Anticipatory and Carryover Coarticulation in Turkish

Aline ASCI, Béatrice VAXELAIRE, Véronique FERBACH-HECKER & Mélina GUEDET
Institut de Phonétique de Strasbourg - E .A. 3403 - Université Marc Bloch – 22 rue Descartes – 67084 Strasbourg France
aline_asci@hotmail.com

ABSTRACT

This investigation is based on X-ray and acoustic data and looks at vocalic anticipatory and carryover effects on adjacent consonants in Turkish. Consonant-Vowel-Consonant-Vowel (C1V1C2V2) sequences and Vowel-Consonant + Consonant-Vowel (V1C1C2V2) sequences are embedded in short carrier sentences. In the C1V1C2V2 context, the vowels are either /y/ and/or / ø / and the consonants are either /s/, /g/ or /t/. Such sequences should allow investigating the effects of anticipatory rounding from the vowels to the contiguous consonants and also the effects of carryover coarticulation from V1 on C2. In the V1C1C2V2 context, the vowels are always /y/ and CC is the /st/ cluster. The latter sequence should serve in observing the effects of anticipatory and carryover gestures from the rounded vowels onto the cluster. Two speakers produced the sentences at a normal speaking rate.

1. INTRODUCTION

Phonological rules determine the typical structure of words in a language, and this is particularly true for Turkish.

Turkish, with reportedly eight vowels, /i ɪ ɛ a o ø u y/ in its vowel system, is usually considered as an agglutinated language that obeys vowel harmony and labial attraction rules (ASCI, 2002 [1]). This means that the following vowel assimilates to the preceding vowel in frontness, *i.e.* front vowels must be followed by front vowels and back vowels must be followed by back vowels. A following high vowel assimilates to the preceding vowel in rounding, *i.e.* high vowels are rounded after a round vowel and un-rounded after an un-rounded vowel (BOYCE, 1989 [3]).

Reported findings (e.g. MacAllister, 1978 [4]; Bell-Berti & Harris, 1982 [2]; Perkell et al. 1993 [7]; Recasens, 1985 [9]) suggest that anticipatory coarticulation has more pronounced effects than carryover coarticulation. However, due to vowel harmony constraints discussed above, the phonological weight of the first vowel might override the predominance of anticipatory coarticulation on carryover coarticulation. The target words examined here should help verify some of these findings and eventually compare the effects of anticipatory coarticulation with those related to carryover coarticulation. Analyses carried out for the /syty/ sequence should give some insights into the effects of anticipatory coarticulation of V1 on /s/ and of V2 on /t/. This sequence should also provide information on carryover effects of V1 on /t/. In the final analysis, configurational modifications of /t/ by a-two-way vocalic coarticulation will also be examined.

As concerns the /gøty/ sequence, V1 and V2 anticipatory effects on /g/ and /t/ respectively, will be studied. Carryover effects of V1 on /t/ may also be observed. As in the previous context, the combined effect of the flanking vowels on the intervocalic plosive /t/ will also be investigated.

In the /ysty/ sequence, it is the anticipatory effects of V2 on /t/ that will first be analysed and, eventually, the propagation of the V2 effects on /s/. However, the latter influence should be less likely as a syllable boundary occurs between the two consonants. Next, an observation of the carryover effects of V1 on /s/ will be made to determine the extent of labialisation spreading-out up to /t/ as a potential result of the phonological weight of the first vowel, discussed earlier.

It is hypothesized that:

- /t/ flanked by two high-closed rounded vowels /y/ will undergo more labialisation than /t/ in the /øty/ context as /y/ is intrinsically more protruded than /ø/;
- /s/ in the sequence /sy/ will be less labialised than /s/ in the sequence /ys/ following predictions related to phonological constraints, but contrary to MacAllister, 1978 [4]).

2. METHOD

The corpus consisted of 44 sentences that embedded the target words (ASCI, 2002 [1]). The three words extracted from this corpus to specifically look at coarticulatory phenomena were: /syty/, /gøty/ and /ysty/. These words provided the following sequences:

(1) C1+V1rounded+C2+V2rounded; (2) V1rounded+C1+C2+V2rounded (with no intrusive vowel between C1 and C2). The rounded vowels were either /y/ or /ø/. Two speakers uttered the speech samples at a normal speaking rate. X-rays and a simultaneous audio recording of the speakers' productions were obtained under medical care. These sequences allowed detailed examination of vocalic anticipatory and carryover coarticulation on consonants /s, t, g/. The temporal extents

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of anticipatory and carryover labial and lingual activities were thus observed.

