

Articulatory Strategies for Back Vowel Fronting in American English

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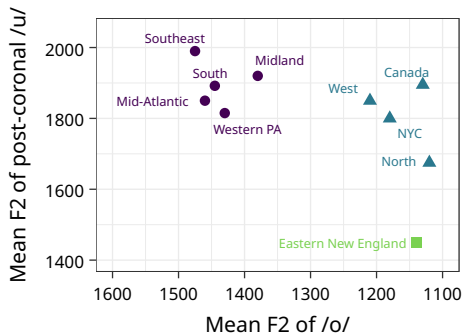
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Back Vowel Fronting

- ▶ Fronting of GOOSE (/u/) and GOAT (/o/) is widespread in global varieties of English:
 - ▶ **North America** (Labov et al., 2006)
 - ▶ **Britain and Ireland** (Harrington et al., 2008; Ferragne & Pellegrino, 2010)
 - ▶ **Australia** (Cox, 1999; Cox & Palethorpe, 2001)
 - ▶ **New Zealand** (Gordon et al., 2004)
 - ▶ **South Africa** (Mesthrie, 2010)

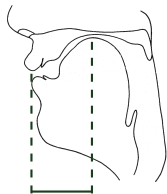
Back Vowel Fronting



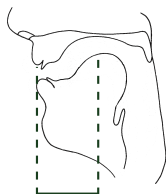
- ▶ Fronting of /u/ found in most North American varieties
- ▶ Sometimes with parallel fronting of /o/

Chart adapted from Labov et al. (2006, 157)

Articulation of Fronted Back Vowels?



front, round: [y, ʊ]



back, unround: [ɨ, ʉ]

- ▶ Increase in F2 can be the result of any gesture that shortens the front cavity of the vocal tract.
 - ▶ Tongue fronting or lip unrounding

Articulation of Fronted Back Vowels?

- ▶ In British varieties, fronted /u/ produced with fronted tongue:
 - ▶ Harrington et al. (2011): In Standard Southern British English, /u/-fronting achieved by tongue fronting; /u/ remains round
 - ▶ Scobbie et al. (2012): In Scottish English, /u/ produced with fronted (but also lowered) tongue; realized as [ø] or [ʊ]
 - ▶ Lawson et al. (2017): Fronted /u/ in Scottish English lower than Anglo and Irish varieties

Articulation of Fronted Back Vowels?

Descriptions of fronted /u/ in American English vary:

- ▶ “clearly more front and **less rounded**” (Hinton et al., 1987).
- ▶ “the canonical back vowels /u/ and /ʊ/ are typically **unrounded** in Californian speech” (Hagiwara, 1997).

but:

- ▶ “The surfer stereotype involves a regular use of *dude*, featuring a simple **fronted** variant of /uw/ - **[dyd]**” (Eckert, 2008).
- ▶ “Some authors have asserted that /u/ is undergoing unrounding as it is fronted, but I am skeptical about that” (Thomas, 2001).

This Experiment

- ▶ Back vowel fronting in two varieties of American English:
 - ▶ Coastal Southern California
 - ▶ South Carolina
- ▶ Both regions exhibit strong fronting of /u/, but differ in the degree of /o/-fronting and the phonological conditioning of fronting.

Research Questions

- ▶ How is back vowel fronting achieved in North American English?
 - ▶ Tongue fronting, lip unrounding, combination of the two?
- ▶ To what extent do the processes of back vowel fronting differ in California vs. South Carolina?
 - ▶ Lip unrounding may be more likely if fronting is less strongly tied to coronal coarticulation (as in South Carolina).

Methods: Participants

- ▶ 22 participants (9 men, 13 women):
 - ▶ 13 speakers from coastal Southern California
 - ▶ 9 speakers from South Carolina
- ▶ Born and raised in respective regions at least through age 18.
- ▶ Data collected at UC San Diego and the University of South Carolina.

