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Three-way rounding contrast in Norwegian vowels

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Distinctive feature theory

- Contrast in lip rounding = binary feature [\pm round]

(Chomsky & Halle 1968; Kenstowicz 1994; Hayes 2009)

- Two possibilities: rounded or unrounded
- A three-way contrast in rounding is not possible

Norwegian

- *Norwegian* = Urban East Norwegian (Kristoffersen 2000)
- Norwegian has four high vowels
- Conventionally transcribed /i y ʉ u/
- All Norwegian vowels have a length contrast
- We will only treat the long vowels here (/iː yː ʉː uː/)

Norwegian high vowels

- /i/ is front unrounded
- /y/ is front rounded
- /u/ is back rounded
- What about 'ʉ'?

Norwegian */ɥ/*

- Most often described as central

(Storm 1908; Broch & Selmer 1945; Popperwell 1963; Sivertsen 1967; Slethei 1996; Kristoffersen 2015)

- Sometimes described as front

(Husby & Kløve 1998; Endresen 2000; Skaug 2005; Ophaug 2010; Knudsen & Husby 2020)

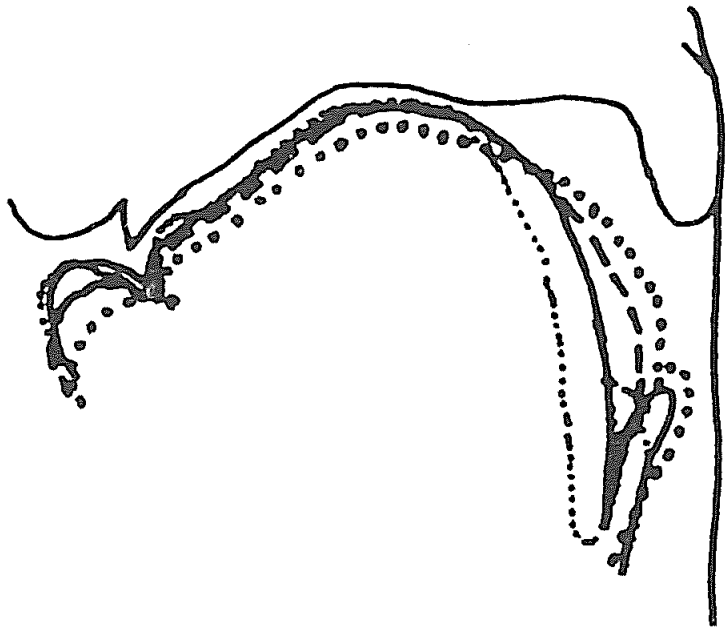
- Somewhere between front and central

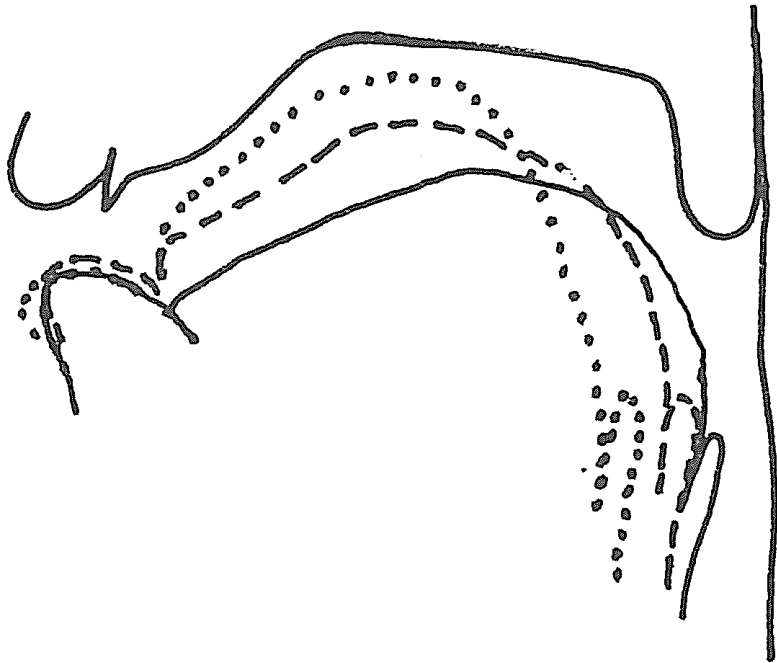
(Vanvik 1979; Endresen 1991)

- One needs experimental evidence to decide

Previous experiment

- MRI of a phonetician from Vestfold (South-Eastern Norway)
(Foldvik, Husby, & Kværness 1988, 1989)
- Comparison of:
 - front vowels /i ʏ e æ/
 - back vowels /u ɔ ɑ/
- Did not investigate the articulation of /y/





