CONSONANTAL AND VOCALIC GESTURES IN THE ARTICULATION OF ITALIAN GLIDE /W/ AT DIFFERENT SYLLABLE POSITIONS

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1. ABSTRACT

Glides have been a challenging sound category from both a phonological and phonetic perspective and this is especially true for Italian. In this language four different glides can be distinguished based on their position in a syllable (pre or post-vowel), grouped together as either "semi-consonanti" (/j/ and /w/) or "semi-vocali" (/i̯/ and /u̯/). As most studies on Italian glides have utilized acoustic data, there is little information on actual articulatory characteristics. In this paper, we present a detailed kinematic analysis of both consonantal and vocalic gestures involved in the production of one specific glide (/w/) using 3D electromagnetic articulography (EMA). The findings allow us to distinguish between different theoretical frameworks on the nature of glides and interpret possible changes in their production in relation to variations in speech rate and position in the syllable.

2. INTRODUCTION

From a phonological point of view, Italian has two phonemes, /j/ and /w/ in word-initial position preceding a vowel (V) (on-glides, respectively it. "iodio" and "uomo"), and has two positional, non/syllabic, variants of the corresponding vowels, /i̯/ and /u̯/ following a vowel (off-glides, respectively it. "daino" and "auto"). The former are also known as "semiconsonanti" when they form diphthongs with the following vowel (as in "iodio" and "uomo"), and the latter as "semivocali" when they form diphthongs with the previous vowel (as in "daino" and "auto", see Marotta, 1988; Nespor, 1993; Schmid, 1999; Bertinetto & Loporcaro, 2005). In the following, we will subsume on- and off-glides under the same phonetic labels [j] and [w].

Generally speaking, in both phonological and phonetic theories, glides present a number of open questions, ranging from the definition of the necessary and sufficient features for their identification (Chitoran & Nevins, 2008), to their characterisation at the acoustic and articulatory level of speech production (Gick, 2003). This situation is even more problematic when Italian glides are considered.

The attempts to distinguish them from prototypical consonants and vowels have always oscillated between a featural position and a structural position. Proponents of the first view (Featural Hypothesis) assume that glides like [w] and possibly [j] are less vocalic than vowels like [i] and [u] because they have a greater constriction degree than corresponding vowels (Nevins & Chitoran, 2008). Others capitalise on different features, like the absence of a stable acoustic or articulatory target position, but this is more controversial (see Maddieson, 2008). Proponents of the second view (Structural Hypothesis) assume that the difference with vowels is not due to a different feature value of glides but to a different timing relationship between their constituting gestures with the ones of the syllabic nuclei (Gick, 2003). This is a process that can be modelled in the gestural theory of speech production (Goldstein et al., 2006): glides are said to be composed of two types of gestures, C-gestures (consonantal in nature) and V-gestures (vocalic in nature), which are phased with respect to each other in fixed, language specific patterns, and this phase lag also depends on the syllabic position. In English, the C-gesture of initial allophones (of glides) is greater in magnitude than the C-gesture in final allophones, and it temporally precedes the V-gesture, whereas in final allophones, C-and V-gestures are phased more closely together. Ambisyllabic allophones behave somewhat in between these characteristics found for initial and final allophones. In other words, final allophones are more vowel-like and initial allophones are more consonant-like (Gick, 2003).

The production of glides have mostly been studied by means of acoustic analysis, which does not provide clear information on the actual gestural configurations of their production. Movement studies so far are rare and for Italian there is only one preliminary articulatory study conducted by means of the Reading EPG system (Calamai & Bertinetto, 2006). Although the authors deserved a relatively marginal consideration to the articulatory differences between omorganic vowels and semiconsonants, they reported that, quite unexpectedly because contrary to the results for English, in the shift from /i/ to /j/, and from /u/ to /w/, the global tongue-palate contacts tend to reduce. However, due to spatial limitations in the number of electrodes that are contacted by the tongue during glide productions and a relatively low sampling frequency (100 Hz), EPG is not particularly suited for studying articulatory behaviours in glides. More importantly, EPG does not indicate which part of the tongue contacts the palate and does not record lips movements, which is essential in /w/. In contrast, 3D electro-magnetic articulography (EMA) provides access to kinematic data with a higher sampling rate (200 Hz) and a superior spatial resolution, making it a more suitable tool for this particular type of research (van Lieshout, Merrick, Goldstein, 2008).