Methods: Materials

- ▶ 203 (mostly) monosyllabic words containing /i u e o ɪ ʊ ɑ ɔ/
 - ▶ Onset consonants: /p t s ʃ k h (b d g)/
 - ▶ Coda consonants: /# p t k/ and /l/ (excluded here)
- ▶ Produced in the carrier phrase “say ____ again”, repeated three times
- ▶ Presented to each participant in unique pseudorandom order

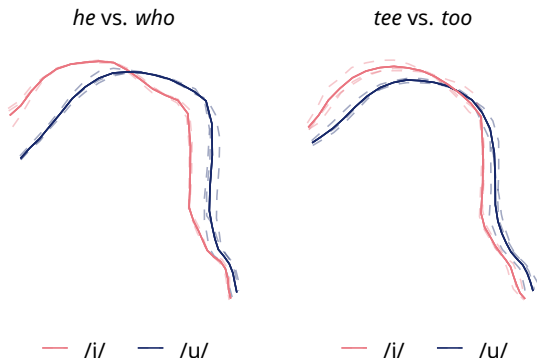
Methods: Recording

- ▶ Simultaneous audio, ultrasound, and video recording:
 - ▶ **Ultrasound:** High speed (84 fps) SonoSpeech Micro ultrasound system, 20mm radius probe
 - ▶ **Video:** Sagittal-view lip video @ 60 frames per second
 - ▶ **Audio:** Recorded at 48kHz/16-bit with AKG C544L headset condenser microphone
- ▶ All three data streams synchronized in Articulate Assistant Advanced (Articulate Instruments Ltd., 2012)

Analysis

- ▶ Acoustic metric: Lobanov normalized F2, rescaled to Hertz (Lobanov, 1971; Kendall & Thomas, 2014)
- ▶ Articulatory metrics:
 - ▶ Tongue fronting: Summed radial difference (cf. Scobbie & Cleland 2017)
 - ▶ Lip rounding: Lower lip protrusion
- ▶ Measurements taken at steady state portions of nucleus and glide

Analysis: Tongue Fronting

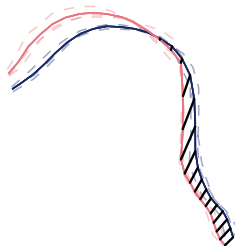
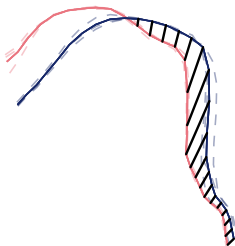


- Quantifying tongue fronting: Summed radial difference (RD- Σ) between /i/ and /u/.

Analysis: Tongue Fronting

/hV/ = 89.03 mm

/tV/ = 57.6 mm

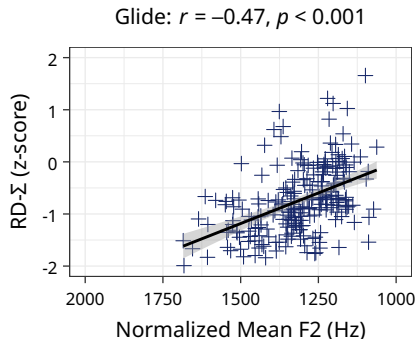
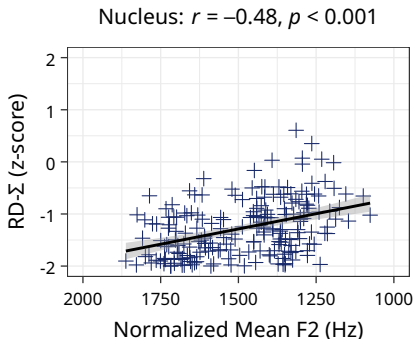


— /i/ — /u/

— /i/ — /u/

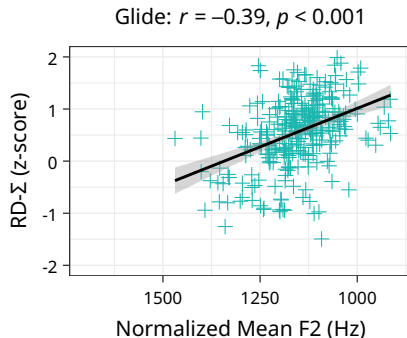
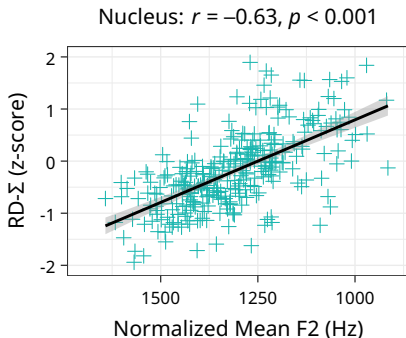
- ▶ Sum of distances between corresponding points on each mean tongue contour
- ▶ Smaller values indicate more fronted tongue

