more recent paper, Stanovich, Nathan, West, and Vala-Rossi (1985) have qualified their strategy view slightly. In comparing performances of third and fifth graders and adults, they replicated the usual finding that both the facilitation in the related contexts and the inhibition in the unrelated contexts were larger in inexperienced readers. Consequently, Stanovich et al., proposed that "... it appears that currently the time-locked version gives a slightly better account of the developmental results, whereas the strategy version seems to give a somewhat better account of the adult data" (1985, p. 1425).

In short, at this point it is not clear if or how the interactive-compensatory model should be modified to account for why the effects of contrast reduction and asterisk insertion produce different interactive effects with the effects of semantic priming. The next experiment is concerned with choosing between the time-locked and strategy versions of the interative-compensatory model. The additivity of repetition and semantic priming effects, as well as the different patterns produced by different methods of degradation will be examined more closely.

Experiment 2

The major problem for the original time-locked version of the model is that the context effects, specifically inhibition in the unrelated condition, does not always vary monotonically with the word recognition latencies in the neutral condition. There are two instances of that problem, as will be described in more detail below. The first is the finding that the magnitude of semantic priming is not smaller for repeated target words than for nonrepeated target words, even though word recognition is faster for repeated words. The second problematic finding is that although inserting asterisks between a target word's letters slows its recognition, such a degradation does not increase the inhibition effect produced when that target appears in an unrelated context. In this experiment, both of these problematic findings were examined together, and hence target quality (clear, asterisks, and mask) and repetition status (repeated and nonrepeated) were manipulated in a within-subjects design.

Semantic Priming and Repetition Effects

The first goal of Experiment 2 was to determine if repetition and semantic priming effects will interact when degraded targets are used. If so, the previously found additive effect may not be a problem for the time-locked version of the interactive-compensatory model. Stanovich and West (1981) proposed that a bottom-up processing variable should have a strong main effect before any interactions with context can be detected. Therefore, the Repetition x Priming interaction needs to be examined under degradation conditions in which the repetition main effect is likely to be stronger.

The predictions of the time-locked version and the strategy version of the interactive-compensatory model are outlined in Table 3. It must be noted that the magnitude of RTs and facilitation and inhibition scores are arbitrary. What is important is the pattern of the predicted results.

[Insert Table 3 about here.]

According to the time-locked version of the model, if only clear targets are considered (column 1 in the top half of Table 3), the difference in RTs between the related and unrelated priming conditions should be smaller for repeated than for nonrepeated words (10 vs 25 ms). Although the time-locked version incorrectly predicts an interaction between repetition and priming effects in the clear condition (such an interaction was not found in previous experiments), the Repetition x Priming interaction needs to be tested with degraded stimuli to provide a better test of the time-locked model. In Table 3, the mask condition (column 3) is predicted to slow word recognition times, thus accentuating both the repetition and priming main effects (Becker & Killion, 1977; Besner & Swan, 1982; Norris, 1984). Under these conditions, the predicted priming effects are 30 ms and 60 ms for repeated and nonrepeated words, respectively. Hence, it may be easier to detect any differences in the priming effects for repeated and nonrepeated words under mask than under clear conditions.

Context Effects with Different Stimulus Quality Manipulations

Stanovich and West (1983) reported that when asterisks were inserted between the letters in a target, the slowed word recognition was not accompanied by more contextual inhibition, even though in another experiment contrast reduction did produce more contextual inhibition. To explain the lack of contextual inhibition with the asterisk degradation, Stanovich and West proposed the strategy version of their model suggesting that the type of degradation should be the major determinant of contextual compensation regardless of the speed of word recognition.

With respect to this issue, the first goal was to replicate the problematic finding reported by Stanovich and West (1983) in a single experiment using a within-subjects design. Such a design rules out the explanation that subjects in the asterisk group employed a general strategy different from the one used by subjects in the contrast reduction group. This general strategy difference was eliminated in the present experiment because subjects did not know before each trial how or if the target word would be degraded.

The "data-limited" degradation in the present experiment (i.e., the mask condition) was not identical to the contrast reduction manipulation of Stanovich and West. However, theoretically, when a target is presented very briefly and also followed by a mask, there is a limitation on the basic bottom-up processes (Jacoby, 1983). Therefore, the brief, masked presentation manipulation is a conceptual replication of their contrast reduction manipulation.