With the help of a grid, measurement parameters for vocal tract configurations were determined on sagittal profiles related to: (1) upper lip position, horizontal and vertical displacements; (2) lower lip position, horizontal and vertical displacements; (3) lip opening or the vertical distance between the upper and lower lips; (4) jaw position, vertical and horizontal displacements; (5) tongue-tip vertical displacement, monitored following a specific point in the alveolar region of the grid, where contact or consonantal constriction would be located; (6) tongue-body displacement, monitored following a specific point in the velar region of the grid, where contact would occur ; and (7) tongue-body displacement, monitored following a specific point in the palatal region of the grid, where constriction for vowel formation would occur. Temporal events were detected on the audio signal and specific timing relations between these events allowed determining, in the CVCV and VCCV domains, acoustic durations that correspond to articulatory opening and closing gestures.

3. RESULTS AND DISCUSSION

Timing of Gestures

The C1V1C2V2 domain /syty/

Results show for speaker A (see Figure 1) that all gestures corresponding to the production of both rounded vowels /y/ are initiated in articulatory configurations corresponding to the production of the preceding consonant /s/ (frames 3 to 8). Thus upper lip protrusion and reduction of palatal constriction, due to tongue body raising, are anticipated during the production of the fricative consonant (frames 3 to 8).

Peak protrusion is, as expected, attained at the acoustic onset of rounded vowel V1 and is maintained throughout vocal tract configurations, corresponding to the formation of this vowel (frames 9 and 10). A 5 mm increase in peak protrusion is observed from /s/ configurations to V1 configurations, and even to early configurations of the apical plosive /t/, well after the acoustic offset of the rounded vowel. The latter effect corresponds to carryover coarticulation.

Minimum dorso-palatal vowel constriction is observed during the production of the apical plosive (frame 13). This reduction in the diameter of the constriction is in fact a vowel-to-vowel gesture that is imposed on the production of the plosive (frames 12 to 15).

The figure shows that upper lip protrusion diminishes during the production of V2, even though this vowel is intrinsically a rounded vowel. This can be explained by the fact that in Turkish, it is the first vowel that determines the phonological feature of vowels in subsequent syllables. Hence, the phonological weight being determined, rounding of subsequent vowels will be an imposed factor rationalized in terms of vowel harmony and labial attraction. The phonological characteristics thus being focused on V1, all other properties conveyed to V2 may therefore be secondary and could be less prominent. Relative un-rounding of V2 is consequently observed in certain cases, regardless of the adjacent context.

The timing of anticipatory and carryover gestures is structurally similar for speaker M. However, un-rounding of V2 is more pronounced for this speaker. It should be made clear that this loss of labialisation is not systematically observed and that, in some cases, protrusion could either be maintained or even enhanced.

The C1V1C2V2 domain /gøty/

The data for this sequence (Figure 2) indicate that upper lip protrusion for the production of /ø/ is at its maximum even before the production of the velar consonant /g/ (frames 1 to 4). In fact maximum amplitude of this gesture is maintained constant throughout the entire sequence (hence the plateau effect in Figure 2). Since no significant un-rounding of V2 is noticed in this context, labialisation of the apical consonant /t/ (frames 9 to 12) may be attributed to the combined effect of the flanking vowels /ø/ and /y/. The latter effect is the result of vocalic anticipatory and carryover mechanisms. Notice that after tongue dorsum release for /g/ (frames 1 to 4), stability of constriction area is due to both rounded vowels that share the same constriction location, thus conveying, here also, anticipatory and carryover lingual effects to the apical consonant.

The V1C1C2V2 domain /ysty/

In this context, it should be noted that labialisation is present before the acoustic emergence of the sequence (frames 1 to 3 in Figure 3), *i.e.* during the pre-phonatory silent phase. The consonant sequence /st/ then undergoes influences from the surrounding rounded vowels. This is especially visible for the protrusion gesture, where upper lip protrusion, that is visible before acoustic onset of the first vowel (frames 1 to 4), gradually increases throughout both consonants, attaining its peak value during configurations associated with production of C2. Thus labialisation of these consonants is due to both carryover and anticipatory effects. Here also, it seems that when the protrusion gesture has been initiated for V1, it is maintained throughout the entire sequence and imposed on V2. A slight un-rounding of V2 is also noticeable here, thereby resembling the scenario already seen in the /syty/ context. Regarding constriction size, it is reduced as from onset of V1 and sustained throughout the sequence, with reinforcing constriction constraints emanating from V2.