Although in our experiment we studied both the Italian on- and off-glides ([j], [w]), in this paper we will only present preliminary results regarding the labiovelar glide [w]. Our experiment was based on the assumption put forward by Gick (2003) that [w] has two designated articulatory components, i.e. [dorsal] and [labial], and they are different in nature (the dorsal gesture is considered vocalic whereas the labial gesture is consonantal). In terms of EMA measurements, the articulators involved for [w] are upper and lower lip (together forming the C-gesture) and Tongue Dorsum (V-gesture). As mentioned above, Gick (2003) asserts that final allophones of glides (like in "how hotter"), compared to initial ones (like in "ha wadder"), show a small temporal lag of the C-gesture with respect to the V-gesture, with ambisyllabic allophones (typically segments that are amendable to resyllabification, like in "how otter") showing lags in between those found for initial and final allophones. From a theoretical point of view, two "gestural syllable position effects" have been identified in consonants occupying a particular syllable position (Browman & Goldstein, 1992): i) syllable-position-specific timing between tautosegmental gestures (a property of gestural configuration) and (ii) final reduction (a property of gestural scaling). In the case of the ambisyllabic consonants, since they are intervocalic consonants affiliated with two flanking vocalic peaks, they are "predicted to share the phonetic characteristics of both syllable-initial and syllable-final consonants" (Turk, 1994:107-108)

In this view, off-glides compared to on-glides are expected to show a reduction in magnitude of the C-gesture and a relatively smaller temporal lag of the C-gesture with respect to the V-gesture, together with more lag variability (Gick, 2003). Possibly, this increase in variability could be due to the greater instability of the VC phasing when compared to CV phasing (Goldstein, Byrd & Saltzman, 2006). We know also that this variability could be further increased by manipulating speech rate (e.g., Nittrouer, Munhall, Kelso, Tuller, & Harris, 1988).

On this assumption, we expect to find articulatory differences between the on-glide and off-glide /w/ gestures, like those composing the Italian words “attuale” [at.’twa.le] and “auto” [‘aw.to], and especially like those lying at word boundaries in the Italian clauses “da uadi” [da.‘wa.di] and “babau alto” [ba.’baw.’al.to]. Further, in order to better study the glides in the last two clauses, we will introduce an innovation with respect to the Gick’s (2003) study, aiming at causing a resyllabification of the glides at word boundaries. This can be achieved by varying speech rate, from a slow and hyper-articulated style to a more usual, hypo-articulated (and therefore faster) style (see below). Specifically, on the basis of greater stability of the CV phasing with respect to VC phasing, we predict that with the increase in speech rate , the on-glide at the word boundary in “da uadi” will preserve its syllabic affiliation but the off-glide at the word boundary in “babau alto” will possibly change its VC affiliation towards a new and more stable CV affiliation.

We will differentiate from Gick’s (2003) study also for exploring variations in magnitude of the articulatory gestures according to the syllabic affiliation of the glides, not only for the lip opening, as Gick (2003) did, but also in the rounding and protrusion of the lips, which are the traditional articulatory correlates of labiovelar glides like [w] (Ladefoged & Maddieson, 1997)

In summary, we want to verify whether on-glides are more consonant-like, and off-glides are more-vowel-like, as in Gick (2003), and whether this finding, if confirmed, will depend on:

- the timing or phasing relationships between the C-and V-gestures, or
- on the magnitude of the C-gesture, or
- on both,

and if and how timing and magnitude vary with changes in speech style.

3. METHODS AND MATERIALS

3.1 Subjects and instruments

We recruited 10 young adults, all fluent speakers of Italian as their first language (8 females and 2 males, average age 32 years), by flyers and word-of-mouth. They were paid for their participation. We preferred Italian students living in Toronto for a short period of time (e.g., doing a language course at the University of Toronto). As to their regional Italian, we were prudent not to include people coming from Campania, due to their tendency for extreme diphthongisation (and reversal of the normal stress patterns: [‘pje.de] vs [‘pi.e.de]), and from the region of Emilia-Romagna, for the spirantisation of the /w/ in words like “attuale” or “auto” (cfr. Telmon, 1993). We verified the pronunciation of these sounds for each participant during the initial phone contact. To be included in the study, participants had to report normal vision (after correction) and have no history of hearing or speaking difficulties. Prior to starting the task, participants were provided with information on the study and asked to sign a consent form, although no clue was given on the goals of the study. Additionally, participants were asked to complete a short questionnaire about general demographic data (Name, DOB, Education, first and (if applicable) second language(s)).

