Stiffness and articulatory overlap in Moroccan Arabic consonant clusters

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Given a post-vocalic cluster containing two consonants (VC1C2), Jun (2004) proposes that C1 is more likely to assimilate to the place of C2 when there is more overlap between the articulations of the consonants than when there is less. Jun (2004, p. 65) proposes specifically that the amount of overlap between two consonants in a cluster depends on the “inherent velocities” of the oral articulators involved. The account of Jun (2004, pp. 63–65) is shown in Fig. 1 and can be summarized as saying that there is more overlap in clusters when C1 is more “rapid” than C2, and there is less overlap when C2 is more rapid than C1. The insight of Jun’s proposal is that the amount of overlap in a cluster can have perceptual consequences that could account for certain patterns of assimilation. However, no quantification of overlap is provided by Jun (2004), nor is it clear what the relevant quantification of “rapidity” is.

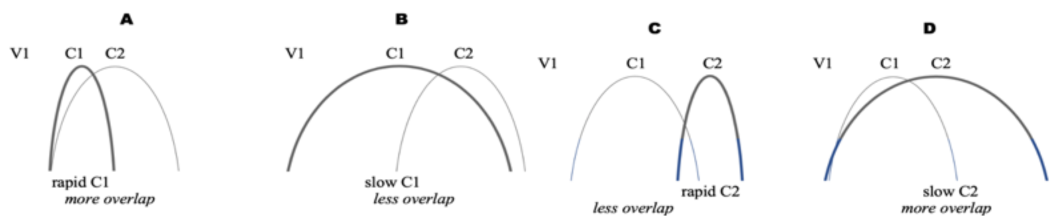

Fig. 1. The predictions of Jun (2004, his examples 5 and 6) for effects of relative rapidity on consonantal overlap in VC1C2 clusters. When rapidity of C2 is held constant, a rapid C1 results in more overlap (A) than a slow C1 (B). When rapidity of C1 is held constant, a slow C2 results in more overlap (D) than a rapid C2 (C).

We used electromagnetic articulography data from 6 speakers of Moroccan Arabic to determine whether the relative “rapidity” of two consonant gestures in word-medial, intervocalic, stop-stop clusters was predictive of overlap in the cluster. We quantified the rapidity of articulatory gestures in two ways. For the closing movement associated with each consonant in each cluster, we calculated both peak velocity ($v^{\wedge}$) and the measured stiffness (k'), defined as $v^{\wedge}$ divided by the amplitude of the closing movement (Kelso, Vatikiotis-Bateson, Saltzman, & Kay, 1985; Munhall, Ostry, & Parush, 1985). We then tested two hypotheses: the *Peak Velocity Order Hypothesis* (PVOH), which holds that C1C2 clusters where $v^{\wedge}_{C1} > v^{\wedge}_{C2}$ should exhibit more articulatory overlap than clusters where $v^{\wedge}_{C2} > v^{\wedge}_{C1}$, and the *Stiffness Order Hypothesis* (SOH), which holds that clusters where $k'_{C1} > k'_{C2}$ should exhibit more articulatory overlap than C1C2 clusters where $k'_{C2} > k'_{C1}$. We tested these hypotheses using two different quantifications of overlap: *onset lag*, defined as the lag between the onsets of movement of C1 and C2, and *relative overlap*, defined as the difference in time from the onset of C2 to the achievement of C1 target, normalized by the duration of the C1 closure plateau.

Data were taken from previous studies of Moroccan Arabic at LMU (affiliation 3 above). 604 tokens were included in analyses. For each consonant, the trajectory of interest was the closing movement of the primary oral articulator (lower lip, tongue tip, or tongue back). The $v^{\wedge}$ and k' of the closing trajectory for each consonant was calculated as above. To test the PVOH, each cluster was classified as to whether C1 or C2 had higher $v^{\wedge}$. To test the SOH, each cluster was classified as to whether C1 or C2 had higher k'. Four linear mixed-effects models were created, with each hypothesis tested once with overlap indexed as relative overlap and once with onset lag. Place order of the cluster (Chitoran & Goldstein, 2006) was also included as a predictor in the models, since this has been shown to influence the amount of overlap in this language for some speakers (Gafos, Hoole, Roon, & Zeroual, 2010).

Fig. 2 shows that the PVOH was not supported: relative overlap was greater when $v^\wedge_{C2} > v^\wedge_{C1}$ (Fig. 2A), contra the PVOH, and there was no difference in onset lag (Fig. 2B). The SOH was supported regardless of which index of overlap was used (Fig. 2C and 2D). While peak velocity would seem to be the most direct test of the proposal of Jun (2004), peak velocity is too subject to contextual affects such as movement amplitude (Munhall et al., 1985). We conclude that the settings of the more abstract control parameter of stiffness associated with each articulatory gesture in a cluster are the relevant factors that give rise to differences in overlap.

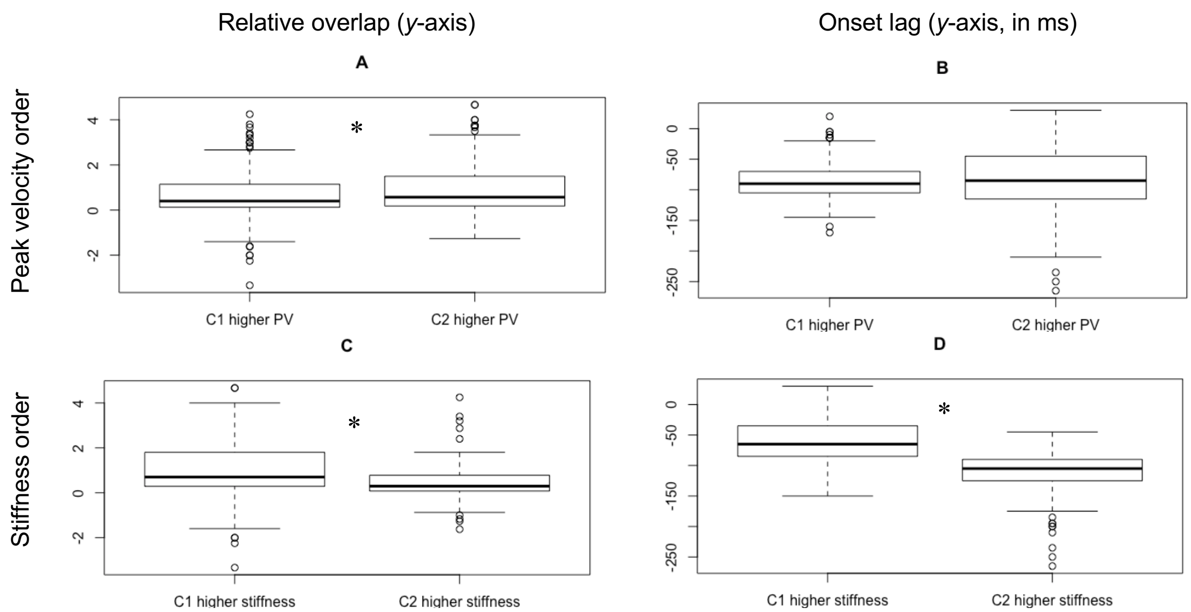

Fig. 2. Boxplots of the amount of overlap in clusters based on Peak Velocity Order (A and B) and Stiffness Order (C and D), as indexed by Relative Overlap (A and C) and Onset Lag (B and D). Significant group differences indicated with an asterisk (|t| *> 2).*

References

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