REPETITION AND ASSOCIATIVE CONTEXT EFFECTS IN SPEECH PRODUCTION*

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An experiment is reported that addresses the impact of lexical constraint on the production characteristics (mean duration and peak amplitude) of a given target word within a sentence production task. Subjects produced aloud sentences from memory that contained a target word (e.g., *cat*) that was either a repetition of an earlier word in the sentence (e.g., *cat*), associatively related to an earlier word in the sentence (e.g., *dog*), or unrelated to an earlier word in the sentence (e.g., *son*). The position within the sentence and phonetic environment of the target were equated across conditions. The results indicated that the mean durations for the target word were shorter in the repetition condition, compared to the associatively related condition, which in turn produced shorter production durations compared to the unrelated condition. In addition, the peak amplitude measurements indicated that the repeated condition produced relatively lower peak amplitudes for the target word, compared to the remaining two conditions which did not differ.

Key words: repetition, association, priming

INTRODUCTION

In an often-cited study, Lieberman (1963) found that contextual constraint influenced the production durations and peak amplitudes of target words. In this research, speakers were recorded as they produced individual sentences. Embedded within each sentence was a target word that was either highly constrained by the sentence context (e.g., *Neither a borrower nor lender be*) or relatively unconstrained by the sentence context (e.g., *Never listen to a man who wants to be a borrower*). Lieberman found that the durations of the target words (e.g., *borrower*) were shorter and the peak amplitudes were lower in the high-constraint context compared to the low-constraint context.

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Lieberman argued that speakers call attention to the words in the low-constraint context by producing these items with greater duration and stress.

Although the Lieberman results are intriguing, there are a number of caveats regarding this study that are important to note. First, with the exception of two sentence pairs, the target words were located in different positions within the sentences for the high- and low-constraint conditions. Studies of vowel and consonant duration have demonstrated that position of a target word within a sentence can have quite a large impact on duration measures (e.g., Umeda, 1975). Second, the target words occurred in different phonetic environments across the two constraint conditions, and there is considerable evidence that the duration of phonemes can be modified by their phonetic context (e.g., Klatt, 1979; Lehiste, 1970). Third, there were only seven target sentences spoken twice by three subjects resulting in a total of 42 possible measurements, of which only 38 were included in the analyses. Thus, the important conclusions drawn from the Lieberman study were based on a relatively small sample.

The notion that constraint can modify production durations was also recently addressed in a study by Fowler (1988; see also Fowler and Housum, 1987). In her second experiment, subjects read paragraphs in which a given target word was preceded by a "prime" in an earlier sentence. The prime was either the same word as the target (repeated condition), a synonym (related condition), or an unrelated word. The target words and primes were always in identical sentence positions. Thus, the phonetic context was kept constant in this study, thereby avoiding the potential problem in the Lieberman study. Fowler found that the production durations of the target words in the repeated condition were 8 msec shorter than in the related condition, which, in turn, were 13 msec shorter than in the unrelated condition. Although the repeated condition produced reliably shorter production durations than the unrelated condition, the related condition did not reliably differ from the other two conditions.

The lack of a reliable effect of relatedness in the Fowler study is of concern for two reasons. First, this pattern calls into question the important inferences drawn from the Lieberman study. At one level, the differences in results may simply be due to the greater constraint imposed by contexts such as common proverbs, as used in the Lieberman study, compared to the single high-associate primes used in the Fowler study. It is also possible, however, that the Lieberman results cannot be replicated in a situation where the immediate phonetic context and position within the sentence contexts are controlled. Second, Balota, Boland, and Shields (1989) have recently reported influences of simple associative relatedness on production durations in a single word priming paradigm. It is unclear why one would not expect an extension of these single word priming effects to a sentence context situation, like Fowler's.

The present study is an attempt to extend the relatedness effects obtained by Balota *et al.* to sentential materials and further investigates whether one can find relatedness effects in a sentential context situation of the kind that Lieberman employed. On each trial subjects read silently a target sentence that was written in the present tense. The sentence was then removed and subjects produced aloud the sentence from memory in the past tense. We had subjects construct the past tense of each sentence because it was possible that, if they were simply reading the sentences, part or all of any observed

effect might be due to pattern recognition processes rather than to speech production processes.[1]

The sentences either included a repetition of the same word, an associatively related pair, or an unrelated pair. The following three sentences are example stimuli:

(1) Her cat chases our cat under the table.