Assuming that general strategy differences did not produce the results in Stanovich and West's (1983) between-subjects experiment, the results of Experiment 2 were predicted to replicate their finding of different context effects for the two different degradation manipulations, thus undermining the time-locked version of their model. In Table 3, considering only *nonrepeated* words, the strategy version predicts that the magnitude of the inhibition effect in the unrelated condition will *not* increase when a target word is degraded by inserting asterisks (0 ms in the second column of Table 3) as compared to a clear target (0 ms). However, when the degradation is produced by a brief, masked presentation, then stronger inhibition effects are expected for the masked (-30 ms in the third column of Table 3) than for the clear (0 ms) stimuli.

If, however, the asterisk and mask manipulations produce similar inhibition patterns, then one can conclude that the differences Stanovich and West obtained were due to the between-subjects design that they used. If the asterisk manipulation also produces stronger inhibition compared to the clear conditions, then the predictions of the time-locked version are borne out (-30 ms for both mask and asterisk conditions in the top half of Table 3). Hence, one problematic finding for the time-locked version would be eliminated.

The two versions of the interactive-compensatory model also make different predictions on how repetition and degradation effects *combine* to produce inhibition in the unrelated condition as an examination of the *clear* and *mask* conditions in Table 3 will show. According to the time-locked version, the magnitude of inhibition effects should vary as a function of word recognition times in the neutral condition (columns 1 and 3 in the top half of Table 3). Consequently, the strongest inhibition should be observed with masked and nonrepeated targets (-30 ms) and the weakest inhibition with repeated, clear targets (0 ms). Since repetition decreases word recognition latencies, the inhibition effect for masked but repeated words should be smaller than the inhibition effect for masked but nonrepeated targets (-10 and -30 ms, respectively, in Table 3). The asterisk manipulation should be identical to the mask manipulation and the predictions summarized for the mask condition should still hold. Hence, according to the time-locked version, in the present experiment it should be the repetition status and *not* the type of degradation that should be important in determining inhibition because both types of degradation will slow word recognition comparably.

The strategy version would predict that inhibition in the unrelated priming condition should not differ as a function of repetition effects. When a target is masked, the executive processes are signaled to compensate for deficient bottom-up processing, no matter how fast (repeated) or slow (nonrepeated) that degraded item is recognized. (In Table 3, the predictions for the strategy version is that the inhibition is -30 ms for repeated and nonrepeated masked targets and 0 ms for repeated and nonrepeated clear targets). With the asterisk manipulation, on the other hand, there should be no inhibition with repeated or nonrepeated targets. That is, according to the strategy version, the type of degradation, and *not* the repetition status, should be the major determinant of contextual inhibition in this experiment.

Effects of Prior Encoding Conditions on Repetition

The final goal of this experiment was to test the effects of prior encoding conditions on repetition effects. In the previous experiments, Jacoby's finding of stronger repetition effects in the unrelated compared to related encoding conditions was not replicated, although both conditions produced repetition effects in a pronunciation task. If Jacoby's finding of stronger repetition effects in the unrelated-neutral condition is replicated in the mask, but not in the asterisk and clear conditions, then this implies that a word should be very data-limited before any effects of prior data-driven processing on repetition effects are observed. Such a result, in addition to replicating and extending Jacoby's findings, may also provide an independent method for classifying degradation manipulations to predict a priori which degradation manipulations will signal the executive processes for contextual compensation. Specifically, a degradation manipulation may be data-limited to the degree that it yields a larger repetition effect in the data-driven unrelated-neutral condition than in the more conceptually-driven semantic-neutral condition and hence, only degradation manipulations which show this effect may signal for contextual compensation, as evidenced by the inhibition in the neutral-unrelated condition.

Method

Subjects. Sixty native English speakers participated in the experiment to fulfill one of the requirements of an introductory psychology course.

Materials and design. One-hundred-and-eighty associated pairs were used to construct the test lists. One-hundred of those pairs were the ones used in the first three experiments. The remaining 80 pairs were selected from the same norms used in constructing materials for the first experiment (Deese, 1965; Palermo & Jenkins, 1964; Postman & Keppel, 1970). A subject saw 90 targets during the first presentation (study list), and these 90 targets were repeated, along with 90 new targets, in the test list. The words which were repeated for one group of subjects were nonrepeated for the other group of subjects, but both groups saw the same 180 words in the test list. The priming conditions for repeated and nonrepeated words were identical to the conditions in Experiment 1 (see Table 1).