Previous experiment – caveats

- Don't report how many tokens per vowel – presumably just *one*
- “the conditions under which the articulation is produced are very unnatural”:
 - The speaker is lying on his back or stomach
 - “pronounced under very noisy conditions”
 - The speaker has to hold the vowel steady for 12–45 seconds

Previous experiment – caveats

- Vowel /y/ not included
- Articulations in supine position appear somewhat unreliable
 - (All vowels are high)
- Vowels /y ʉ u/ not tested in prone position

Our study

- Ultrasound and video
- Speaker sits upright on a chair
- Speaker holds the ultrasound transducer comfortably under his chin
- Video camera records lips from a distance

Our study – advantages

- Speaker is in a normal position for speech
- No foreign objects interfere with normal tongue or lip movements
- Speaker can talk naturally:
 - Normal volume (in a quiet room)
 - Normal, casual speech rate

Our study

- Male 29-year-old speaker of Norwegian
- All Norwegian vowels produced in four different contexts:
 - #_# (in isolation)
 - b_#
 - d_#
 - #_r
- Four tokens for each vowel

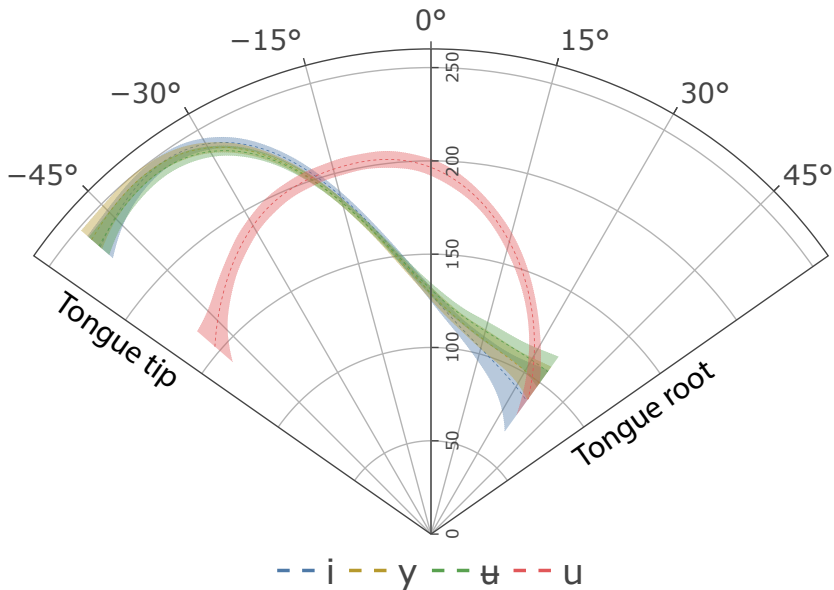
Our study

- All tokens produced in a carrier phrase:

/si: __ fɔ mæ/

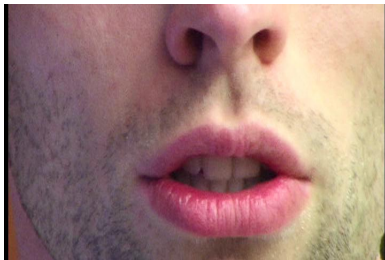
'Say __ for me'