(2) Her dog chases our cat under the table.

(3) Her son chases our cat under the table.

Our major interest in these productions was the duration of the fifth word (*cat*) in each of these sentence contexts. It is important to note here that both the position within the sentence and the phonetic environment of the target word were equated across these sentence context conditions. If the presence of a single highly-associated word can influence production durations, then one might expect that the production durations of the target word *cat* would be shorter in (2) compared to (3). In addition, one might expect (1) to produce shorter production durations than (2) because of simple lexical repetition.

METHOD

Subjects

Twenty-one students and staff members at Washington University, ranging in age from 18 to 36 years, served as unpaid subjects. All subjects were native speakers of American English. Three subjects correctly produced less than six complete sentence sets of a possible 18 sentence sets. Their data were not included in the final analysis.

Apparatus

Sentence productions were recorded on a Sony TC-645 tape recorder with a Shure 575S microphone at a tape speed of 7½ ips. Recordings were made in a sound attenuated room. The tape-recorded sentences were re-recorded for analysis on the tape deck of a Voice Identification Series 700 sound spectrograph. Wide band spectrograms and overall amplitude displays were made of each recorded sentence.

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[1] There is already considerable evidence indicating that sentence context can influence word recognition processes in reading. For example, Balota, Pollatsek, and Rayner (1985) found in an eye-movement monitoring study that first fixations and gaze durations on a given target word were shorter when the context constrained the target word compared to when it did not constrain the target word (see also Stanovich and West, 1983). Thus, in order to insure that any observed effects are not due to word recognition processes, we had subjects generate sentences from memory.

Stimuli

Eighteen sets of prime-target pairs were constructed, with the three pairs in each set corresponding to the three experimental conditions, i.e., repeated (*cat–cat*), associatively related (*dog–cat*), and unrelated (*son–cat*). The related pairs were selected from stimulus sets developed by Balota (1983) in a study designed to address semantic priming effects. In each of the word pair sets, the primes differed across the three conditions while the target remained constant. The 18 sentence sets are displayed in the Appendix.

The target words and the words directly preceding and following them were selected so that the targets could be isolated on spectrograms for the purpose of measuring their duration. For example, for the target word *cat*, the beginning and ending stop consonants allow it to be isolated from the phonemes in the surrounding words *our* and *under*. It is also noteworthy that the target and primes in each word pair set were of equal syllable length so that the total number of syllables in each version of a sentence remained equal. As a result, the only change across the three target conditions was the identity of the prime word, thereby retaining the same overall stress pattern across the three sentences of a set.

In addition to the target sentences, six practice sentences and one buffer sentence were constructed. The buffer sentence was included at the end of the experimental trials to reduce the possibility of a change in intonation for the last experimental sentence.

Procedure

Subjects were seated in a sound attenuated room with the stack of stimulus cards directly in front of them. A microphone was placed approximately 25–30 cm from their mouth. The subjects were instructed to read each sentence silently, convert it from the present tense to the past tense, and then produce the sentence aloud from memory in the past tense. In order to prevent subjects from reading directly from the cards, they were instructed to turn each card face down before their production. Subjects were instructed to produce each sentence as if they were relating the information to someone, using a normal speech rate and loudness level. The experimenter remained in the testing room during the production of the first few practice sentences to insure that subjects correctly carried out the task. Subjects then proceeded at their own pace until all sentences had been produced. They were observed through a one-way mirror to insure that they did not read the sentences directly from the cards, i.e., that they turned each card over prior to sentence production.

The 54 sentences were presented to each subject in random order, counterbalancing the position of the three conditions for a given sentence across each group of three subjects. The sentences were re-randomized after every third subject. In randomizing the sentences, if two sentences belonging to the same set were spaced closer than three sentences apart in the designated order, one of the sentence cards was inserted in another position in the stack in order to minimize transfer effects.

In order to eliminate any potential confounds across conditions, a conservative scoring procedure was adopted. Specifically, sentences were omitted from further analyses if the subject made any changes in the sentence as printed on the card other than the verb

tense change, or if any phoneme errors or unusual pauses were noted. When a sentence was discarded, the two other member sentences of that sentence set were also discarded, so that only sets in which all three versions of the sentence were judged to be complete were retained for analysis. The eighteen subjects produced on average 9.2 "errorless" sentence sets (27.6 sentences per subject).