A base test list was constructed using the 180 target words and their corresponding primes. In order to have a target word appear in all five priming conditions, five versions of the base list were created. In addition, each of these five versions had three different forms. In each form the primes were kept identical, and they were always clear, but the target words appeared in one of the three stimulus quality conditions: clear, mask, or asterisk. In the mask condition, the target word was presented very briefly and later a mask composed of ampersands covered the location of the word. In the asterisk condition, asterisks were inserted between the letters of a target word (e.g., L*O*W). Across subjects, each word appeared in one of the 5 (Priming) x 3 (Stimulus Quality) x 2 (Repetition) conditions. All conditions were within-subjects.

Procedure. The instructions and procedure were identical to those of the first experiment with the following exceptions. The lag between the two presentations of a repeated target was 91-179 items, because the study list was longer in this experiment. In addition to the practice list given before the study list, there was also another practice list given before the test list. The first practice list, which included only clear targets, introduced subjects to the priming conditions and to the task. The second practice list given before the test list included targets with asterisks and with masks, as well as clear targets to familiarize subjects with the degradation conditions.

The SOA was 700 ms, as in the previous experiment. Clear targets were displayed for 1000 ms followed by a 4500 ms blank screen. In the asterisk condition, the target was displayed for 800 ms followed by a 4500 ms blank screen. In the mask condition, the target word was displayed for 30 ms, followed by a 30 ms blank screen. The mask that then appeared stayed on the screen for 1000 ms followed by a 2000 ms blank screen. The mask condition was not as degraded as in Jacoby's (1983) experiment, because the dependent variable was pronunciation latency rather than accuracy. Thus, the target duration was chosen so as not to produce a high number of errors.

Results and Discussion

ANOVAs were performed on the pronunciation latencies of targets in the test list, with repetition status, stimulus quality, and priming conditions as the within-subjects variables. The data are presented in Table 4.

[Insert Table 4 about here.]

Semantic Priming and Repetition Effects

The first ANOVA involved comparing priming effects across repeated and nonrepeated words in neutral, related, and unrelated priming conditions for the three different stimulus quality conditions. The repeated words included in the analysis were all paired with a neutral prime in the study list (neutral-neutral, neutral-semantic, and neutral-unrelated conditions).

Overall, there was a significant main effect of repetition, with repeated words pronounced 17 ms faster than nonrepeated words, $F(1,59) = 31.23$, $MS_e = 2373.03$. There was also a main effect of stimulus quality, $F(2,118) = 37.70$, $MS_e = 5118.31$. Compared to RTs to clear targets, RTs to asterisk targets were 40 ms slower and RTs to masked targets were 39 ms slower. However, this latter effect was qualified by a significant Stimulus Quality x Priming interaction, $F(4,236) = 7.70$, $MS_e = 1949.88$. The overall interaction of priming and repetition effects across the three stimulus quality conditions was nonsignificant, $F(2,118) = 1.63$, $MS_e = 2033.41$.

Clear condition. For clear targets, there was a significant main effect of repetition, $F(1,59) = 7.58$, $MS_e = 2527.51$. The repeated targets were pronounced 15 ms faster than nonrepeated targets. The priming main effect was also significant, $F(2,118) = 7.38$, $MS_e = 1993.86$. As in the previous experiment, there was no interaction between those two variables, $F<1$. The facilitation and inhibition scores are summarized in the first column of Table 5. For repeated words, relative to the neutral condition, there was a +12 ms (-0.6%) effect in the related context and a -1 ms (-0.3%) effect in the unrelated context. The corresponding values were +27 ms (-0.3%) and +3 (-0.2%) for nonrepeated words (*lsd* = 16 ms).

[Insert Table 5 about here.]

One problem in accepting this lack of an interaction between semantic priming and repetition effects as evidence against the time-locked version is that the interaction may not have been detected because the main effects were not large enough. This criticism is not very convincing because both repetition and priming main effects were significant. However, in order to have a stronger test of the model, the same interaction was examined when the repetition and priming effects were numerically larger, namely, under conditions of degradation.

