

## Prosody and intrasyllabic timing in French

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### Abstract

Durational variation associated with accentuation and final lengthening is examined in a corpus of articulatory data for French. Both factors are associated with measurable differences in acoustic duration. However two different articulatory strategies are employed to make these contrasts although both result in superficially longer and more displaced gestures.

### Introduction

The importance of prosodic organization in speech timing has been acknowledged for a number of years. Stress and accentuation are known to affect the acoustic durations of syllables in a number of languages. For example, in French, syllables with right-boundary tonic accents or stresses and non-emphatic initial accents are longer than unaccented syllables. The basic rhythmic group or prosodic word is defined by right boundary tonic accents, and not by left boundary prominences as in English stress feet. On the other hand, like English, French displays final lengthening. Accented syllables at the right edge of phrases Q units consisting of one or more prosodic words Q are significantly longer than accented syllables interior to the phrase (Crompton 1980, Touati 1987, Fletcher 1990). Intonational analyses (e.g., Martin 1987) would suggest that phrase-final accents are more prominent than phrase-internal accents. It is often assumed, therefore, that acoustic duration is an important cue to these prosodic relations, and that final lengthening is part of the same linguistic process as accentuation.

The articulatory correlates of these high-level prosodic relations are not that well studied in either French or English. Most studies have focused on the relationship between two categories of prosodic strength - stressed and unstressed, and have usually excluded final syllables. One recent study has attempted to redress the situation for English. Edwards, Beckman, and Fletcher (1991) compared lip and jaw articulation in phrase-final accented, and non-final pitch accented and reduced syllables. They found distinct differences in the ways in which accentuation and final lengthening were realized in their corpus and concluded that, a) the kinematic patterns associated with accentuation and final lengthening reflect different underlying articulatory maneuvers, and b) final lengthening does not necessarily belong to the same kind of phonological process that governs prominence relationships per se, but to some kind of local timing process.

The phrasal phonology of French is somewhat different from English in that final syllables are always accented in the former but only optionally accented in the

latter. It is of interest, therefore, to see whether the duration increase in phrase-final accented syllables in French (final lengthening) is associated with similar qualitative patterns of articulator motion to those of the phrase-internal accented/unaccented contrast. In an earlier study, Vatikiotis-Bateson (1988) found consistent differences in the kinematic parameters, duration, peak velocity and articulator displacement in the opening and closing gestures of non-final accented and unaccented syllables in French. Accented syllables were associated with bigger as well as longer gestures as would befit a prominence contrast. Final syllables were excluded from the original study. In the present investigation, part of the French corpus recorded for Bateson's earlier study was reanalyzed to look specifically at the final / nonfinal contrast.

## Methods

The model sentence, "*L'interet, qui aveugle les uns, fait la lumiere des autres.*" ["The curiosity that blinds some, illuminates others"] was analyzed.

Three speakers of standard French (without traces of strong regional accents) produced ten repetitions of the sentence using the syllables /ba/ and /ma/ at two self-selected tempi; conversational and fast. A prosodic analysis of each sentence repetition was performed. The speakers consistently recited the sentence with three prosodic phrases, usually pausing after each phrase. All phrase-internal accents were classified as one type, regardless of whether they were right boundary tonic accents or phrase-initial accents, since there was no discernible difference in the movement amplitudes associated with either accent type. The comparison between this group and the opening gestures of phrase-final syllables constitutes the basis of the final/nonfinal contrast in this study. The unaccented/accented contrast is also based on the comparison between this group and the gestures of unaccented syllables.

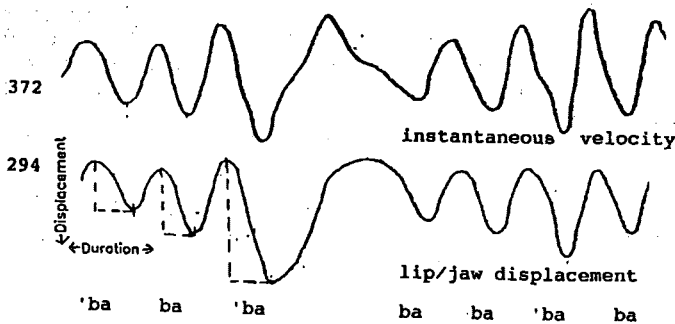


Figure 1. Selspot trace representing lip / jaw position and instantaneous velocity for part of a reiterant version of the sentence: "*L'interet qui aveugle les uns, fait la lumiere des autres.*"

