

Main Points

- The language of a speaker determines the overall slow-rate glottal regime used to interpret a written cue.
- Increasing rate in a repetitive speech task induces reorganization of glottal regimes.
- Speakers shift to a regime in which a glottal abduction gesture is aligned with stop release.
- Shifts involve not only rephasing of gestures, but also deletion and addition of glottal gestures.
- Combined results suggest both language specific structures, and language general motoric tendencies.

Background

Stetson's Motor Phonetics

From Stetson (1945, p.78):

"The possible movements and movement combinations of the speech apparatus for any and all languages are limited and the movements are cross-connected and reciprocal.

From the range of these possible movements and combinations, each language has come to select its own type of syllable movement and to differentiate the syllables by a group of phonetic signals."

=> Universal inventory is articulatorily determined. Speakers in production experiments can be induced to shift from one item in the inventory to another.

Rate-induced Resyllabification

VC syllables repeated at fast rates are perceived as CV's (Stetson, 1951.; Tuller & Kelso, 1991; de Jong *et al.*, 2001a)

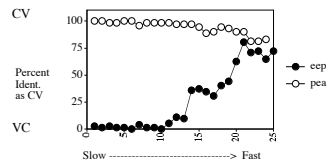


Figure from de Jong *et al.* (2001a)
'cep ... cep ... cep ... cep .. cep .. cep .. pea pea pea pea'

- Repeated VC forms (such as 'cep', filled symbols) identified as VC's at slow rates (to the left), BUT:
- Perceived as CV's at faster rates (to the right).

Glottal-to-Oral (GtO) Phase-shift

Tuller & Kelso (1991):

- Glottal phase = timing of peak glottal opening with respect to 360 degree syllable repetition cycle.
- Glottal phase for VC's shifts to values for CV's at fast rates.

Motor Phonetics Updated

- GtO timing**, = collective variable indicating syllable affiliation, similar to Keating's (1984) use of Voice Onset Time (VOT) as index of voicing contrasts.
- Modes in Timing**: Speakers cluster around certain values. These clusters indicate preferred modes of coordination.
- Motoric Influence**: Modes are observed in production and perception, but phase shifts are driven by production factors.
- Stability**: Some modes are more stable than others, fast rate shifts from one mode to a more stable mode.
- Cross-language Markedness**: Relative stability of CV and VC coordinations partially accounts for prevalence of CV structures cross-linguistically.

F.5.P1:3 The Phonetics of Resyllabification in English and Arabic Speech.

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Research Question

Do phase-shift results generalize across different languages?

To investigate: Examine glottal coordination in repetitive English and Arabic speech.

Methods

- METRONOME PACER**: controls repetition rate
- Start slow (450 ms/syll.) for six beats & increase to fast (200 ms/syll.) by 12.5 ms per beat, -OR-
 - Start fast (200 ms/syll.) for six beats & decrease to slow (450 ms/syll.) by 12.5 ms per beat.
 - Rates span comfortable range (Nelson *et al.*, 1984)
 - Continuous rate change means modes in speech output are due to the production system, not the elicitation technique.

TEXT PROMPTS: Simple bisegmental forms:

- VC & CV, where C = {b, p, t, k} & V = {i, æ}.
- Front vowels used to facilitate glottal tracking.

ARTICULATORY RECORDINGS

- Recorded at Haskins Laboratories
- Include following information:
 - Acoustic traces digitized at 20 kHz
 - Glottal transillumination traces at 635 Hz
- (Glottal transillumination traces are the output of a photo-transducer placed externally, which detects a light source placed in the upper pharynx, modulated by the size of the glottis; Baer *et al.*, 1983.)

SPEAKERS

- One native American English speaking male in 30's (first author).
- One native Arabic-speaking female from Amman in 20's.

TOTAL CORPUS

- 4 repetitions of each trial X 2 metronome types X 2 syllabifications X 4 C's X 2 V's X 30 syllables per trial = approx. 3840 syllables per speaker.

Acknowledgements

Work supported by the NIDCD (grant #R03 DC04095) and by the NSF (grant #BCS-9910701). We thank Stuart Davis for his comments on Arabic syllabic patterning, Bob Port for his comments on articulatory modes, and Kyoko Nagao for continuous feedback on this work. We also thank Bushra Zawaydeh and Mafuyu Kitahara for their invaluable enthusiasm in contributing to this work (<http://www.es.indiana.edu/~mkitahar/Photos/Haskins/Haskins.html>). Portions of this work have been reported in de Jong *et al.* (2001b).