Asterisk condition. For the targets with asterisks inserted between their letters, there was a significant repetition main effect, $F(1,59) = 21.45$, $MS_e = 2837.30$, with repeated words being pronounced 26 ms faster than nonrepeated words. The priming main effect was also significant, $F(2,118) = 32.84$, $MS_e = 2239.08$. However, the interaction of those two variables was, once again, not significant, $F<1$. The facilitation and inhibition scores are summarized in the second column of Table 5. The repeated words showed a +40 ms (+0.5%) facilitation in the related condition and +7 ms (+0.3%) effect in the unrelated condition. For nonrepeated words, the corresponding scores were +50 ms (+1.9%) in the related condition and +1 ms (+0.5%) in the unrelated condition. The facilitation in the related priming condition was significant for both repeated and nonrepeated words (*lsd* = 16), but there was no inhibition in the unrelated priming condition. The important finding is that even though the repetition and priming main effects were numerically larger in the asterisk vs. clear condition (26 vs. 15 ms for repetition and 40 vs. 18 ms for semantic priming), there was still no interaction of repetition and semantic priming effects. This constitutes stronger evidence against the time-locked version of the interactive model.

Mask condition. One final test of the Repetition x Priming interaction was performed on the data from masked targets. For masked targets, the repetition main effect was marginally significant, $F(1,59) = 3.51$, $MS_e = 2124.37$, $p<.10$. The repeated words were pronounced 9 ms faster than nonrepeated words. However, the priming main effect was highly significant, $F(2,118) = 32.21$, $MSe = 2498.05$. Once again, there was no interaction between these two effects, $F<1$. The facilitation and inhibition scores for masked targets are summarized in the third column of Table 5. For repeated words, both the facilitation in the related condition (+20 ms and -0.4%) and the inhibition in the unrelated condition (-31 ms and -1.7%) were significant (*lsd* = 17 ms). Likewise, for nonrepeated words, both the facilitation in the related condition (+30 ms and +1.4%) and the inhibition in the unrelated condition (-23 and -1.4%) were significant, but still, the overall context effect (RTs in the unrelated condition minus the RTs in the related condition) was not different for repeated and nonrepeated targets, 51 vs. 53 ms, respectively. In sum, the semantic priming and repetition interaction was not observed in this experiment either, even under degraded stimuli conditions.

Context Effects with Different Stimulus Quality Manipulations

First, the data from nonrepeated words were considered in order to analyze the effects of stimulus quality without any confounding from repetition effects. A 3 (Priming Conditions: related, unrelated, and neutral) x 3 Stimulus Quality (clear, asterisk, and mask) ANOVA on the data from nonrepeated words indicated a significant Priming x Stimulus Quality interaction, $F(4,236) = 3.13$, $MS_e = 1981.77$.

As can be seen in the bottom half of Table 5, the facilitation effects in the related condition of all three stimulus quality conditions were significant (*lsd* = 16 ms), but the most important observation pertains to the inhibition effects in the unrelated condition. Here, only the -23 ms (-1.4%) effect in the mask condition was significant. There was no inhibition in either the clear or the asterisk condition. This pattern is exactly as predicted by the strategy version (see Table 3). The strategy version assumes that when the bottom-up processes are not impaired (as is the case in the clear and asterisk conditions), then contextual compensation is not needed. The time-locked version, on the other hand, assumes that any degradation manipulation that slows word recognition should lead to contextual compensation. This prediction was clearly not supported.

Even stronger evidence against the time-locked version of the model appears when the magnitudes of the stimulus quality effects are considered. The main effect of stimulus quality was significant, $F(2,118) = 26.99$, $MS_e = 3982.67$. Compared to a clear target, inserting asterisks slowed pronunciation latencies by 53 ms, whereas masking slowed pronunciation latencies by 29 ms. The time-locked version predicts contextual compensation to vary as a function of the pronunciation latencies. Thus, in the unrelated condition, even *larger* inhibition effects are predicted for the targets with asterisks, compared to masked targets, which clearly wasn't the case.