Articulatory (and acoustic) data were collected using 3D EMA (Electromagnetic Articulatography; AG500 Carstens Elektromedizin GmbH, Germany) at the Oral Dynamics Lab (ODL) in the Department of Speech-Language Pathology at the University of Toronto. The AG500 system allows for 3D recordings of articulatory movements inside the vocal tract, thus providing detailed information on the nature and direction of gestural coarticulation patterns. For the purpose of this study, transducer coils were placed on the vermillion borders of the upper and lower lip, the tongue tip (1 cm behind actual tip of the tongue), the tongue body (2 cm behind tongue tip coil location), the tongue back (at least 1 cm behind tongue body location, but as far back as tolerated by a subject) and the lower jaw (using a thermoplastic mould to ensure stable and accurate placement). Additional coils were placed on the subject's forehead, bridge of the nose and left and right skin covering the mastoid for reference purposes (mainly to record head motion). A supplementary, independent acoustic recording was assured by using a second headset microphone connected to a solid-state audio recorder, but it was not considered for the present work.

3.2 Stimuli

We presented subjects with a series of short sentences containing the targets. Targets were vowels, diphthongs, words and phrases formed by the segments "I" and "U" (we will use capital letters when the syllabic status is not at discussion) added to the vowels [e]/[ɛ] and [o]/[a], respectively, in order to produce hiatuses, onglides and offglides. All words and phrases were inserted in the carrier phrase "ha detto x chiaramente" ("He said x clearly"). Each item was repeated twice over one session, and there were 3 sessions using a normal, habitual rate and 3 other sessions using a formal, slow rate (see below), for a total of 408 sentences (204 recordings containing the same phrase repeated twice). All the sequences were presented in random order to the participants on a computer screen using *Direct RT*, a stimulus presentation program.

For this paper we only present data from one subject (female, Ph.D. student, 20 years old, coming from Torino), and only from sentences containing the "U"+ /a/ targets. This participant was chosen for the completeness of her data and the clarity of her pronunciation. Using articulatory (EMA) as well as acoustic (PRAAT) measures, we studied segmental series as those of the following table:

segments changing syllabic status	*contextual vowels*	*hiatus (V.V)*	*onglide (GV)*	*unambiguous VG at word boundary*	*ambiguous VG/GV at word boundary (due to resyllabification)*	*offglide (VG)*	*hiatus (V.V)*
u/w	a	tua /'tu.a/	attuale /at.'twa.le/	ma # uadi /'ma 'wa.di/	babau # alto /ba.'ba←w→'al.to/	auto /aw.to/	baule /ba.'u.le/

Table 1. Verbal stimuli ordered for position (pre/post vowel [a]) and syllabic status (glide or vowel in hiatus) for the "U" segment

These phonetic sequences all form legal (pseudo)words or phrases in Italian. They are characterised by the same stress pattern (always tonic), and even the new sequences resulting from resyllabification at word boundaries represent legal phonotactic sequences in Italian. In addition, we asked participants to pronounce in isolation the vowels /u/ and /a/ , again embedded in the same carrier phrase. In order to promote different patterns of syllabification of the stimuli lying at word boundaries, two rates of delivery were requested from our participants. In their slow, hyper-articulated rate, they were expected to coarticulate less (Cho, 2001), and to produce a glottal stop between the vowel ending the previous word and the vowel beginning the following word (Bertinetto & Loporcaro, 2005), thus preserving their syllabic affiliation, as in "babau [ʔ] alto". To this end, immediately before the presentation of the sentence to be read, a pre-recorded sentence was played from a loudspeaker, conditioning the subject to emphasize the target by means of contrastive focus (e.g. the subject heard "Ha detto "babau basso" chiaramente?" and immediately after he\she had to read aloud "No, ha detto "babau alto" chiaramente"). In their normal, less hyper-articulated speech rate (we explicitly asked them for connected, informal speech), they were expected to show resyllabification (in "babau alto" subjects were expected to perform resyllabification of /w/ to possibly create a sequence like "baba walto").

