

The Feature [sonorant] in Lexical Access

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Abstract

Does the feature [sonorant] influence access to lexical entries? We created two nonwords by replacing a fricative in a real word with either another fricative (match condition) or a resonant (mismatch condition). Participants heard the nonwords and were asked to recover the real word. Errors were greater in the mismatch condition, suggesting that [-sonorant] is represented in the target fricative. Similar effects appeared when we used stops instead of fricatives. Resonant targets showed no difference in match and mismatch conditions.

1. Introduction

In current feature geometry, the feature [sonorant] is a root node feature, distinguishing resonants from obstruents. Its prominence in the hierarchy of features suggests that it may manifest itself in various cognitive tasks. Marks, et al. [1] demonstrated such an effect in the word reconstruction task. Participants heard a nonword, e.g., *bavalry* and were told it could be changed into a real word (*cavalry*) by changing just one consonant. Errors in recovering the correct word were much higher when the word contained an obstruent that had been replaced with a resonant than when the word contained an obstruent that had been replaced by another obstruent. Essentially, the target words were easier to recover when the target segment and the replacing segment matched on the feature [sonorant]. When the target segments were resonants, the target words were recovered equally well whether the target segment was replaced by an obstruent or a resonant.

The present study replicates and extends that study in an effort to better understand these processing differences. We subdivided obstruents into stops and fricatives, comparing them separately to resonants in the word reconstruction task. Experiment 1 compared fricatives with resonants and Experiment 2 compared stops with resonants, testing whether fricatives alone or stops alone were responsible for the obstruent effect observed in Marks et al. [1].

2. Background

Feature geometry uses the feature [consonantal] to distinguish vowels from consonants. [consonantal] is a root node feature and makes one of the most basic distinctions among phonemic segments [2,3,4,5,6].

Vowels and consonants appear to contribute unequally to the recovery of items from the mental lexicon, as shown by the word reconstruction task created by van Ooijen [6]. In this task participants are given a nonword, such as /tibl/ and told that it can be changed to a word by changing either one vowel or one consonant. The vowel change word in this case is /tebl/ and the consonant change word is /fibl/. Van Ooijen found that listeners made fewer errors when asked to change a vowel than when asked to change a consonant and were generally faster in changing vowels. When given the option of changing either a vowel or a consonant, listeners made vowel changes more quickly and accurately than consonant changes. Collectively, van Ooijen called these effects *vowel mutability* and suggested that vowels offer less reliable information about the identity of a word than do consonants.

Vowel mutability effects are robust. They have been shown in spoken English [6], spoken Spanish [7], spoken Dutch [8], and printed English and printed Spanish [9]. The effects have been demonstrated with both accuracy and latency measures, so they seem to be reliable.

The feature [sonorant] is a second root node feature, distinguishing the class of obstruents from the vowels and vowel-like consonants, i.e., glides, liquids, and nasals. Our objective is to investigate the contribution of this feature to lexical access.

Preliminary investigations have also shown differences in processing for the feature [sonorant] in a modified form of the word reconstruction task [10]. Participants were given a nonword that could be changed to a real word by changing just one consonant. In half the cases, the replacing consonant matched the replaced consonant on the feature [sonorant], e.g., the target word *cavalry* was replaced by the nonword *bavalry*, where both /k/ and /b/ are [-sonorant]. In the other half of the cases, the replacing segment did not match the replaced segment on the feature [sonorant], e.g., the target word *cavalry* was replaced by the nonword *mavalry*, where /k/ is [-sonorant] but /m/ is [+sonorant]. Participant errors in this task were significantly higher in the mismatch condition than in the match condition, but only when obstruents were the target segments. When resonants were the target segments, differences between the match and mismatch conditions were minor. The same pattern of results emerged when a similar study was conducted in Spanish.

Finally, there is some evidence for differential processing for the feature [continuant] in word reconstruction [11]. Moates, et al. created nonwords by replacing one consonant in a real word with another consonant. In half the cases, the replacing consonant matched the replaced consonant on the feature [continuant], e.g., *dackward/backward* for [-continuant] and *thirsty/sirsty* for [+continuant]. In the other half of the cases, the replacing consonant did not match the replaced consonant on the feature [continuant], e.g., *oblong/othlong; sunlight/punlight*. Listeners made fewer errors in recovering the real word when the replacing segment matched the replaced segment on the feature [continuant]. This effect occurred, however, only for fricatives; stops showed no differences in the match and mismatch conditions.