Spectrograms were made of each complete sentence. Rules of segmentation were established for each target word prior to measurement. For example, the rules for the target word *cat* in the sentence *Her ___ chases our cat under the table* stated that (1) the boundary between the [r] in *our* and the [k] in *cat* was the offset of the high frequency component of the [r], and (2) the boundary between the [t] in *cat* and the [ʌ] in *under* was the onset of energy for the vowel. Adherence to these rules allowed for consistent measurement of targets across conditions and subjects. After boundaries were marked for each target word, the duration of the target was measured in milliseconds.

Relative amplitude differences were determined by measuring the differences in millimeters between the peak amplitude of the primary vowel in the target word and the primary vowel in the nearest stressed word preceding the target word. The millimeter measures were then converted to decibels (dB).

RESULTS

The mean production durations varied in the predicted direction. Specifically, they were longer in the unrelated condition (350 msec) than in the related condition (340 msec) and shortest in the repeated condition (329 msec). A one-way repeated measures analysis of variance (ANOVA) yielded a significant effect of condition, $F(2, 34) = 11.96$, $p < 0.001$. Pairwise comparisons indicated that the related condition differed significantly from the unrelated condition, $t(17) = 2.61$, $p < 0.05$, and the repeated condition, $t(17) = 2.24$, $p < 0.05$.

The above observations were also supported by an item analysis. This analysis yielded a main effect of condition, $F(2, 17) = 5.87$, $p < 0.01$. Although the difference between the repeated and related condition was significant, $t(17) = 1.94$, $p < 0.05$, one-tailed, the difference between the related and unrelated conditions did not reach significance. This was due to the variability introduced by a single item that only two of the 18 subjects produced correctly in all three conditions. When this item was removed from the item analysis, there were reliable differences between both the repeated and the related conditions, $t(16) = 2.09$, $p < 0.05$, one-tailed, and the related and the unrelated conditions, $t(16) = 2.86$, $p = 0.01$.

Turning to the amplitude measures, there was only an impact of repetition. That is, the mean relative amplitude for the repeated words was 1.62 dB less than the amplitude of the reference vowels, whereas the related and unrelated conditions produced amplitude differences of 0.11 and −0.23 dB, respectively. A one-way ANOVA on the amplitude data yielded a significant main effect of condition, $F(2, 34) = 19.74$, $p < 0.001$. Pairwise comparisons indicated that the repeated condition produced lower

relative amplitudes than either the unrelated condition, $t(17) = 5.25$, $p < 0.001$, or the related condition, $t(17) = 4.81$, $p < 0.001$. The related and unrelated conditions did not differ significantly, $t(17) = 1.45$. These observations were also supported by an item analysis which yielded a reliable difference between the repeated condition and the related condition, $t(16) = 5.27$, $p < 0.001$, and the repeated and the unrelated condition, $t(16) = 4.69$, $p < 0.001$. However, the difference between the related and unrelated conditions again did not differ, $t(16) = 1.45$.

Finally, an analysis of the error rates indicated that the three conditions did not differ reliably, $F < 1.00$, for both subjects and items.

DISCUSSION

The results of the present experiment indicate effects of both repetition (on duration and amplitude measures) and of relatedness (on duration only). Thus, we were able to replicate the Lieberman data using a more tightly controlled design, and we extended the Balota *et al.* results to sentential materials. As stated earlier, although Lieberman reported an influence of redundancy on production duration and intelligibility, differences in phonetic environment and position within sentence contexts could have contributed to the obtained pattern of data.

The present results are actually quite consistent with the mean differences reported by Fowler (1988). As noted, Fowler found differences between identical and related conditions, and between related and unrelated conditions of 8 msec and 13 msec, respectively. The corresponding mean comparisons in the present study yielded 11 msec and 10 msec. The lack of significance of the 8 msec difference in Fowler's study may be attributed to a smaller number of observations per cell in her design. It should be noted that, although these effects are rather small, they are of the same magnitude as theoretically important priming effects in naming onset latency data (see Neely, 1991, for a review).