Tongue Frontedness, Southern California /u/



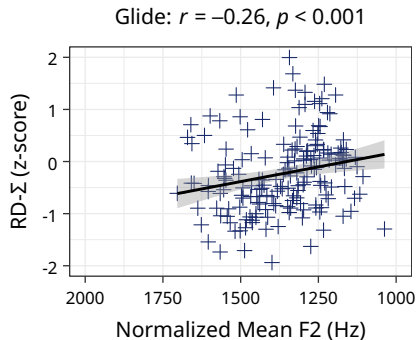
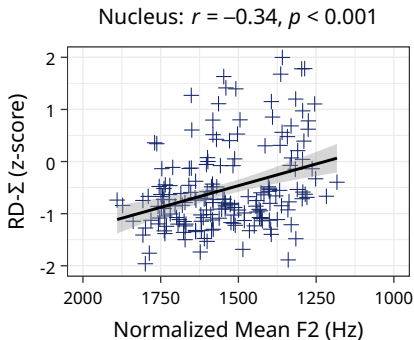
- F2 negatively correlated with RD-Σ: higher F2 associated with fronter tongue position.

Tongue Frontedness, Southern California /o/



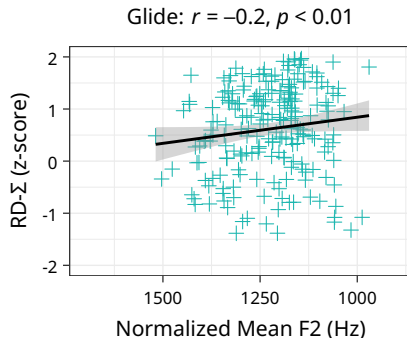
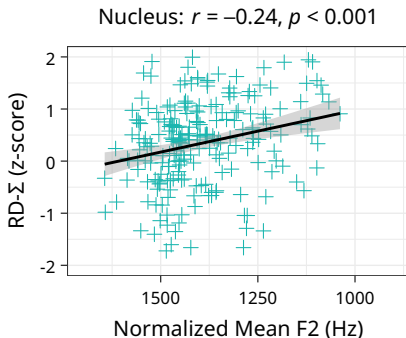
- Strong correlation of F2 and tongue frontedness for /o/

Tongue Frontedness, South Carolina /u/



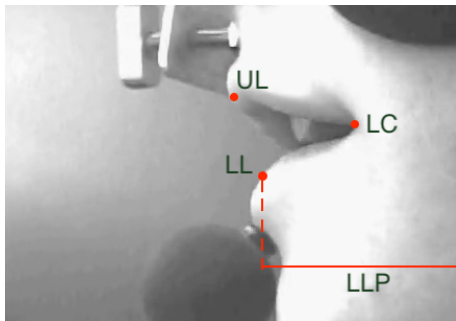
- F2 weakly correlated with tongue frontedness, substantial interspeaker variation

Tongue Frontedness, South Carolina /o/



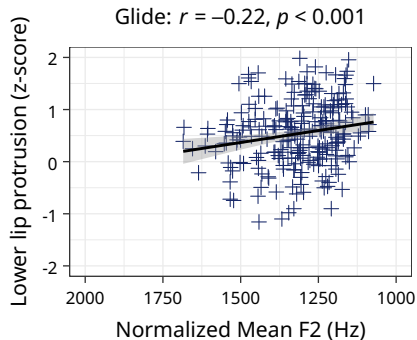
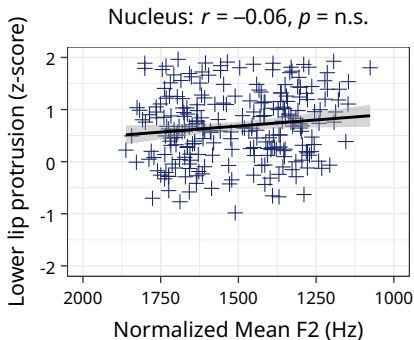
- Weak correlation between F2 and tongue frontedness for /o/

