THE EFFECT OF SPEECH STYLE AND DEACCENTUATION ON VOWEL INTRUSION IN TURKISH COMPLEX ONSETS

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ABSTRACT

Inserted vowels, common in loanword phonology, are typically assumed to be epenthetic, but can also be intrusive – the result of an open transition between adjacent consonant gestures. Inserted vowels in onset clusters in Turkish loanwords, I argue, are such intrusive vowels, rather than being harmonizing epenthetic vowels as previously claimed ([7], [20], [13], [21]).

Acoustic data from a production experiment with six speakers shows that onset-repairing vowels are shorter than underlying vowels. They are also more affected by the following vowel, particularly in deaccented casual speech. Furthermore, a switch from careful to casual speech significantly shortens underlying vowels, but not inserted vowels, suggesting that even in careful speech, the duration of non-lexical (intrusive) vowels is already reduced to the limits of what Turkish gestural timing allows. These results have implications for Turkish syllable structure, vowel harmony, and the phonologization of vowel insertion.

Keywords: vowel intrusion, Turkish, deaccentuation, vowel harmony, gestural timing

1. VOWEL INSERTION

While inserted vowels are often assumed to be phonologically-present epenthetic vowels, they can also be intrusive vowels with no phonological presence, which result from an open transition between adjacent consonants (e.g., [19], [9], [8], [11], [12]). Both epenthetic and intrusive vowels occur in Turkish. Illicit coda clusters (1a,b) are repaired with epenthesis of a high vowel that harmonizes with the preceding lexical vowel according to the standard Turkish progressive backness and rounding harmony [7]. This inserted high vowel is always written, and can host stress.

(1) a. *sabır* [sab**ɯ**r] ~ [sabr.a] 'patience.(DAT)'
b. *burun* [bur**u**n] ~ [burn.a] 'nose.(DAT)'
c. *prens* [p**i**rens] 'prince'
d. *spor* [s**ɯ**por] ~ [s**i**por] 'sport'

Previous reports ([7], [20], [13], [21]) also describe insertion in onset clusters (1c,d) as harmonizing epenthesis. Under this analysis, Turkish phonology prohibits onset clusters, even in loanwords, and allows regressive as well as progressive vowel harmony. However, unlike true epenthetic vowels in Turkish, onset-repairing vowels do not consistently harmonize, are prescriptively unwritten, and reportedly vary according to speech style—[7] claims they only occur in causal speech.

These differences between coda- and onset-repairing insertion in Turkish are explained if onset cluster repair is intrusion, not epenthesis. In vowel intrusion, the timing of adjacent consonant gestures creates the percept of an intervening vowel, whose quality is determined by the gestural demands of the surrounding context. Because they reflect gestural timing, intrusive vowels often disappear in fast or casual speech ([11], [12]).

1.1. Acoustics of Turkish onset-repairing vowels

[3], on which this study builds, provides an acoustic study of non-lexical onset-repairing vowels in careful speech, in real and nonce words beginning with /br dr gr/ onset clusters, followed by /i a o/. Six Turkish speakers (three male; ages 18-35) participated, and repeated each word five times in a carrier sentence. Participants were instructed to speak carefully, and the carrier sentence elicited contrastive focus on the target words.

Underlying onset clusters produced with ≥ 20 ms of high amplitude formant structure during the interconsonantal interval (ICI) were coded as containing an inserted non-lexical vowel. Non-lexical vowels were present in 88.3% of underlying clusters in [3]. The duration of non-lexical vowels had a unimodal distribution, indicating onset cluster repair is a gradient process, rather than an optional categorical process (which would result in two modes). Non-lexical vowels were significantly shorter than lexical vowels, suggesting they lack a durational target. Their F1~F2 values were more affected by coarticulation with the following vowel than the formant values of underlying vowels were. This is expected if non-lexical vowels are targetless, since the coarticulatory impact of the following vowel [16] affects the ICI more strongly in the absence of a specified vocalic target there. The consonantal context is also expected to be have a stronger effect on a targetless vowel, although this prediction was not supported in [3].

Contrary to previous descriptions of onset-repairing vowels as targets for phonological vowel harmony, non-lexical vowels <v> in [3] more closely resembled the schwa-like /ɯ/ than harmonizing /i/ or /u/. This discrepancy may be explained by differences in the speech styles under consideration. [3] considers careful laboratory speech, whereas previous impressionistic reports probably refer to more casual, naturalistic speech. If onset cluster repair results from gestural timing relations in Turkish, onset repairing vowels may take on more of the characteristics of a following vowel in speech styles and prosodic conditions where gestures tend to overlap more.