It is interesting to note here that the present results, along with the Lieberman and Fowler studies, indicate that contextual constraint can influence performance across a rather wide range of constraint manipulations. For example, Lieberman found influences of common maxims such as *A stitch in time saves nine.* In the Fowler study, there was an influence of constraint when repeated words had the same referent. The present study also yielded an impact of repetition, but here the repeated words had different referents. Finally, the present results, along with the tendency noted in the Fowler data, suggest that the mere presence of an associatively related word earlier in the sentence context is sufficient to modulate production durations of a target word. Thus, any theoretical framework used to explain these data will need to account for an influence of context at a number of different levels in speech production. We shall now briefly turn to two such frameworks.

First, one may interpret these data within Grice's (1975) *cooperative framework.* According to this framework, the speaker takes the listener's constraints into consideration, adjusting output to maximize effective communication. The repeated or *given* word

is more easily understood by the listener as a result of its previous presentation, and therefore requires less emphasis (i.e., duration and relative peak amplitude) in order to be understood by the listener, whereas a *new* word, such as in our unrelated condition, requires relatively more information in order to provide sufficient stimulus information for processing. The cooperative framework can also account for the difference between the related and unrelated conditions. The associative relationship between the prime and target words provides some degree of overlap, and therefore the listener can better predict the target by its associative relationship to the prime word. Thus, the target word should be more easily recognized by the listener in the related condition than in the unrelated condition, and the speaker accommodates this ease of retrieval by modulating the production duration.

A second framework to interpret the present results is provided by Dell's (1986) interactive activation model. According to this model, levels of processing within the production network are connected so that activated nodes at higher levels (e.g., lexical-level representations) facilitate the selection of nodes at lower levels (e.g., phonological-level representations), while feedback from lower levels may affect selection of higher-level nodes. The present results suggest that while the prime is being processed activation spreads to associates, one of which is the related target. Therefore, the target receives an extra input of activation in the related condition, compared to the unrelated condition. This extra activation has the consequence of increasing the activation that spreads to lower levels in the system that deal more directly with the actual production of the target word, thereby producing the impact of associative relatedness on production durations. The shorter production durations observed in the repeated condition compared to the related condition may be explained within this framework in terms of the sheer number of levels that mutually reinforce a given target production. In the case of a repeated target, feedback occurs across all levels within the network, from the semantic level down to the phonetic level, because the prime is completely redundant with its target at every processing level. Hence, the repeated condition should produce the shortest production durations, as was observed. Future work is clearly needed to actually implement these predictions within the interactive activation framework.

In summary, the results of the present experiment support the view that production durations of words in sentence contexts are influenced by repeated and associatively related prime words. While this is not a new finding, we believe that we have provided more compelling evidence as a result of carefully controlling both positions of the target words within the sentence contexts and the target words' phonetic environments.

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APPENDIX

1. There is a _____ in the basement and a mouse in the kitchen. (*mouse, cat, chair*)
2. The older _____ picks the younger boy to be on the team. (*boy, girl, one*)
3. The _____ speaks to Jack's teacher before class. (*teacher, student, workman*)
4. Our _____ takes their daughter to the concert. (*daughter, mother, neighbor*)
5. Susan buys a _____ but wants a frying pan to use as well. (*pan, pot, bowl*)
6. He says he is _____ because he really is ill today. (*ill, sick, tired*)
7. John takes this _____ and the new brush to do the job. (*brush, paint, wood*)
8. Her _____ chases our cat under the table. (*cat, dog, son*)
9. There is a _____ beside the pine tree by the lake. (*tree, bush, boat*)
10. The big _____ jumps over the green frog in the puddle. (*frog, toad, boy*)
11. Anne's _____ works at the firm where my father does business. (*father, mother, lawyer*)
12. Sarah finds a _____ scarf and a silk skirt at the store. (*silk, wool, nice*)

13. This _____ comes from a plant his mother sent to me. (*plant, seed, dye*)
14. There is a _____ in the closet and a ghost under the bed. (*ghost, spook, shirt*)
15. The _____ chases the new bird from the yard. (*bird, crow, noise*)
16. The _____ reaches his doctor by telephone. (*doctor, patient, butler*)
17. These _____ match my shoes in color. (*shoes, socks, cards*)
18. The English _____ and the Spanish king are sitting together at the banquet. (*king, queen, judge*)

Note: The prime words in the parentheses are ordered: repeated, related, and unrelated.