Analysis: Lip Rounding



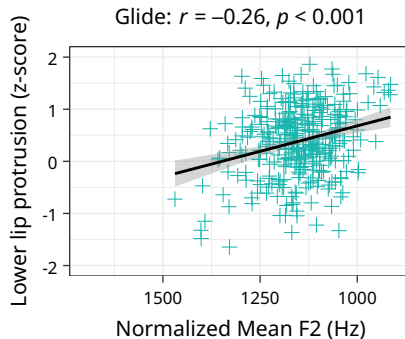
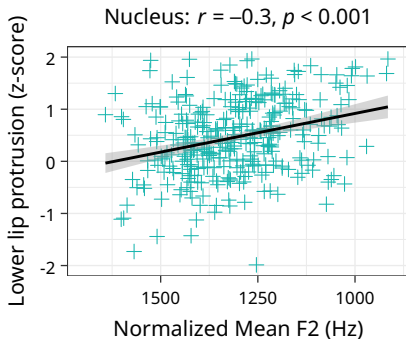
- ▶ Lower lip protrusion: distance of LL from posterior edge of video frame, z-score normalized
- ▶ Higher value indicates increased rounding

Lip Rounding, Southern California /u/



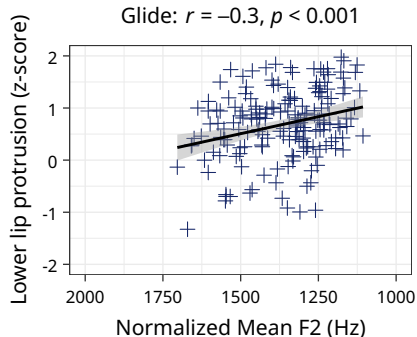
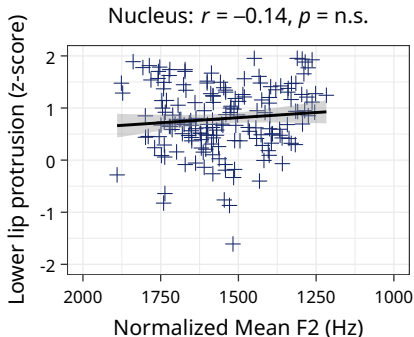
- At nucleus, F2 and lip protrusion not correlated: High F2 tokens have similar degree of rounding to low F2 tokens.

Lip Rounding, Southern California /o/



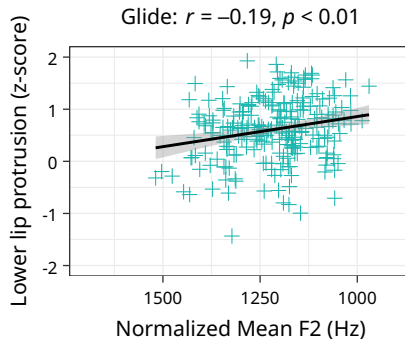
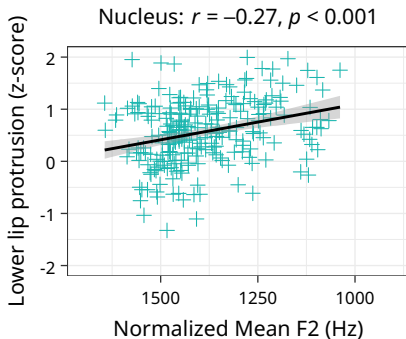
- Weak negative correlation of lip protrusion and F2

Lip Rounding, South Carolina /u/



- At nucleus, no correlation of lip protrusion and F2

Lip Rounding, South Carolina /o/



- Weak negative correlation of lip protrusion and F2




Discussion

- ▶ For California speakers:
 - ▶ Strong correlation of raised F2 with fronted tongue
 - ▶ For /u/, no evidence for unrounding, contra some previous descriptions
- ▶ For South Carolina speakers:
 - ▶ Lip rounding for /u/ retained for most speakers
 - ▶ Tongue fronting not clearly responsible for raised F2
 - ▶ Substantial individual variation, requiring future analysis

Discussion

- ▶ Why retain rounding?
 - ▶ Acoustic fronting generally conditioned by onset place of articulation
 - ▶ Retention of (visible) rounding may help to preserve perceptual contrast between /i/ and /u/ (cf. Havenhill, 2018; Havenhill & Do, 2018)
- ▶ Implications for diachronic development of front round vowels?