After filtering the original EMA data by means of a 10 Hz Lambda filter, we derived a set of measures using the INTERFACE program (Tisato et al., 2005, see Fig.1):

- Lip Aperture (LAP, i.e. the vertical distance between Upper and Lower Lip). In producing "U", LAP values are expected to be smaller than values for /a/ (i.e., lips are more constricted, but see Noiray et al., 2011).
- Lip Rounding (LR, i.e. the horizontal distance between the left and right corners of the lips). In producing "U", LR values are expected to be smaller than values for /a/ (posterior vowels and labiovelar glides are rounded in Italian, see Bertinetto & Loporcaro, 2005; for a kinematic description, see Magno et al., 1995)
- Upper Lip Protrusion (UP, i.e. the position in the front-back dimension of the coil on the mid of the vermilion border of the upper lip). In producing "U", UP values are expected to be higher than values for /a/ (i.e., the upper lip protrudes for posterior vowels and labiovelar glides in Italian, see Bertinetto & Loporcaro, 2005; for a kinematic description, see Magno et al., 1995)
- Tongue Back Vertical (TBV, i.e. the position in the high-low dimension of the coil attached on the tongue dorsum). For producing "U", TBV reaches higher values, meaning that the tongue dorsum is in an higher position than for /a/. We did not use the Tongue Back front-back dimension (cf. Gick, 2003) because a preliminary analysis revealed that the positions for [a] and [u] were indistinguishable. We don't have an explanation, at this moment, for this difference between Italian and English speakers.

The articulatory targets for the phonetic segments were automatically detected by Interface as the points where the velocity of the movement reached the threshold of 15% of the maximal velocity (see Fig.1, the white arrows points to the "U" target).

4. RESULTS

We analysed with Praat the high-quality acoustic signal acquired by means of the headset microphone and the solid state recorder, and we measured all the acoustic duration and formant values for the segments "U" across the different targets. However, space constraints do not allow us to present these acoustic analyses here.