2. CASUAL AND DEACCENTED SPEECH

The present study extends [3] to incorporate casual and deaccented speech, and to further probe a possible interaction between a vowel's lexical status and the degree to which a preceding consonant gesture affects it.

In casual, fast speech, gestures overlap more, producing greater coarticulatory effects compared to careful, hyperarticulated speech, where gestures tend to pull apart ([5], [15], [10]). If onset cluster repair is driven by gestural timing relations, then we would expect it to behave differently in casual speech (more gestural overlap) than in careful speech (less gestural overlap). In casual speech, the gesture for the following lexical vowel will overlap the ICI more, potentially causing the non-lexical vowels to take on more of the backness and rounding of the following lexical vowel. This may create the percept of harmony previously reported. [7] describes harmonizing vowel insertion in casual speech only (no insertion in careful speech).

To test speech style effects, I collected casual speech using the same methods and participants as [3], but with a different carrier sentence (2) that elicited the deaccentuation of targets (X_2, Y_2).

(2) Fatma X_1 ve Y_1 dedi, Erhan da X_2 ve Y_2 dedi.
'Fatma said X and Y, Erhan also said X and Y.'

Targets X and Y were real and nonce words beginning with /CrV/, where C = /b, d, g/ and V = /i a o/; /CV_1rV_2/ words were also included as controls. Participants were instructed to pretend they were talking with a close friend. They read each list five times. Casual speech was collected after Careful speech. Careful speech was the same dataset as [3].

If non-lexical vowels are targetless, we expect differences in their durations and formant values compared to underlying vowels, which have durational and gestural targets. With the greater gestural overlap in Casual speech, both the preceding consonant and following vowel may affect the intrusive vowel more strongly. For example, in Careful speech, intrusive vowels before /i/ were intermediate between a front vowel /i/ and a back vowel /ɯ/ [ANON]. In Casual speech, the gesture for the following /i/ may overlap with the ICI more, making intrusive <i> more /i/-like. Greater gestural overlap could also cause the preceding consonant to have a larger impact on the ICI. Hence, the vowel's lexical status is predicted to interact with its host word's prosodic status and speech style (focused, in Careful speech; first mention in Casual speech; or deaccented second mention in Casual speech), as well as its surrounding consonants and vowels.

3. DURATION OF <V> IN CASUAL SPEECH

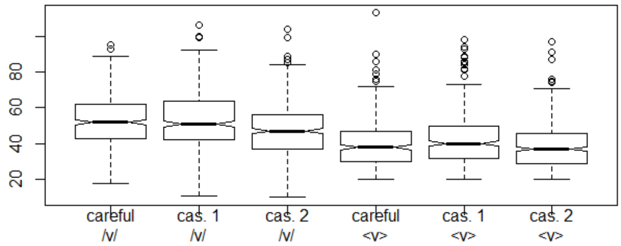
Using 20 ms of formant structure during the ICI as the threshold for whether a token contained a non-lexical vowel (the same threshold as [3]), insertion rates in the Casual condition varied by subject from as low as 60% (S3) to as high as 99% (S4), with an average of 87% – practically the same as the 88% insertion rate in Careful speech.

I conducted a mixed effects linear regression analysis of vowel duration, using R [18], lmer [2], and lmerTest [14], with random slopes and intercepts by subject for lexical status, V2, and speech style. Fixed effects were: speech style, preceding consonant /b d g/, following vowel /i a o/, and the vowel's lexical status and hypothesized category. Since non-lexical vowels have no underlying category, they were assigned to the hypothesized categories [i] before V2 = /i/, [u] before V2 = /o/, and [ɯ] before V2 = /a/, according to the predictions of [7] and [21].

The best-performing model included three interactions: C with speech style, lexical status with V2, and lexical status with speech style. It outperforms a model without the vowel's lexical status in a maximum likelihood ratio test ($\chi^2(11)$ = 759.56, $p < 0.0001$). Speech style had a significant main effect, with vowels in the Casual second mention being 6.21 ms shorter ($\varepsilon = 1.60$, $p = 0.001$) than in Careful speech. This shortening of lexical vowels confirms that second mentions were indeed deaccented.

Lexical status also had a significant main effect, with non-lexical vowels being 7.76 ms shorter than lexical vowels ($\varepsilon = 3.06$, $p < 0.05$). But Casual non-lexical vowels were longer than would be expected given those main effects alone, in both first (β = 3.26, ε = 1.06, p < 0.005) and second mentions (β = 4.60, ε = 1.08, p < 0.001). That is, the duration of non-lexical vowels is more stable under changes in speech style (≈ degree of gestural overlap) than that of lexical vowels (Figure 1).