Thank you!

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Southern California: Participant Demographics

Speaker ID	Gender	Age	Ethnicity	Outside	SoCal Origin
Cal001	F	21	White	0	Los Angeles County
Cal002	F	20	White	0	Long Beach
Cal003	F	19	White	0	San Marcos
Cal004	F	21	Vietnamese	0	Santa Ana, San Diego
Cal006	F	20	Latina	0	Chino, La Jolla
Cal007	M	22	White	0	Sun Valley, Thousand Oaks
Cal008	M	18	Asian	0	Rowland Heights
Cal009	F	21	Mexican-American	0	Garden Grove
Cal010	F	34	Filipino	0	San Diego
Cal011	M	20	Afghan	0	Laguna Niguel
Cal012	M	21	White/Asian	0	Camarillo, Northridge
Cal013	M	18	Mixed	0	Orange County
Cal014	M	18	Filipino	0	Walnut

South Carolina: Participant Demographics

Speaker ID	Gender	Age	Ethnicity	Outside	SC Origin
SC001	M	30	White	0	Richland
SC002	F	27	White	1	Lexington, Richland
SC003	F	22	White	0	Spartanburg, Richland
SC004	F	27	White	3	Berkeley, Dorchester, Richland
SC007	F	50	White	4	Greenville, Spartanburg, Richland
SC008	M	27	White	4	Aiken, Richland
SC009	F	18	White	0	Kershaw, Richland
SC010	F	27	White	2	Kershaw, Richland
SC012	M	20	White	0	Greenville

Vowel Chart: Southern California

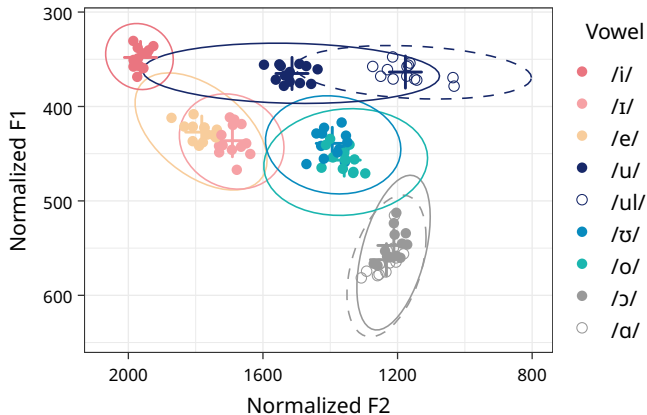


Figure 1: Normalized mean formant measurements for Southern California speakers.

Vowel Chart: South Carolina

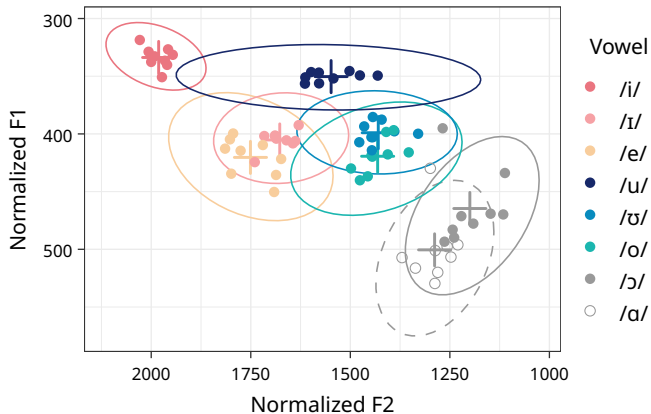


Figure 2: Normalized mean formant measurements for South Carolina speakers.

Distribution of /u/, Southern California

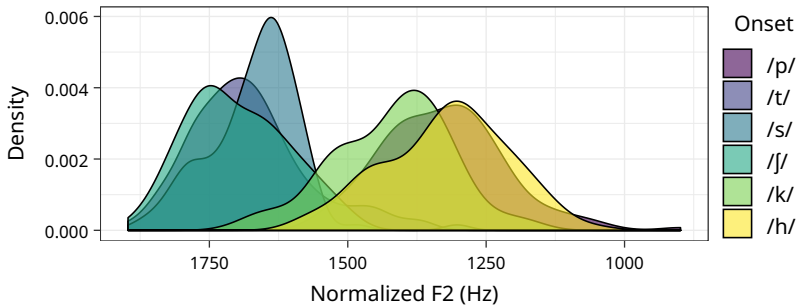


Figure 3: F2 for /u/ by onset, Southern California speakers.