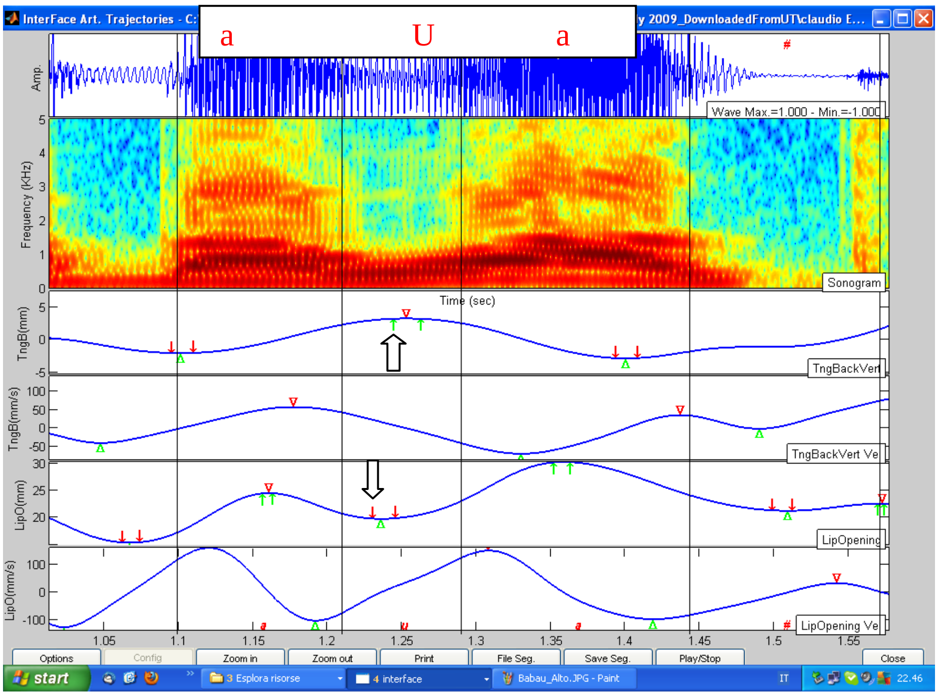

Fig. 1: Display of Trajectories window of Interface. From top to bottom: 1) waveform of the sequence "(ba)bau alto"; 2) sonogram; 3) movement trajectory (mm) of the back of the tongue in the vertical dimension (TBV); 4) instantaneous velocity trajectory (mm/s) for the movement of TBV; 5) Lip Aperture (LAP) variations in the vertical dimension (mm); 6) instantaneous velocity of the LAP variations (mm/s). The position for the /w/ is a peak for TBV, a valley for LAP. Red and green triangles locate the absolute kinematic peaks, while red and green arrows locate the points where the velocity of the movement reaches the threshold of 15% of the maximal velocity. Vertical white arrows associated with the left velocity boundaries show the beginning of the "U" target in the TBV and LAP movement signals. UP and LW are not shown.

In order to better identify the peaks corresponding to kinematic targets on the "Trajectories" window of Interface, we manually segmented and labelled the acoustic EMA signal for "U" and [a] segments, by means of visual inspection of waveform (amplitude variations) and sonogram (F2 and F1 formant trajectories), using auditory feedback. As for kinematic measures, since our final aim is to see how much the kinematic values for U segments are different from those characterizing the /u/ vowel, we decided to express the kinematic values (for LAP, TBV, UP and LW) in relative terms, viz. as the difference between the peak values achieved by each parameter for the /u/ vocalic target at slow rate and the peak values achieved for the U target in the "tua", "attuale", "ma uadi", "babau alto", "auto" e "baule" words both at normal and slow rate (i.e. we took their peak values minus the values for the /u/ vowel). Furthermore, before making statistical comparisons among U values in the different targets, we decided to divide them in two different blocks, because the U positions in "tua", "attuale", "auto" e "baule" are preceded or followed by an alveolar consonant, and consequently tongue and lips positions at the U targets are likely to be affected by the movements towards and from this consonant. This kind of problem does not affect U positions to the same degree in the "ma uadi" and "babau alto" sequences. Fig. 2 shows the /u/-normalized Lip Aperture (LAP) values for the U-target in the different words. A two-way ANOVA was performed on the LAP values, with "U-words" and "Rate" as factors. "U-words" proved not to be significant (F(3, 39)= 0.557, p=0.525), while "Rate" was significant (F(1, 39)= 10.015, p=0.003).

The "Rate" by "U-words" interaction was not significant (F(3, 39)= 2.276, p=0.095). For all targets, interlip vertical distance (LAP) increased from slow to normal rate, but this was strongest for /u/ vowel in "tua" and for the onglide /w/ in "attuale". A two-way ANOVA was performed on the LAP values of the U targets for the "U-words" "ma uadi" and "babau alto", crossed with "Rate". The only significant result was the difference between the two targets (F(1, 21)= 6.783, p= 0.017), with LAP values greater for "babau alto". "Rate" and the"U-words" by "Rate" interaction were not significant (F(1, 21)= 0.665, p= 0.424; F(1, 21)= 0.038, p= 0.847).

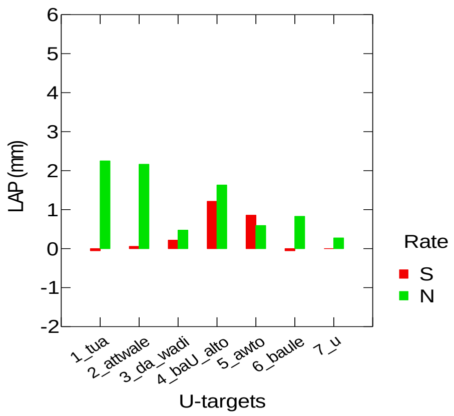

Fig. 2: u-normalized LAP values (mm), for U-targets in the U-words, at slow (S) and normal (N) rates

Fig. 3 shows the /u/-normalized Lip Rounding (LR) values for the U-target.

