The role of labiolingual gestural coordination in spatiotemporal facilitation of Turkish, Turkmen and Hindi

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Motor facilitation and gestural economy

- Lingual harmonic patterns due to economized speech gestures yield motor facilitation by increasing speech rate or accuracy[1].
- Harmonic patterns articulated with lip protrusion gesture require more articulatory effort and so they do not yield motor facilitation.
- Back harmonic languages do not participate in height harmony[2], consequently, only back harmonic patterns yield motor facilitation.
- We present results from a study with two back harmonic languages Turkish and Turkmen and one non-harmonic language Hindi.
- Turkish front rounded vowels articulated with lip protrusion make larger gestures than back rounded vowels[3].
- We show that Turkish & Turkmen front round vowels formed with lip protrusion do not yield motor facilitation in back harmony. As also Hindi.

Turkish rounded vowels

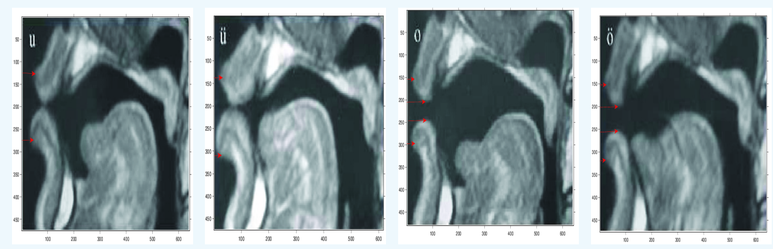

Figure 1: MRI Images of Turkish front & back rounded vowels

- Front rounded vowels have larger vertical opening than the back rounded vowels.
- Front rounded vowels are protruded transversely more than the back rounded vowels.

Research questions and variables

- Do back harmony patterns increase speech or error rates? & Do intervocalic consonants exert any influence on speech or error rates?
- Do back harmony patterns formed from front unrounded vowels increase speech/error rates compared to back harmony patterns formed from front rounded vowels?

Variables

Harmony Type (HT): Back harmony (**BH**), Disharmony (**DH**), Height harmony (**HH**); ***Consonantal Type (CT)***: /**p**/, /**t**/, /**k**/; ***Random Variable***: Speaker; ***Condition types***: Front unrounded (**FU**), front rounded (**FR**); ***Fixed effects***: Speech & error rates

Experimental procedure and analysis

- 10 each, native Turkish and Turkmen, and 7 native Hindi speakers.
- We presented each token of the experimental stimuli for 5 seconds on a computer screen & instructed speakers to utter each phrase **as many times as possible, as quickly as possible, as accurately as possible**.
- Measurement: number of syllables uttered; **speech rates** were measured as - number of syllables/5 sec & **Error rates** were measured as - (number of syllables/number of tokens)∗100.
- Speech rates and error rates were converted into logarithmic form for reducing the skew.
- **Statistical model**: Linear Mixed Effects (LME) model is used for verifying random effects of speaker and fixed effects of harmony & consonantal type.

Stimuli

Type	FU condition	FR condition
BH	i-e,e-i,u-o,o-u 36 pipe la pupo 36	y-ø,ø- y,u-o,o-u 36 pypø la popu 36
HH	i-u,u-i,e-o,o-e 36 pope la pupi 36	y-u,u- y,ø-o,o-ø36 pypu la pøpo 36
DH	i-o,o-i,u-e,e-u 36 pipo la popi 36	y-o,o-y,u-ø,ø-u 36 pøpu la pypø36

Hypotheses

H1: Speech rate: DH $\leq$ BH $>$HH

H1: error rate: DH $\geq$ BH $<$HH

H2: speech rate: FU$>$FR; error rate: FU $<$FR

H3: speech rate: /p/ $>$/k/ $<$/t/

H3: error rate: /p/ $<$/k/ $>$/t/

Speech rates - HT & CT - LME test

LME test conducted to verify speech rates **DH** $\leq$ **BH**$>$**HH**

Speech rates	Turkish	Turkmen	Hindi
FU	p$<$0.05	p$<$0.05	p$>$0.05
FR	p$<$0.05	p$<$0.05	NONE

Verifying speech rates /**t**/$>$/**k**/$<$/**p**/

Speech rates	Turkish	Turkmen	Hindi
FU	p$>$0.05	p$>$0.05	p$>$0.05
FR	p$>$0.05	p$>$0.05	NONE

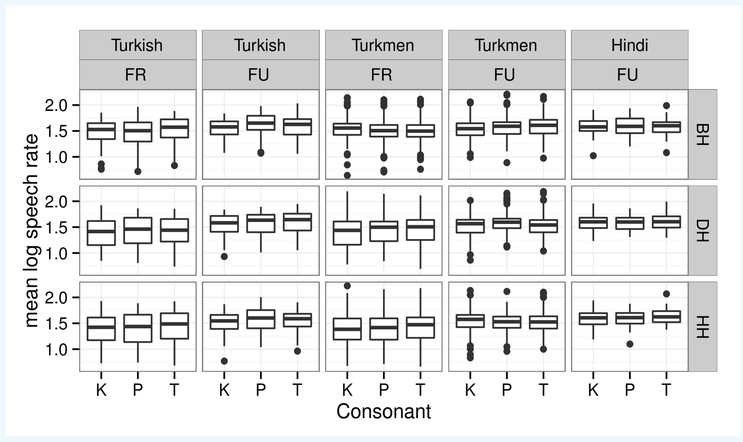

Figure 3: Speech rates of select languages

FU yields higher speech rates than FR (p-value$<$0.05)& BH yields higher speech rates than DH and HH in FU & FR conditions, in both Turkish and Turkmen. No significant results obtained in Hindi.