- Fronting of /u/ is strongest after coronal onsets

Distribution of /o/, Southern California

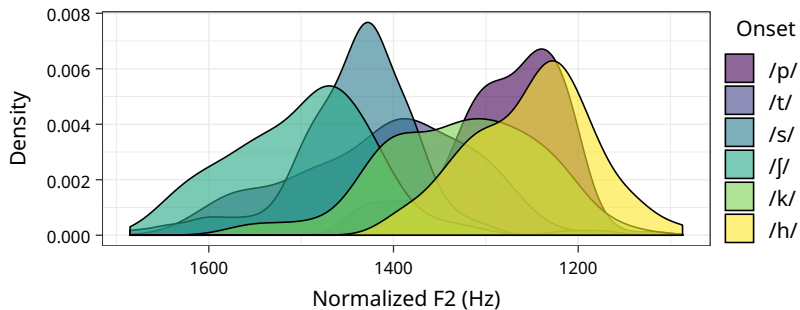


Figure 4: F2 for /o/ by onset, Southern California speakers.

- Less bimodal distribution for /o/

Distribution of /u/ , South Carolina

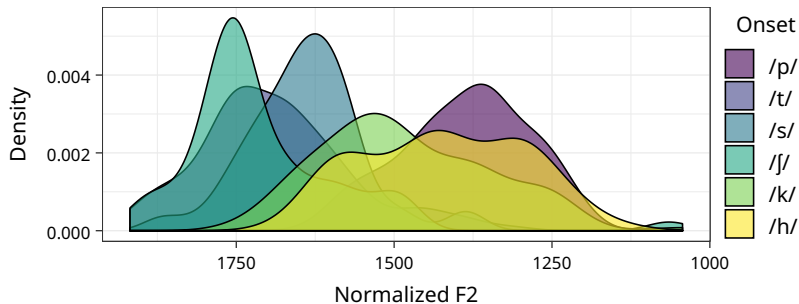


Figure 5: F2 for /u/ by onset, South Carolina speakers.

- Distribution less bimodal; some tokens of /u/ strongly fronted after non-coronal onsets.

Distribution of /o/, South Carolina

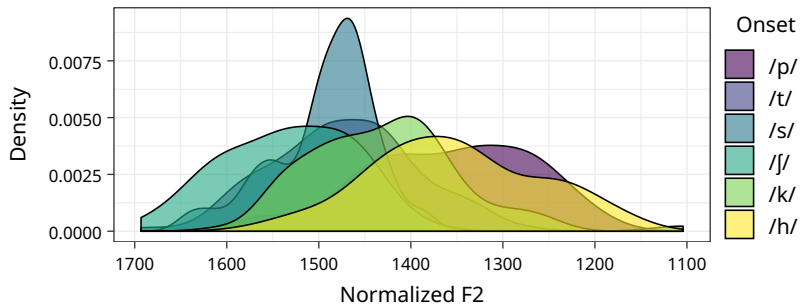
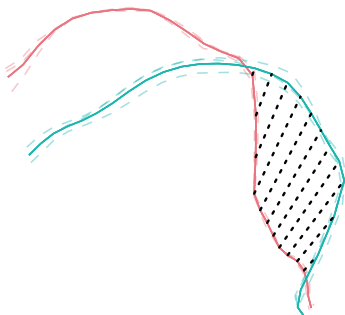


Figure 6: F2 for /o/ by onset, South Carolina speakers.

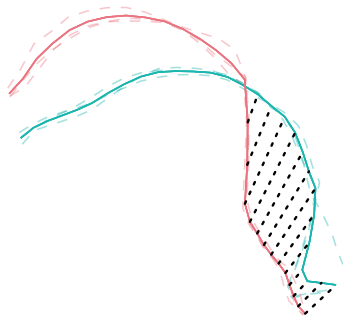
Analysis: Tongue Fronting

he vs. *hoe*, RD- Σ = 153.05 mm



— /i/ — /o/

tea vs. *toe*, RD- Σ = 138.74 mm



— /i/ — /o/