The two versions of the interactive compensatory model also make different predictions on how repetition and degradation effects combine. According to the strategy version, the degradation manipulation should produce a similar pattern of results for both repeated and nonrepeated targets, because context compensation is signalled when bottom-up processes are impaired (as in the mask but not in the asterisk condition), regardless of how fast (repeated) or slow (nonrepeated) that degraded word is pronounced (see Table 3).

The time-locked version, on the other hand, predicts an ordering of inhibition effects in the unrelated condition, depending on word recognition latencies in the neutral condition. If the neutral-unrelated conditions are ordered from the one predicted to show the most inhibition to the one predicted to show the least inhibition, the following pattern is expected: degraded and nonrepeated > degraded and repeated = clear and nonrepeated > clear and repeated. According to the time-locked version, then, repetition effects, but not the type of degradation, should be the important determinant of inhibition in the unrelated priming condition.

The results again support the strategy version. The inhibition effects in the unrelated condition were about as large for repeated and masked targets (-31 ms) as they were for nonrepeated and masked targets (-23 ms). For clear and asterisk conditions, on the other hand, there was no inhibition for either repeated or nonrepeated words. Therefore, it seems that the time it takes to recognize a word is not the critical variable for compensatory processes to start operating. Rather, the deficiency in the bottom-up processing seems to signal contextual compensation.

To summarize, the critical finding against the time-locked version is that even though word recognition was slowed considerably with the asterisk manipulation, there was no inhibition in the unrelated condition indicating contextual compensation. Therefore, it seems that the time it takes to recognize and pronounce a word is not the critical variable for compensatory processes to start operating. This corroborates the finding already reported when nonrepeated words with slower pronunciation latencies did not show more contextual compensation than repeated words. Hence, the results of Experiment 2 provided strong support for the strategy version of the interactive compensatory model.

Effects of Prior Encoding Conditions on Repetition

As in Experiment 1, the three neutral conditions at test were compared. For repeated words, these conditions were semantic-neutral, unrelated-neutral, and neutral-neutral. The relevant results are presented in Table 4. A 3 (Encoding Conditions During the First Presentation) x 2 (Repetition Status) x 3 (Stimulus Quality) ANOVA showed that the repetition main effect was significant, with repeated words having 14 ms faster pronunciation latencies than nonrepeated words, $F(1,59) = 35.82$, $MS_e = 1575.88$. The main effect of stimulus quality was also highly significant, $F(2,118) = 41.62$, $MS_e = 5041.16$. Compared to clear targets, both the asterisk and masking manipulations slowed pronunciation latencies, by 48 and 30 ms, respectively.

The encoding conditions main effect was marginally significant, $F(2,118) = 2.44$, $MS_e = 1731.70$, $p<.10$, and so was the Repetition x Stimulus Quality interaction, $F(2,118) = 2.56$, $MS_e = 3118.64$, $p<.10$.

Clear condition. For clear targets, neither the repetition nor the encoding conditions main effects were significant, both *F*s<1. The marginally significant interaction of repetition and encoding conditions effects, $F(2,118) = 2.48$, $MS_e = 2815.45$ indicated that only the repetition effect in the Neutral/Neutral condition was significant (*lsd* = 19).

Asterisk condition. For the targets with asterisks, the repetition main effect was significant, $F(1,59) = 17.88$, $MS_e = 2459.79$. Repeated words were pronounced 22 ms faster than nonrepeated words. Neither the effect of encoding conditions nor interaction of repetition and encoding conditions effects were significant, both *F*'s<1. To summarize, all three encoding conditions produced significant repetition effects which statistically did not differ from each other.

Mask condition. In the mask condition, the repetition main effect was significant, $F(1,59) = 10.34$, $MS_e = 2618.69$, with repeated words having 17 ms faster latencies than nonrepeated words. Neither the encoding conditions main effect, nor the Encoding Conditions x Repetition interaction was significant, both *F*'s<1. As in the asterisk condition, the three encoding conditions produced statistically equivalent repetition effects in the mask condition as well. Contrary to Jacoby's results, the unrelated-neutral condition did not produce larger repetition effects than the semantic-neutral condition in the mask condition either, even though the stimuli were briefly presented and masked as in Jacoby's experiments. One factor that may still be important is the duration of the target word before the mask is presented. In Jacoby's (1983) experiment, the target duration was adjusted for each subject to produce only 50% accuracy (60% in his second experiment). The average duration of the target was 26 ms across his four experiments and the mask immediately followed. In the current experiment the task was not one of perceptual identification in which accuracy was measured. Rather, the dependent variable of interest was the pronunciation latency. Because of this, for all subjects, the target was presented for 30 ms, followed by a 30 ms blank screen before the mask appeared so that the error rates would not be too high. At this point, the finding of greater repetition effects on a target following an unrelated, rather than a related, study condition cannot be extended to a pronunciation task with latencies as the dependent variable.