As concerns initial hypotheses, /t/, flanked by /y/ in the /yty/ context does not undergo more labialisation than /t/ in the /øty/ context, contrary to our expectations (compare Figures 4 and 5). Such a finding could be attributed to the following fact: V2 in the /yty/ context undergoes a noticeable un-rounding whereas V2 in /øty/ does not, an un-rounding that reduces the impact of the two-way coarticulatory effects on the intervocalic consonant in the first context. As predicted, /s/ followed by /y/ is more labialised than /s/ preceded by /y/ (compare degree of lip opening in Figures 6 and 7).

4. CONCLUSIONS

The effect of position of the vowel in the sequence is clear. Thus V1 is characterized by a more pronounced labialisation than V2, everything else being equal. A comparison can therefore be made between the two vowels in the /syty/ and /ysty/ sequences, revealing a relative unrounding of V2. Such a remark is difficult to make in the /gøty/ sequence, as the two vowels do not intrinsically have the same degree of labialisation. The weight of the first vowel /ø/ sems therefore to be contradicted by the highly protruted phonetic characteristic of V2 /y/, resisting the usually observed un-rounding.

Both phonological factors related to vowel harmony and phonetic mechanisms that determine coarticulatory directions seem to be at work here. If vowel harmony constraints impose carryover rounding on subsequent vowels when V1 is rounded, they do not necessarily determine the amplitude of anticipatory gestures. Thus the /s/ in the sequence /ys/ is subject to the carryover vowel-to-vowel harmony gesture and it is more labialised (protruded) than the /s/ in the /sy/ context. However, due to anticipatory coarticulation, the /s/ in the latter case is still remarkably labialised.

It has been shown in related studies (e.g. Abry & Lallouache, 1995 [8]; Vaxelaire et al., 1999 [6]; Maeda, 1999 [5] and Hecker, 2002 [10]) that some of these coarticulatory gestures are necessary requirements for appropriate auditory and visual perception of sounds. Preliminary work is investigating the auditory effects of these gestures, especially in the anticipatory domain.

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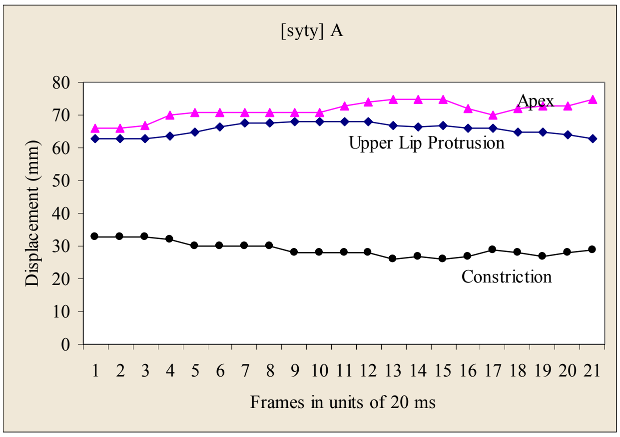

Figure 1. Frame by frame analysis for /syty/. Speaker A

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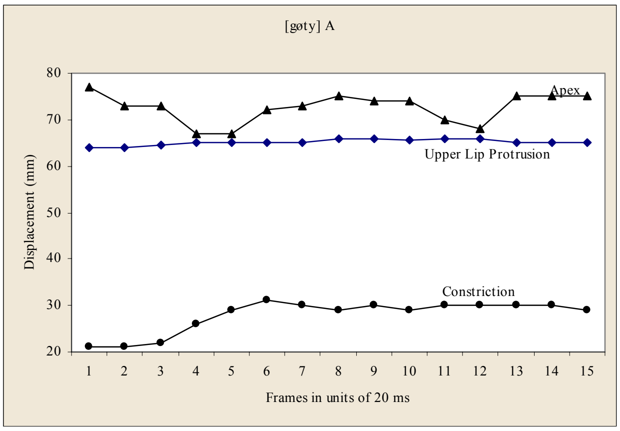

Figure 2. Frame by frame analysis for /gøty/.
Speaker A.