Figure 1: Duration (ms) of lexical vowels /V/ and non-lexical vowels <v> by speech style.



This suggests that even in the less-overlapped Careful speech, the two consonant gestures in underlying onset clusters are already coordinated almost as closely as Turkish gestural timing allows them to be. Consequently, they cannot overlap much more even in casual, deaccented speech.

4. F1 AND F2 IN CASUAL SPEECH

To test for the predicted effects of speech style on the quality of non-lexical vowels, I conducted a mixed effects linear regression analysis of F1 and F2 within each V2 condition. Fixed effects were the vowel's lexical status, the preceding consonant (reference = /d/), and speech style (reference = Careful), as well as the interaction of lexical status with speech style and with the preceding consonant. Models included random slopes and intercepts for lexical status, consonant, and speech style, by subject, and were tested against each other using maximum likelihood ratio tests.

4.1. Speech style effects on F1

For vowels before /i/, a model of F1 that includes a three-way interaction between preceding consonant, prosodic condition, and word shape outperformed other models in maximum likelihood ratio tests (all *p*s<0.05), although lmerTest [14] assigned the individual three-way interaction terms *p* > 0.1. The only significant effect involving the vowel's lexical status was an interaction with a preceding /b/ (β = 29.0 Hz, ε = 9.18, p < 0.005): after /b/, non-lexical <i> had a raised F1 compared to lexical /i/.

In the other two vowel conditions (V2 = /o/, V2 = /a/) the best-performing model of F1 included an interaction between the vowel's lexical status and speech style. However, in neither model were any of the individual effects significant.

4.2. Speech style effects on F2

I conducted a mixed effects linear regression analysis of F2 following the same procedure as for F1, again including only harmonic lexical vowels.

4.2.1 F2 differences before /i/

For the F2 of vowels before /i/, the best-performing model included two-way interactions between lexical status and preceding consonant, and lexical status and prosodic condition (Table 1). There was a significant main effect of lexical status, with F2 being lower in non-lexical vowels than in lexical /i/ (β = -224.75, ε = 61.14, p<0.01), in line with the hypothesis that non-lexical vowels lack /i/'s [-back] target.

Table 1: Fixed effects for F2 before /i/. F2 ~ /Cr/ * style + C * /Cr/ + (/Cr/ + C + style | subj)

	β	ε	p
(Intercept)	1970.8	75.6	< 0.001
/Cr/	**-224.8**	**61.1**	**0.001**
Casual 1	-16.5	23.0	0.49
Casual 2	**-52.4**	**17.5**	**0.004**
/b/	128.0	55.8	0.065
/g/	**157.6**	**39.8**	**0.007**
/Cr/: Cas1	16.6	24.1	0.49
/Cr/: Cas2	**50.1**	**24.2**	**0.039**
/Cr/: /b/	**-196.3**	**24.4**	**< 0.001**
/Cr/: /g/	**-128.7**	**24.4**	**< 0.001**

Non-lexical vowels preceded by /d/ had a higher F2 than those preceded by /b/ (β = -196.32 Hz, ε = 24.4, p < 0.001) or /g/ (β = -128.69 Hz, ε = 24.43, p < 0.001). In contrast, among lexical vowels, a preceding /g/ increased F2 significantly (β = 157.6 Hz, ε = 39.8, p < 0.01) compared to a preceding /d/. This interaction between the preceding consonant and a vowel's lexical status suggests that /d/ has a much larger raising effect on the F2 of non-lexical vowels than lexical vowels, in keeping with the hypothesis that non-lexical vowels are targetless and therefore more subject to coarticulatory effects from all sides. In contrast, when the adjacent vowel is lexical and has its own target, whatever F2-raising effect /d/ may have is outdone by other properties of /g/ (perhaps /g/'s tendency as a dorsal consonant to assimilate in place to an adjacent vocalic target).

Speech style or prosodic condition had a significant main effect, with F2 being significantly lower in lexical vowels in Casual second mentions compared to Careful focused speech (β = -52.35 Hz, ε = 17.54, p < 0.005). However, non-lexical vowels in Casual second mentions had a significantly higher F2 ($\beta = 50.07$ Hz, $\varepsilon = 24.21$, $p < 0.05$) compared to their Careful counterparts, suggesting that the deaccented, Casual speech condition causes the following /i/ gesture to overlap the preceding ICI and its non-lexical vowel more, as predicted.