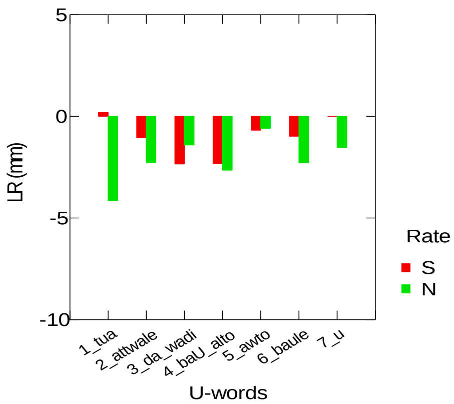

Fig.3: u-normalized LR values (mm), for U-targets in the U-words, at slow (S) and normal (N) rates.

We could note that the values for the U-targets were reduced with respect to the value for vowel /u/, with the exception of the vowel /u/ in “tua” at normal rate. This means that, for the U-target, lips were less rounded in the U-words than in the isolated vowel /u/. A two-way ANOVA was performed on the LR values, with “U-words” and “Rate” as factors. The differences for the “U-words” were not significant ($F(3,33)= 0.999$, $p=0.405$), while “Rate” was significant ($F(1,33)= 8.718$, $p=0.006$). The interaction “U-words” by “Rate” was not significant ($F(1, 33)= 2.812$, $p= 0.055$. Almost all the targets reduced the lips’ intercorner horizontal distance from slow to normal rates (with the exception of the offglide /w/ in “auto”). Another two-way ANOVA was performed on the LR values of the U targets for the “U-words” “ma uadi” and “babau alto”, crossed with “Rate”. Results were not statistically significant for any of the factors (“U-words”: $F(1, 21)= 0.827$, $p=0.374$; “Rate”: $F(1, 21)= 0.210$, $p=0.651$;”U-words” by “Rate” interaction: $F(1, 21)= 0.853$, $p=0.366$).

Fig. 4 shows the /u/-normalized Tongue Body Vertical (TBV) values for the U-target in the U-words. As a general observation, almost all the U-targets in the U-words have greater values (i.e., more constriction) than the value for vowel /u/. A two-ways ANOVA was performed on the TBV values, with “U-words” and “Rate” as factors. The differences for the “U-words” were significant ($F(3,39)= 8.740$, $p< 0.000$), while “Rate” was not significant ($F(1,39)= 0.036$, $p=0.851$), and nor was the interaction “U-words” by “Rate” ($F(3,39)= 0.686$, $p=0.566$). A Bonferroni post-hoc pairwise analysis showed that the normalized value for /w/ glide in “auto” was significantly greater than all other targets but “attuale”, and the value for “attuale” was significantly greater than that for vowel [u]. Another two-way ANOVA was performed on the TBV values of the U targets for the “U-words” “ma uadi” and “babau alto”, crossed with “Rate”. Results were not statistically significant for any of the factors (“U-words”: $F(1, 21)= 1.742$, $p=0.201$; “Rate”: $F(1, 21)= 0.662$, $p=0.425$;”U-words” by “Rate” interaction: $F(1, 21)= 0.211$, $p=0.650$).

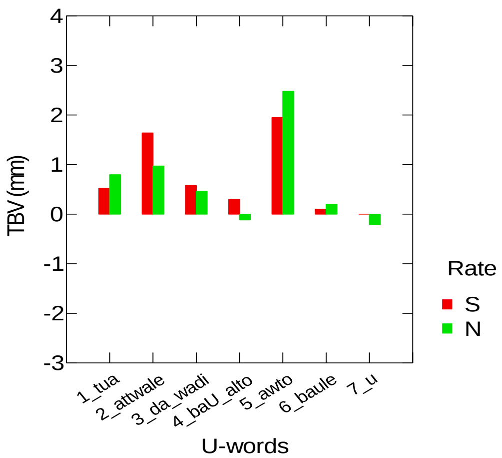

Fig. 4: u-normal. TBV values (mm), for U-targets in the U-words, at slow (S) and normal (N) rates

Fig. 5 shows the /u/-normalized Upper Protrusion (UP) values for the U-target in the U-words.