Error rates - HT & CT - LME test

LME test conducted to verify error rates **DH** $\geq$ **BH**$<$**HH**

Error rates	Turkish	Turkmen	Hindi
FU	p$>$0.05	p$>$0.05	p$>$0.05
FR	p$<$0.05	p$<$0.05	NONE

Verifying error rates /**t**/$<$/**k**/$>$/**p**/

Error rates	Turkish	Turkmen	Hindi
FU	p$>$0.05	p$>$0.05	p$>$0.05
FR	p$>$0.05	p$>$0.05	NONE

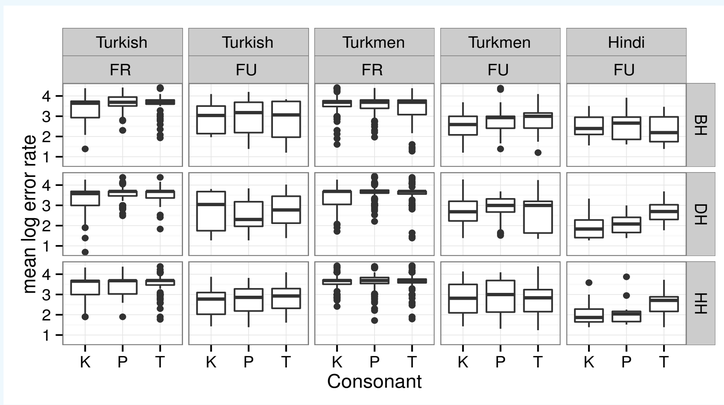

Figure 4: Error rates of select languages

FU yields lesser error rates than FR (p-value$<$0.05)in both Turkish and Turkmen. No significant results occurred for error rates of Turkish, Turkmen & Hindi in FU condition. BH error rates of FR condition are increased in Turkish and decreased in Turkmen.

Speaker variance -LME test

Variance & residual deviance for speakers are less than 1; data is normally distributed.

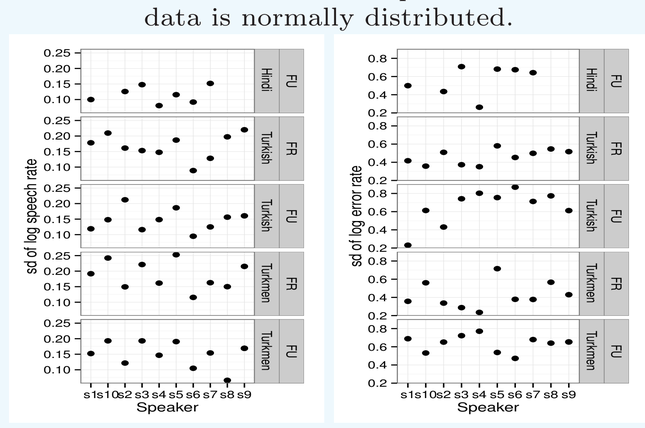

Figure 2: Speaker variance of speech & error rates

References

[1] Jennifer Cole. Emergent feature structures: Harmony systems in exemplar models of phonology. *Language Sciences*, 31(2):144–160, 2009.

[2] G.D. Linebaugh. *Phonetic Grounding and Phonology: Vowel Backness Harmony and Vowel Height Harmony*. PhD thesis, University of Illinois at Urbana-Champaign, 2007.

[3] Mehmet Akif Kiliç and I Giriç. Türkiye tiirkçesi'ndeki ünlülerin sesbilgisel özellikleri. *Dilbilimi Journal of Linguistics*, 2003.

[4] M. Lindau. Vowel features. *Journal of the Linguistic Society of America Baltimore, Md*, 54(3):541–563, 1978.

Discussion, Conclusion and Further research

- Back harmonic patterns yield temporal facilitation in Turkish and Turkmen; labial protrusion of front rounded vowels prevents motor facilitation in back harmony. However, lip spreading and lip compression gestures yield temporal facilitation. Hindi, a non-harmonic language, does not yield any facilitation. Consonants /p/ and /t/ aid the harmonic patterns in temporal motor facilitation in Turkish and Turkmen respectively.
- Spatioteompral facilitation in labial and lingual gestural coordination will be examined with EMMA, MRI and acoustic modelling.