Comparison of tongue curvature : i vs y vs ʏ vs u





/i/



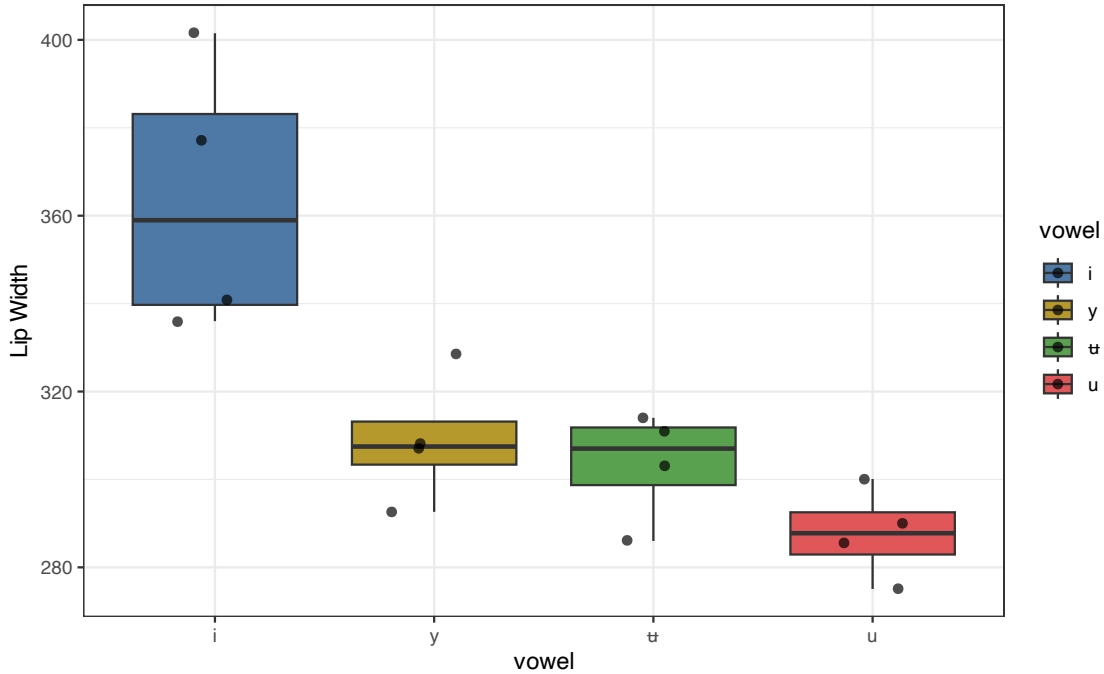
/y/

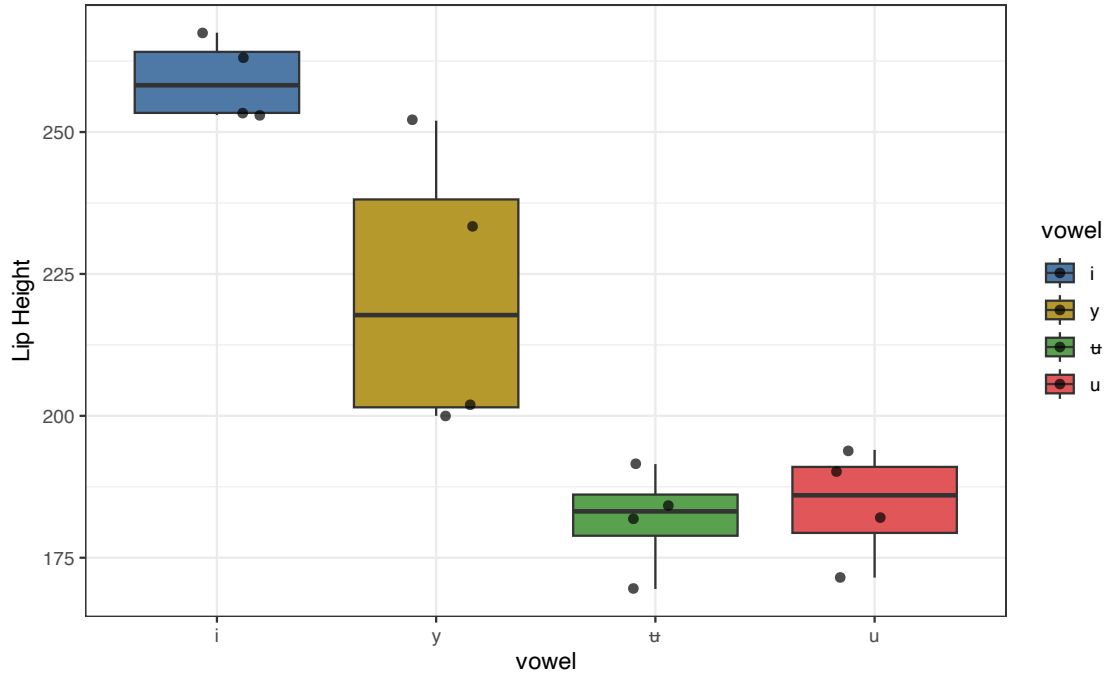


/ɨ/



/u/





Results

- /i y ʊ/ are all high and front
- They differ in lip rounding, but not in tongue position
- The differences in lip rounding can be described by:
 - lip *contraction* (horizontal plane)
 - lip *compression* (vertical plane)

Results

- /ʉ u/ are both contracted and compressed
- /y/ is contracted, but not compressed
- /i/ is neither contracted nor compressed

Features

- This three-way distinction in rounding cannot be captured with a binary feature $[\pm\text{round}]$.
- Lip contraction and compression are best captured with two distinct features:
 - $[\pm\text{contracted}]$
 - $[\pm\text{compressed}]$






Features

- /ʊ u/ are [+contracted, +compressed]
- /y/ is [+contracted, -compressed]
- /i/ is [-contracted, -compressed]





Conclusion

- Norwegian makes a three-way distinction in rounding for /i y ʉ/
- This distinction can be captured with two binary features [±contracted] and [±compressed]
- Norwegian appears to be one of extremely few languages that use *both* contraction and compression to distinguish between vowels

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