In brief, fricatives and stops show differential mental processing. A word containing a fricative is harder to recover from the mental lexicon when that fricative has been replaced with a stop than when it has been replaced by another fricative. Words containing a stop are equally easy to recover whether that stop has been replaced by a fricative or by another stop.

Would this outcome help us understand the handling of feature [sonorant]? We explored this possibility in two experiments using the word reconstruction task. In experiment 1, we hypothesized that fricative target words would produce more errors in the mismatch condition than in the match condition, but resonant target words would show no such difference. In experiment 2, we hypothesized that stop target words would show no difference in errors in the match and mismatch conditions, and resonant target words would show none either.

3. Experiment 1

3.1. Method

3.1.1. Participants

Four groups of 20 students enrolled in an introductory psychology course at Ohio University participated for a small amount of course credit. All participants reported that English was their first language and that they had no hearing difficulties.

3.1.2. Materials

The materials were selected to fulfill a 2 x 2 design. The first variable was Fit (match, mismatch), whether the replacing segment matches the target segment on the feature [sonorant]. The second variable was Target Segment (fricative, resonant), whether words containing a fricative target are harder to recover than words containing a resonant target.

We chose seven fricatives as target segments: /f, v, s, z, T, Δ, Σ/. We chose eight words for each target segment. Four of the words were two-syllable words and the other four were three-syllable words. The target segment always fell in the stressed syllable of its word. In two of the four, the target segment fell in the onset of the stressed syllable and in the other two it fell in the coda of the stressed syllable. We created two nonwords from each target word by replacing the target fricative with either another fricative (match condition) or with a resonant (mismatch condition).

We also chose seven resonants as target segments: /m, n, N, l, r, w, j/. For each target segment, we again chose eight words that contained the target segment, following the same procedure given for selecting fricative target words. We again created two nonwords from each target word by replacing the target resonant with either another resonant (match condition) or with a fricative (mismatch condition).

In brief, the fricative target words had a list of match nonwords and a list of mismatch nonwords, as did the resonant target words.

Because the task involved accessing the target words, it was necessary to control for several variables that influence lexical access. The target words for both fricatives and resonants were balanced for word frequency, number of segments, number of consonants, uniqueness point, and whether the consonant change occurred before the uniqueness point. Each list was recorded on a separate audiotape by a female phonologist reading at a rate of one nonword every 10 sec.

3.1.3. Procedure

We gathered the participants in small groups in a listening laboratory which permitted them to listen to tapes individually over headphones. As they heard each nonword, they were asked to write down what they thought the real word might be or to leave the line blank. After participants finished listening to the tapes, we tested their knowledge of the target words.

3.2. Results

The response sheets were scored for errors, which included either no response or a word that was not the target word. The overall error rate was about 44%, which permitted a fair evaluation of the independent variables without floor or ceiling effects.

We performed an analysis of variance (ANOVA) on the errors using a 2 x 2 design having Fit (match, mismatch) and Target Segment (fricative, resonant) as between-subject variables. The analysis showed a significant main effect for both Fit and Target Segment, $F(1,88) = 57.09$, $p < .001$ and $F(1,88) = 10.38$, $p < .005$ respectively. The interaction between Fit and Target Segment was also significant, $F(1,88) =$

48.6, $p < .001$. For resonant targets, the error rates in the match and mismatch conditions were virtually identical, but for fricative targets the errors in the mismatch condition were significantly higher than in the match condition. Mean and standard deviation proportions for the four cells of the design are shown in Table 1.

Table 1: *Proportion means and standard deviations of errors in experiment 1*

	Match	Mismatch
Fricatives	0.26 (0.06)	0.54 (0.10)
Resonants	0.46 (0.10)	0.47 (0.09)

3.3. Discussion

Resonant targets showed no difference in the match and mismatch conditions, but fricative targets showed a significantly higher error rate in the mismatch than in the match condition. This pattern is very similar to that for fricatives compared to stops found previously [11]. Fricatives showed far more errors in the mismatch than in the match condition, but stops showed no differences in these two conditions. A similar pattern appears when obstruents are compared to resonants [1]. The obstruents showed far more errors in the mismatch than in the match condition, but resonants showed no differences. Arguably, the high error rate in the mismatch condition for obstruents was caused by the fricatives in the obstruent materials.