Because the prior encoding conditions did not produce different repetition effects across mask and asterisk conditions, this method could not be used to determine a priori whether a degradation manipulation will produce contextual compensation. However, the main point of this experiment is still valid. Contextual compensation as determined by the inhibition in the unrelated condition changes depending on the nature of the target degradation, and not pure word recognition latencies in the neutral condition. Hence, as an inspection of Table 3 and 5 shows, the results strongly support the strategy version of the interactive compensatory model.

General Discussion

The first finding in the present experiments was that semantic priming and repetition effects were additive in a pronunciation task (Experiments 1 and 2), thus replicating the pattern found in lexical decision experiments (den Heyer et al. 1985; Durgunoglu, 1986; Wilding, 1986). Even when the overall magnitude of semantic priming and repetition main effects were increased using a degradation manipulation (Experiment 2), still no significant interaction was detected between the two effects. This robust additivity needs to be considered in developing and evaluating models of contextual effects in word recognition, as well as models of repetition effects.

The two degradation manipulations (mask and asterisk) yielded different context effects when single word contexts were used, replicating and extending the findings reported by Stanovich and West (1983). The asterisk condition produced only facilitation with related contexts, whereas the mask condition produced both facilitation in related contexts and inhibition in unrelated contexts, even though both degradation manipulations slowed word recognition. This different pattern of context effects in asterisk and mask conditions was also obtained when word recognition latencies were further manipulated by repetition.

Jacoby's finding of more accurate perceptual identification of a word after it was "studied" in an unrelated than in a related context could not be extended to a pronunciation task, even with relatively impoverished test stimuli (mask condition in experiment 2). Of course, in the present experiments response latency, rather than accuracy, was the measure of interest. Therefore, the stimuli were presented at durations that did not produce high error rates. The effects of prior encoding conditions on repetition is an important piece of data for Jacoby's influential model of data-driven and conceptually-driven processing. Therefore, further experiments which test the effects of prior encoding conditions while manipulating target duration and quality, as well as the type of task, are needed. For the purposes of this paper, not finding differential effects of prior encoding conditions on the magnitude of repetition priming effects had another consequence. The differential effects of encoding conditions could not be used as an independent framework to determine which degradation manipulation will produce inhibition in unrelated contexts. However, the main point that not all degradation manipulations produce contextual inhibition, even though they slow word recognition, is still valid.

According to the interactive compensatory model, under normal reading conditions, contextual information is not used because word recognition based on bottom-up processes is very rapid. In the original time-locked version of the model, context effects were assumed to operate when word recognition was slowed for any reason. However, as summarized above, inhibition in the unrelated condition, which is taken to be the signature of contextual compensation, does not always increase monotonically with slowed word recognition. For example, in the present experiments, although nonrepeated words were recognized slower than repeated words, RTs to nonrepeated words did not show larger context effects. Similarly, contextual inhibition was only observed in the mask but not in the asterisk condition, even though both manipulations slowed word recognition.

These findings can be explained by the strategy version of the interactive-compensatory model. This version states that slowed word recognition is not always accompanied by contextual compensation. The *type* of stimulus degradation determines when contextual compensation is signaled. When the stimuli are very data-limited so as to disrupt bottom-up processing, then contextual compensation is often used. It seems that adult readers will depend on their decoding processes, even when those processes are slowed, unless the data are inadequate for such an analysis. With very poor stimuli, they will usually turn to context for help. For children, on the other hand, contextual compensation may be used much sooner, because they may not be as efficient as adults in their decoding skills.

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Footnote

[1]The only exception to additivity of repetition and semantic priming effects was reported by Stanovich, West, and Freeman (1981) with second-grade children. During the *first* testing period, the main effects of repetition and priming as well as their interaction was significant. However, when children were tested for the second time at the end of the school year, neither the repetition effect nor the interaction of repetition and semantic priming effects reached significance.