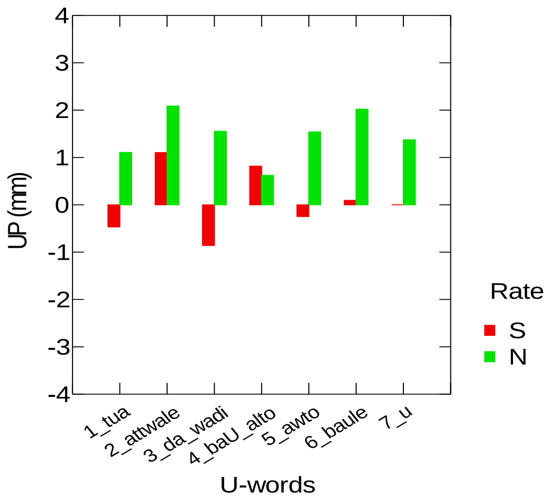

Fig. 5: u-normalized UP values (mm), for U-targets in the U-words, at slow (S) and normal (N) rates

A two-way ANOVA was performed on the UP values, with "U-words" and "Rate" as factors. The differences for the "U-words" were significant ($F(3,39)= 3.008$, $p= 0.042$). Also "Rate" resulted in a significant finding ($F(1,39)= 24.997$, $p<0.000$), but not the interaction "U-words" by "Rate" ($F(3,39)= 0.422$, $p=0.738$). /w/ glides in "attuale" and "auto" were characterized by greater values than those characterizing vowels. Another two-way ANOVA was performed on the UP values of the U targets for the "U-words" "ma uadi" and "babau alto", crossed with "Rate". Results were not statistically significant for any of the factors ("U-words": $F(1, 21)= 0.226$, $p=0.640$; "Rate": $F(1, 21)= 2.007$, $p=0.171$;"U-words" by "Rate" interaction: $F(1, 21)= 2.775$, $p=0.111$).

Finally, we tried to verify the hypothesis put forward by Gick (2003) that final allophones (of glides), compared to initial ones, show a smaller temporal lag of the C-gesture (LAP) with respect to the V-gesture (TBV), with ambisyllabic allophones (typically segments that are amenable to resyllabification) showing lags in between those found for initial and final allophones. Based on this assumption, at slow speech rate the off-glide in "babau alto" was expected to be smaller in magnitude for the C-gesture, and relatively shorter in the temporal lag of the C-gesture to the V-gesture, than the on-glide in "ma uadi". At normal rate, the off-glide possibly would tend to become more similar to the on-glide, due to resyllabification.

Fig. 6 show the mean values of the time lag between the LAP peak and the TBV peak (LIP_LAG) for the U targets in the "U-words": "u" (isolated vowel), "da uadi" and "babau alto". For "u" (isolated vowel) we considered only the slow rate productions, because at normal rate the contextual effects of the consonants in the carrier sentence ("Ha detto "u" chiaramente") resulted in a large temporal variability of the LIP_LAG interval.

A two-way ANOVA was performed on the UP values, with "U-words" and "Rate" as factors. Differences were not significant for any of the factors ("U-words": $F(1,96)= 0.071$, $p=0.791$; "Rate": $F(1,96)= 0.959$, $p=0.330$; "U-words" by "Rate" interaction: $F(1,96)= 1.716$, $p=0.193$.

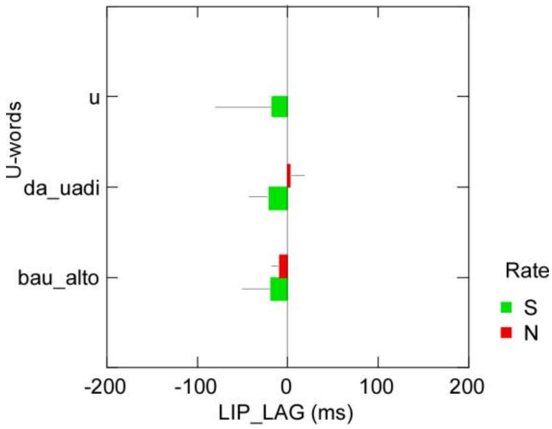

Fig. 6: Mean values (and SD) of the time lag between the LAP peak and the TBV peak for the U targets in the "U-words" (negative values: TBV peak leads)