Vertical movements of the lower lip/jaw complex were recorded using the optoelectronic SELSPOT system at Haskins Laboratories. The position files were numerically differentiated to obtain instantaneous velocity. For position of the lower lip/jaw, (Figure 1) peaks and valleys of the movement trace correspond to

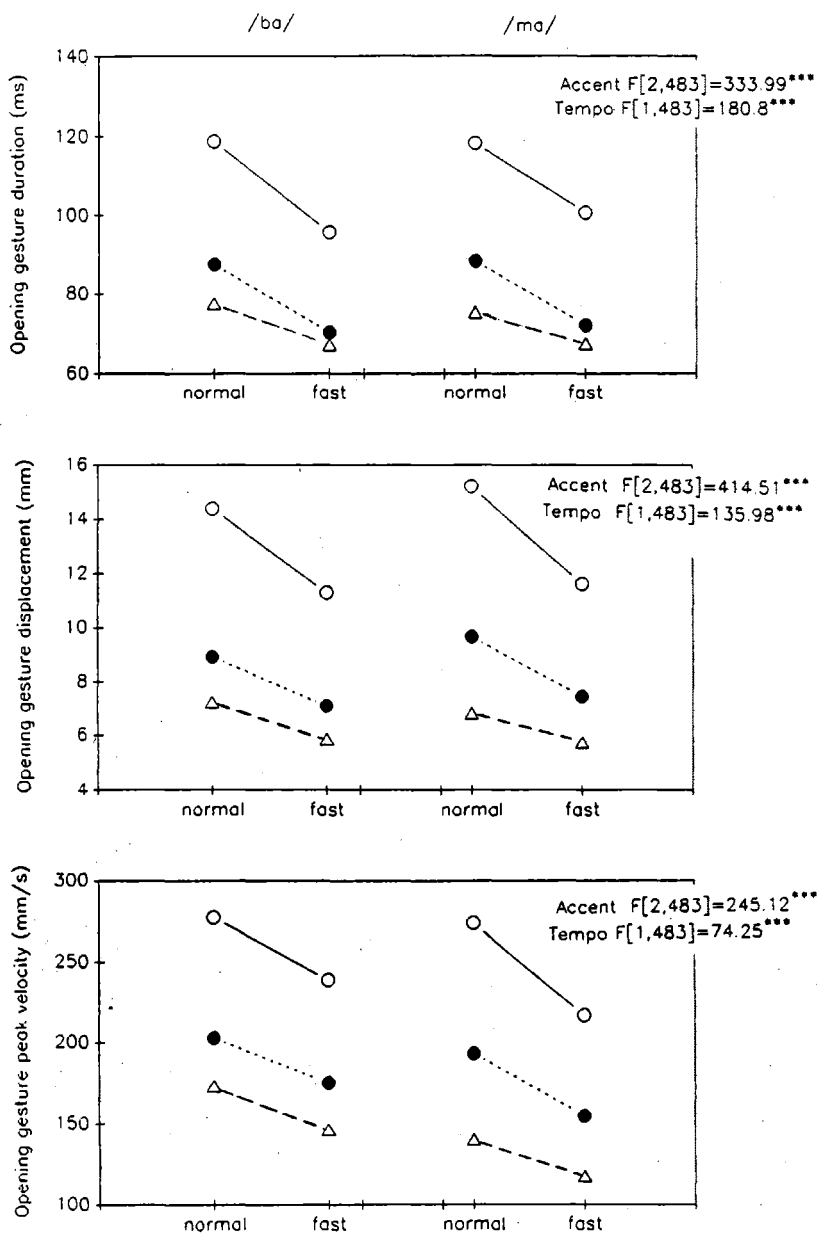


Figure 2. Mean gesture durations, displacements, and peak velocities, for normal and fast tempo /ba/ and /ma/ opening gestures, contrasted for accent and position in utterance. (Subject BA)

points of maximum closure (for the bilabial) and maximum opening (for the vowel). Measurements of movement duration, peak velocity, (Vp) and displacement (Disp.) were obtained for the lip/jaw lowering gestures for each repetition. It was not possible to obtain measurements for the closing phase of syllable production relevant to the final/non-final contrast because all syllables were open in structure and a pause generally followed final syllables. The closing phase for the non-final accented/unaccented contrast was described in the original study.

The times where velocity reaches its peak in both opening gestures were also measured. We are calling the period from the onset of a gesture's movement to the moment of peak velocity "the acceleration phase" and the time period from the peak moment to the offset of the gesture's movement "the deceleration phase". These measures may give us some indication of the nature of the underlying control mechanisms that give rise to the surface temporal patterning of the lip/jaw movements studied here.