English Observations

Gestural Variety at Slow Rates

CV's usually: Glottal Opening + Modal Voicing (even /b/)

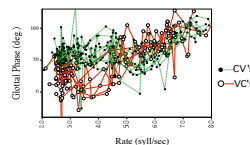
VC's always: Glottal Closure + Modal Voicing + ...

Coda consonant varies:

- Glottal Opening (voiceless)
- Glottal Closure (glottalized)
- No Movement (voiced)

Rate-induced Phase-shift

Eliminate VC's with glottalized and voiced consonants. Fast speech rate changes induce shifting of glottal opening to later phase of release-to-release cycle.



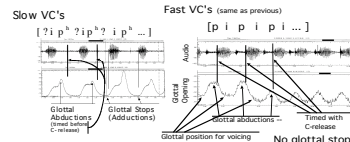
Phase is determined with respect to acoustic center of stop closure (= 0 degrees).

CV's (filled symbols) have fixed phasing around 50 degrees. VC's have phasing around 0 degrees at slow rates, shifting to CV values at fast rates.

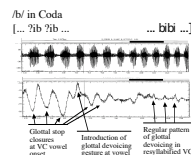
Rate-induced Recomposition

Changes also involve recomposition of gestural orchestration.

Subtractions: Slow rate CV's have glottal stop which is eliminated at fast rates. Example below.



Additions: Speaker adds voiceless gestures to voiced VC's.



Arabic Observations

Additional Variety at Slow Rates

CV : Speaker often had voiced /b/, with no glottal movement for the stop.

HOWEVER:

Arabic productions of CV's with /b/ sometimes did have clear glottal devoicing movements synchronized with end of vowel.

Results in barely perceptible post-vocalic /h/.

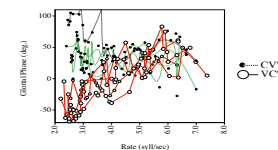
17/64 trials had clear evidence for post-vocalic glottal opening for an /h/.

VC: Arabic speaker had VC patterns similar to English speaker, though glottal closures were less obvious. Hence Arabic patterns generally involved a single peak for devoicing.

Exception: 3/64 glottalized codas with no peak.

Rate-induced Phase-shift

Peak timing shifts to a later phasing at fast rates for CV forms.



Effects are larger, since post-vocalic /h/ has very early phasing at slow rates.

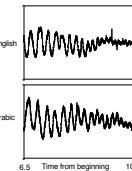
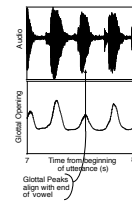
Glottal Retention

Arabic speaker resists the removal of glottal stops.

Illustrative traces to the right: productions of /ib/, movement between voicing and glottal adduction (no voiceless gestures).

English speaker loses adduction 3/4's of way through trial.

Arabic speaker retains evidence of glottal closure throughout trial.



Summary Discussion

ENGLISH

- Slow rate glottal regimes exhibit allophonic options, including glottalization of coda consonants.
- Each VC form has prosodic syllabic initial glottal marker.
- Rate increases change glottal regimes from various slow-rate configurations toward a glottal abduction roughly synchronized with the release of the stop.
- Previous rephrasing results are but one example of this more general reorganization.
- Part of reorganization is grouping syllables together without initial glottal marker.
- Reorganization also can add devoicing gestures with CV-time timing.

ARABIC

- While each VC form may have a prosodic onset, each CV form also tends to have a prosodic coda. Both CV and VC actually tend to be CVc.
- Reflects tendency in Arabic colloquial phonology toward filling syllabic templates (Broselow, 1992; Davis & Zawaydeh, 1997).
- Rate increases tend to move glottal regimes toward same pattern as English speaker.
- Rephrasing effects are larger, since they also involve post-vocalic /h/.
- Arabic speaker tends to resist loss of initial glottal closures.
- Perhaps this resistance reflects use of glottal stop in Arabic lexical contrasts as a consonantal marker. Glottal stop is proper part of the syllable being repeated, not part of higher level prosodic domain.

GENERAL

- Linguistic function determines behavior in production experiments. Actions are typical of native consonants; composition is determined by prosodic patterning typical of native system.
- Speakers of both languages tend to implement a glottal opening synchronized with the stop release in fast speech. Rate has a common effect for both speakers; suggesting that this common behavior is driven by production factors.

Motor Phonetics Updated

- Not all gestural coordinations and compositions are motorically equal. Motorically preferred structures appear as modes in speech behavior and can be induced in speech experiments.
- The common appearance of these speech modes in numerous languages would suggest that motor factors act as background pressures in the historical determination of linguistic systems.
- Motor structures, however, may get integrated into different languages for different linguistic functions. These functions, in turn, determine what speakers will do in speech experiments.

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