5. DISCUSSION AND CONCLUSIONS

This very preliminary single-subject study stemmed from the proposal of Gick (2003) to consider the traditional segments of a syllable-based allophony as composed by two type of gestures, C-gestures and V-gestures, which are different for degrees of constriction and are phased with respect to each other in fixed, language particular patterns. He provided evidence that in English not only labiovelar on-glides differ from labiovelar off-glides, but also that these two differ, at least in constriction degree, from the labiovelar ambisyllabic glide emerging from the resyllabification of a word-final offglide followed by a word-initial vowel ("how otter"). In setting up an experiment for the Italian language, we wanted to verify if the nature of Italian [w] as a function of syllabic context (on-glide, off-glide, ambiguous glide) would depend on (i) the existence of two types of gestures (C-and V-gestures) in the same segment, (ii) which articulator would play the consonantal and which the vocalic function, (iii) the timing or phasing relationships between the C-and V-gestures, or (iv) the magnitude of the C-gesture.

Further, in order to study the resyllabification at word boundaries in Italian without having access to words beginning with the /h/ phoneme, as in English, we devised a similar context by means of a variation in speech rate, from slow and hyper-articulated style to usual more hypo-articulated style. In this way, we expected subjects to preserve the word-based syllabic affiliation in the sequences "da uadi" and "babau alto" at slow rate, even by inserting a glottal stop at word boundaries, but to change these affiliations at a more casual style. The possible variations in magnitude of the articulatory gestures according to the syllabic affiliation of the glides was also examined in the rounding and protrusion gestures of the lips, as they are the traditional articulatory correlates of labiovelar glides like [w].

The main result that we found in the articulatory behavior of a female student, coming from Torino, is that only the vertical position of the tongue body (TBV) distinguishes significantly the various realizations of the "U" segments. In fact, when "U" segments are glides, they have always greater values than their vowel counterparts ([at.'twa.le]" is greater than ['tua], and ['aw.to] is greater than [ba.'u.le] for TBV values). This is at odds with the smaller tongue-palate contact found for the onglide /w/ with respect to the vowel /u/ by Calamai & Bertinetto (2006). However, no significant difference exists between the

TBV position for the on-glides in [at.’twa.le] and [da#‘wa.di] and the TBV position for the off-glides in [‘aw.to] and [baw#alto]. The last result does not support the common opinion that on-glides are more consonantal than off-glides, because one of the defining characteristics of consonants with respect to vowels is the greater degree of constriction (or magnitude) of the articulatory gesture for consonants, and we did not find this difference. These results only apply to measures of featural kind, related to the degree of constriction (i.e magnitude) of the gestures, the aperture, protrusion and rounding of the lips and for the rising of the tongue body. But according to Gick (2003), the articulatory gestures of on-glides and off-glides could be differentiated not only for degree of presence of a certain feature, but also for structural reasons, in particular the phasing of the C-gesture and V-gesture. The Lip-Lag interval, i.e. the temporal distance between peak values for lip closure and tongue dorsum backing, distinguished in English on-glide from both off-glides and ambi-syllabic glides (Gick, 2003). Specifically, there is a tendency to produce [w] as on-glides by having the C-gesture, which for English is realized by the lips, precede the V-gesture (i.e the tongue dorsum gesture). For the [w] off-glides the articulatory peaks of LAP and TBV tend to occur almost simultaneously. When we looked for this kind of evidence in Italian, we found the opposite to be true: in the case of the on-glide in [da#‘wa.di] at slow rate, the tongue body, not the lips, leads and moves away from the peak vowel.

Trying to interpret this set of results, which seem at odds with results for English, is not a simple matter. For sure, more subjects need to be analyzed, and differences in the experimental designs have to be taken into account. For instance, Gick (2003) used the front-back position of the tongue body while we used the high-low position, because the former did not distinguish between [a] and [u]/[w] realizations. In sum then, the results for a single female Italian subject indicate that the articulatory variable which shows the most difference among [u] vowel and the two glides is the degree of constriction in the vertical dimension of the tongue body, which is more constricted in the case of glides. We did not find any strong evidence instead for differentiating [w] on-glide from [w] offglides on any featural or structural bases. To conclude, we must entertain the possibility that in some languages, like Italian, the “primary” (consonantal) articulation of labiovelars might be the velar, not the labial as in English (see Anderson 1976, quoted by Gick, 2003).

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