## Results

Figure 2 shows the mean values for the individual kinematic parameters for subject BA for both syllables. Final opening gestures have significantly longer durations, greater displacements, higher peak velocities than non-final gestures. Posthoc simple main effects analyses revealed that these differences are statistically significant above the 0.01 level at both tempi (Duration of /ba/ and /ma/ :  $F=79.24, 33.43$ ; Disp.,  $F=60.36, 32.99$ ; Vp.,  $F=29.99, 17.19$ ). Subject DP's data pattern in similar ways. However, the duration difference is lost at fast tempo for both syllable-types, although final gestures are still bigger and faster than non-final gestures (Disp.,  $F=10.28, 3.61$ , Vp.,  $F=6.39, 4.72$ ). Subject CG also shows bigger, longer opening gestures (Duration:  $F=28.81, 61.04$ ; Disp.:  $F=4.89, 3.69$ ) but with no change in peak velocity. For all subjects, lengthening a final syllable at normal tempo involves increasing opening gesture duration and amplitude, like lengthening in the accented/ unaccented contrast. Final accented gestures seem to pattern on the surface like an increase in prominence.

The velocity profiles of each class of opening gesture were then examined. For two subjects (BA and DP) the actual time it takes to reach the velocity peak in normal tempo gestures is the same, and not significantly different for final and non-final gestures at fast tempo. For subject CG there is a small but consistent duration difference in acceleration duration for /ba/ syllables but not for /ma/ syllables ( $F=6.27$ ). With respect to the deceleration times, the latter portion of final gestures is consistently longer than in non-final gestures at both tempi for all subjects (BA:  $F$ 's 182.83, 155.37; DP:  $F$ 's 35.02, 21.44; CG:  $F$ 's 28.53, 21.35).

By contrast, the major duration differences among unaccented and accented gestures are localized in the acceleration portion, that is the point from onset of the movement to the point where maximum velocity is reached (BA:  $F$ 's 11.35, 18.96 DP:  $F$ 's 6.22, 20.76; CG:  $F$ 's 5.55, ns). There are no significant differences in the duration of the slowing down portion of the gesture for this contrast.

The timing of the velocity peaks seems to indicate that two different articulatory maneuvers are involved in making the accented/unaccented contrast on the one hand, and the final/non-final contrast, on the other. The earlier timing of the peaks, together with the smaller observed displacements in unaccented gestures, might indicate that the intention is to produce smaller gestures in unaccented syllables and bigger gestures in accented syllables. In other words the gestures in either case are

different in shape and magnitude, suggesting different underlying dynamic parameters - such as force/stiffness and movement amplitude if we were to model these movements in a linear mass-spring model framework (Kelso et al 1985, Vatikiotis-Bateson (1988), Edwards et al. 1991). The small timing difference among accented and unaccented opening gestures falls out directly from the intragestural dynamics.

Another kind of articulatory maneuver is potentially involved in the production of the final/non-final contrast. The shorter, less displaced gestures of non-final syllables could be the result of a change in intergestural timing. The onset of the following opening gesture associated with the upcoming syllable in the phrase truncates the non-final closing gesture. This seems plausible given that the bulk of the timing difference between final and nonfinal opening gestures is localized in the tail end of final gestures. The gestures for accented final and nonfinal syllables have the same basic shape until the point where peak velocity is reached -- presumably somewhat beyond this point. Non-final gestures are cut short but final gestures are not. Moreover, the magnitude of difference in overall gesture duration is far greater in the final/nonfinal contrast than in the unaccented/accented contrast.

## Conclusion

In summary, accentual lengthening and final lengthening are associated with different articulatory maneuvers in this corpus of French. Nonfinal accented and unaccented gestures are probably associated with different underlying intragestural parameter settings (i.e., underlying amplitude, force or stiffness) as suggested in the original study. Final accented and nonfinal accented gestures may or may not have the same intragestural specifications, but observed displacements and associated timing patterns are mainly the product of changes in intergestural timing. Phrase-internal accentuation represents a true change in prosodic prominence in that the primary intention is to produce a bigger syllable. By contrast, final lengthening in French may be more of a targeted durational contrast as suggested by Edwards et al. for English. That is, the intention might be to produce a longer as well as a more prominent syllable. These results support Edwards et al.'s conclusion that acoustic duration is not a sensitive cue to these qualitative differences in linguistic timing.

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