Table 1

The Priming Conditions in Experiments 1 and 2

Repetition Status and Condition Name	Study list		Test list	
	prime	target	prime	target
Repeated				
Semantic-Neutral	high	LOW	xxx	LOW
Unrelated-Neutral	in	LOW	xxx	LOW
Neutral-Neutral	xxx	LOW	xxx	LOW
Neutral-Semantic	xxx	LOW	high	LOW
Neutral-Unrelated	xxx	LOW	in	LOW
Nonrepeated				
------Neutral	------		xxx	COME
------Neutral	------		xxx	COME
------Neutral	------		xxx	COME
------Semantic	------		go	COME
------Unrelated	------		hand	COME

Table 2

Mean RTs (in milliseconds) and Error Rates in the Test Phase of Experiment 1 as a Function of Repetition Status and Priming Conditions

Priming Conditions	Repetition Status			
	Repeated		Nonrepeated	
(Study) Test	RT	%E	RT	%E
(Semantic)-Neutral	532	0.5	550	0.8
(Unrelated)-Neutral	532	1.3	544	2.8
(Neutral)-Neutral	536	1.3	545	0.8
(Neutral)-Semantic	511	0.5	517	1.5
(Neutral)-Unrelated	537	1.0	546	1.8

Table 3

The Predicted RTs in the Neutral Condition and Facilitation and Inhibition Scores in Related and Unrelated Conditions in Experiment 2 According to the Two Versions of the Interactive-Compensatory Model

	Stimulus Quality		
	Clear	Asterisk	Mask
Time-Locked Version			
Repeated Words			
Neutral	480	570	560
Related	+10	+20	+20
Unrelated	0	-10	-10
Nonrepeated Words			
Neutral	500	600	600
Related	+15	+30	+30
Unrelated	-10	-30	-30
Strategy Version			
Repeated Words			
Neutral	480	570	560
Related	+10	+20	+20
Unrelated	0	0	-30
Nonrepeated Words			
Neutral	500	600	600
Related	+15	+30	+30
Unrelated	0	0	-30

Table 4

Mean RTs (in milliseconds) and Error Rates in the Test Phase of Experiment 2 as a Function of Priming Conditions, Repetition Status and Stimulus Quality

Type of Degradation and Priming Conditions	Repetition Status			
	Repeated		Nonrepeated	
(Study) Test	RT	%E	RT	%E
Clear Condition				
(Semantic)-Neutral	753	1.4	744	0.3
(Unrelated)-Neutral	742	0.3	743	0
(Neutral)-Neutral	734	0.3	755	0.6
(Neutral)-Semantic	722	0.9	728	0.9
(Neutral)-Unrelated	735	0.6	752	0.8
Asterisk Condition				
(Semantic)-Neutral	789	0.5	806	1.9
(Unrelated)-Neutral	777	1.1	799	1.1
(Neutral)-Neutral	781	1.1	808	1.9
(Neutral)-Semantic	741	0.6	758	0
(Neutral)-Unrelated	774	0.8	807	1.4
Mask Condition				
(Semantic)-Neutral	763	2.7	789	4.5
(Unrelated)-Neutral	766	3.0	777	3.4
(Neutral)-Neutral	769	0.8	784	5.6
(Neutral)-Semantic	749	1.2	754	4.2
(Neutral)-Unrelated	800	2.5	807	7.0

Table 5

Mean RTs and Error Rates in the Neutral Condition and Facilitation and Inhibition Scores in Related and Unrelated Conditions as a Function of Repetition Status and Stimulus Quality in the Test Phase of Experiment 2

Repetition Status and Type of Prime	Stimulus Quality					
	Clear		Asterisk		Mask	
	RT	%E	RT	%E	RT	%E
Repeated						
Neutral	734	0.3	781	1.1	769	0.8
Related	+12	-0.6	+40	+0.5	+20	-0.4
Unrelated	-1	-0.3	+7	+0.3	-31	-1.7
Nonrepeated						
Neutral	755	0.6	808	1.9	784	5.6
Related	+27	-0.3	+50	+1.9	+30	+1.4
Unrelated	+3	-0.2	+1	+0.5	-23	-1.4

*Significant at $p < .05$ level