To summarize, non-lexical vowels before /i/ have a lower F2 than lexical /i/, as expected if they are targetless. This difference is mitigated when the preceding consonant is coronal, presumably since /d/ raises F2. Furthermore, in deaccented Casual speech, F2 is diminished in lexical vowels, but increased in non-lexical vowels.

4.2.2. F2 differences in [u] before /o/

Comparing the F2 of lexical /u/ and non-lexical <u> before /o/, the best-performing model includes significant interactions of lexical status with both speech style and the preceding consonant and speech style. Only the interaction with the consonant is individually significant – F2 in non-lexical <u> is higher after /g/ than after /b/ ($\beta = 202.7$ Hz, $\varepsilon = 32.2$, $p < 0.0001$), reflecting /b/'s lowering effect on F2. That is, the preceding consonant has a stronger coarticulatory effect on non-lexical (targetless) <u> than on targeted /u/.

4.2.3 F2 differences in [ɯ] before /a/

The best-performing model of [ɯ] before /a/ includes significant interactions of speech style with lexical status and consonant. No effects involving lexical status were significant within the model, although there are significant interactions between speech style and the preceding consonant. As expected, F2 is significantly lower after /b/ ($\beta = -201.7$ Hz, $\varepsilon = 40.0$, $p < 0.005$). In /d/ conditions, F2 is higher in Casual speech (Casual, first mention: $\beta = 80$ Hz, $\varepsilon = 23$, $p < 0.005$; Casual, second mention: $\beta = 65$ Hz, $\varepsilon = 20.6$, $p < 0.005$). But this F2-raising in Casual speech is reversed after /b/ (Casual, first mention: $\beta = -62.17$ Hz, $\varepsilon = 20.65$, $p < 0.005$; Casual, second mention: $\beta = -45.88$ Hz, $\varepsilon = 20.80$, $p < 0.05$) and /g/ (Casual, first mention: $\beta = -71.59$ Hz, $\varepsilon = 19.63$, $p < 0.001$; Casual, second mention: $\beta = -56.05$ Hz, $\varepsilon = 19.86$, $p < 0.005$).

5. DISCUSSION

This study hypothesized that onset cluster repair in Turkish results from gestural timing, and predicted that a change in speech style—and the degree of gestural overlap—would affect non-lexical vowels more than lexical vowels. As predicted, the change in speech style caused significant acoustic differences in all vowels, but the direction and magnitude of the changes depended on the vowel's lexical status. All vowels, regardless of lexical status, are shorter in deaccented second mentions, but the duration of non-lexical vowels does not change as much as that of lexical vowels, contradicting the cross-linguistic tendency of intrusive vowels to disappear in fast speech [12]. This indicates that Turkish phonology must specify a gestural phasing between the two consonants that minimizes C_1-C_2 overlap, ensuring open transitions.

The differences in formant values were clearest before V2 = /i/. Deaccented speech decreases F2 in lexical /i/, but increases F2 in non-lexical vowels. This suggests that /i/'s front tongue body target is undershot in deaccented casual speech, while targetless intrusive vowels gain a higher F2 by virtue of the following /i/'s greater overlap with the ICI.

This study also found that the preceding consonant affected non-lexical vowels more than lexical vowels. A preceding /d/ increases F2 more in <i> than in /i/, and /b/ decreases F2 more in <u> than /u/. Such differences are expected if the acoustics of non-lexical vowels in Turkish onset clusters are determined by gestural pressures from the surrounding context, as in vowel intrusion.

While intrusive vowels are often said to vary with speech style, few studies directly compare their properties in different speech styles. This study set out to do so, and found differences between careful and casual speech, even in the laboratory setting. Greater acoustic differences – perhaps reflecting a greater change in the degree of gestural overlap – occurred when target words were not only produced with a "casual" speech style, but were also deaccentuated, because they occurred in a given-information, second-mention context. Many of the interaction effects between lexical status and speech style in this study were only significant when Careful, focused speech was compared to Casual, deaccented speech—illustrating the gradient nature of speech style and gestural overlap.

This understanding of onset cluster repair as vowel intrusion has implications for Turkish phonology. If onset-cluster "repair" does not actually change the phonological structure of the word, then it is not a repair *per se*, and Turkish syllable structure must tolerate onset clusters, at least in loanwords. Furthermore, if the vowels in onset clusters are not independent phonological objects, they cannot be targets for phonological vowel harmony, and should not be used as evidence for the directionality of Turkish vowel harmony ([7], [20], [1], [13]). Lastly, Turkish exemplifies phonology's grammatical specification of gestural alignment, as previously argued by, e.g., [9], [12], [19].

6. REFERENCES

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