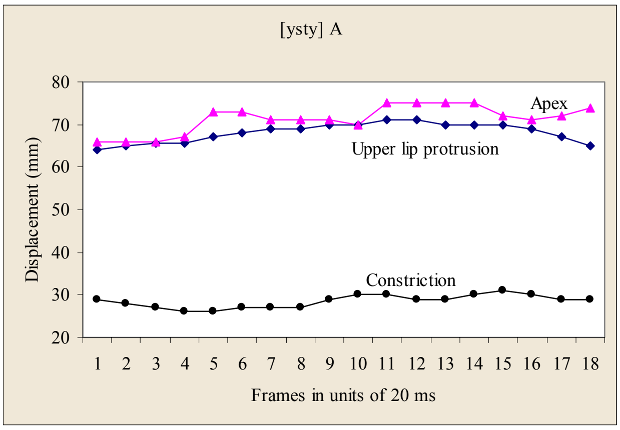

Figure 3. Frame by frame analysis for /ysty/.
Speaker A.

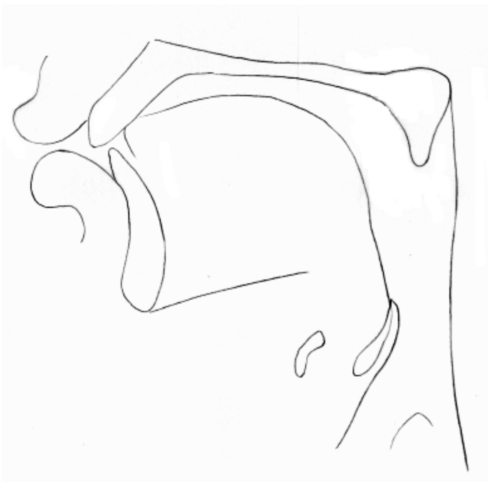

Figure 4. Vocal tract sagittal profile for /t/ in /syty/.

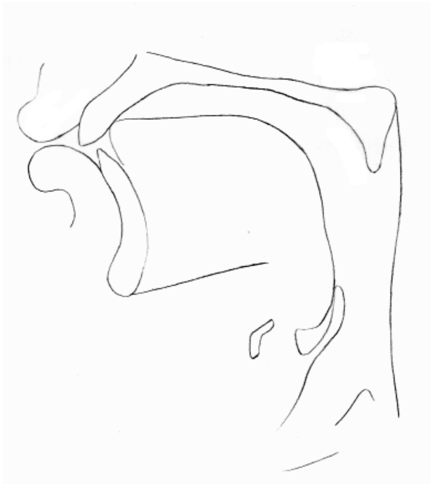

Figure 5. Vocal tract sagittal profile for /t/ in /gøty/.

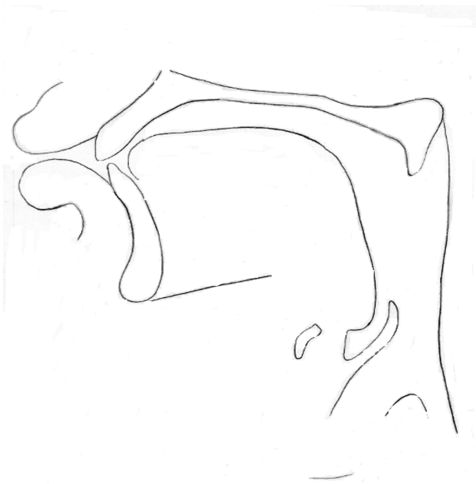

Figure 6. Vocal tract sagittal profile for /s/ in /ys/

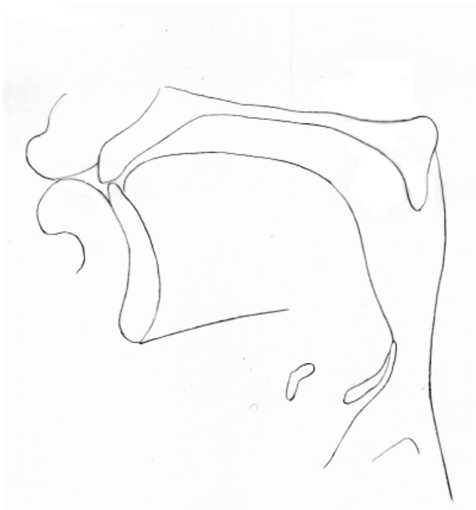

Figure 7. Vocal tract sagittal profile for /s/ in /sy/