4. Experiment 2

In Experiment 2 we used stops as targets instead of the fricatives used in Experiment 1.

4.1. Method

4.1.1. Participants

Eighty students from the same pool used in Experiment 1 participated. No participant from Experiment 1 also participated in Experiment 2.

4.1.2. Materials

The eight target segments were /p, t, k, b, d, g/ plus the two affricates /tʃ, dʒ/. Otherwise, the materials were developed in the same manner as used in Experiment 1.

4.1.3. Procedure

The procedure was the same as in Experiment 1.

4.2. Results

The data were scored in the same manner as in Experiment 1. Means and standard deviations for the proportions of errors are shown in Table 2.

Table 2: *Proportion means and standard deviations of errors in Experiment 2*

	Match	Mismatch
Stops	0.46 (0.08)	0.60 (0.09)
Resonants	0.45 (0.08)	0.51 (0.07)

We performed an analysis of variance (ANOVA) on the errors using a 2 x 2 design having Fit (match, mismatch) and Target Segment (stop, resonant) as between-subject variables. The analysis showed significant main effects for both Fit and Target Segment, $F(1,77) = 32.59$, $p < .001$ and $F(1,77) = 8.38$, $p < .005$ respectively. The interaction between Fit and Target Segment was also significant, $F(1,77) = 5.16$, $p < .05$. Resonant targets showed no differences between match and mismatch conditions, but stop targets showed significantly more errors in the mismatch than in the match condition.

4.3. Discussion

Resonant targets showed no differences in the match and mismatch conditions, but stop targets showed more errors in the mismatch than in the match condition. The pattern is the same as seen in [1], which compared the more general class of obstruents to resonants.

5. Comparison between experiments

The designs for Experiments 1 and 2 were identical, so it was possible to enter them in a combined statistical analysis. Mean error rates for the eight conditions are shown in Table 3.

Table 3: *Proportion means and standard deviations of errors in Experiments 1 and 2.*

	Match	Mismatch
Experiment 1		
Fricatives	0.26 (0.06)	0.54 (0.10)
Resonants	0.46 (0.10)	0.47 (0.09)
Experiment 2		
Stops	0.46 (0.08)	0.60 (0.09)
Resonants	0.45 (0.08)	0.51 (0.08)

We performed an ANOVA on the errors using a 2 x 2 x 2 design having Fit (match, mismatch), Target Segment (obstruent, resonant), and Experiment (1, 2) as between-subject variables. The main effects for Fit and Experiment were significant, $F(1,165) = 87.22$, $p < .001$ and $F(1,165) = 25.3$, $p < .001$ respectively. The Fit x Target interaction was also significant, $F(1,165) = 43.82$, $p < .001$, as were the Target x Experiment and Fit x Target x Experiment interactions, $F(1,165) = 18.4$, $p < .001$ and $F(1,165) = 12.88$, $p < .001$ respectively.

The triple interaction showed errors in the match and mismatch conditions to be essentially the same for resonants in both experiments. Errors in the mismatch condition were significantly higher for both stops and fricatives, with the difference being greater for fricatives than for stops.

6. General Discussion

As expected, the feature [sonorant] manifested itself in the ease with which participants recovered target words. When the replacing segment matched the target segment on the feature [sonorant], errors were fewer than when the replacing segment did not match. This effect appeared for stop and fricative targets but not for resonant targets. If we combine the effects for stops and fricatives, the joint effect is the same as observed between obstruents and resonants in Marks, et al. [1].

Comparing stops and fricatives separately to resonants showed that both stops and fricatives contribute to the obstruent effect. In the present study, fricatives showed a greater difference between match and mismatch conditions (0.28) than did stops (0.14), so fricatives arguably contributed more heavily to the obstruent effect observed in Marks, et al. [1].

Why do obstruents show this effect but resonants do not? The class of sonorants includes vowels, though vowels were not used in the present study. Vowels have been shown to be more easily processed in the word reconstruction task than consonants (1,7,9). This ease of processing may apply to all sonorants, not just vowels. A test of this hypothesis should be the next step in exploring how the feature [sonorant] influences lexical access.

Three models of spoken word recognition incorporate feature processors: Trace [12], the Distributed Cohort Model [13, 14,15] and Stevens' Feature-Based Model [16]. Arguably, all can explain why a mismatch on the feature [sonorant] reduces access to the target word, but it is not clear that any can explain why that effect occurs for obstruents but not resonants.

7. References

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