LIN 350

Other Experimental Methods

So far…

- In this course, the focus has been on acoustic measurements
  - f0
  - Duration
  - Formants
  - VOT
  - Center of Gravity
  - …
- And a little bit of perceptual measurement
  - Categorization experiments

Simplicity

- More or less, everything we've done has been done for the sake of simplicity
  - All we need is a laptop!
- Simplicity is good sometimes, but we may be after some aspect of speech that is not so simple
- There have been lots of tools developed over time used to measure the phonetic properties of speech
- Today's lecture will review some of the different types of measurements and experimental techniques that researchers have, and continue to, use to collect phonetic data

Multiple Descriptions of the Same Object

A group of blind men heard that a strange animal, called an elephant, had been brought to the town, but none of them were aware of its shape and form. Out of curiosity, they said: "We must inspect and know it by touch, of which we are capable". So, they sought it out, and when they found it they groped about it. The first person, whose hand landed on the trunk, said, "This being is like a thick snake". For another one whose hand reached its ear, it seemed like a kind of fan. As for another person, whose hand was upon its leg, said, the elephant is a pillar like a tree-trunk. The blind man who placed his hand upon its side said the elephant, "is a wall". Another who felt its tail, described it as a rope. The last felt its tusk, stating the elephant is that which is hard, smooth and like a spear.

X-ray

- Radiation is projected through the head tissue and recorded
- Positions of articulators are then manually traced

- This was the first imaging technique used to measure speech
- Drawbacks include obfuscation from the skull and the radiation itself
- New x-ray data is not collected, but old x-ray data continues to be analyzed and used

X-ray

J2. Cinéradiographic Studies of Speech: Procedures and Objectives. S. E. G. Öhman, *Royal Institute of Technology, Stockholm, Sweden,* and K. N. Stevens, *Massachusetts Institute of Technology, Cambridge 39, Massachusetts.*—Simultaneous sound recordings and cinéradiographic films showing lateral views of the speech mechanism have been obtained for a variety of utterances generated by several speakers. Procedures are described for making frame-by-frame tracings from the films and for obtaining from these tracings quantitative data on the movements of the various speech-generating structures. Interpretation of these data is discussed in terms of several objectives: (1) obtaining further understanding of the relations between the positions of the articulatory structures, vocal-tract configurations, and acoustic outputs; (2) examining the dynamic properties of the various components of the articulatory mechanism and the interrelations among the movements of these components; and (3) gaining an understanding of the transformation from a discrete linguistic description of speech to the continuous motions of the articulatory structures. Attention in this paper is centered on the second of these objectives, and, in particular, data on the relative movements of various parts of the tongue and of the structures in the vicinity of the larynx for several vowel–consonant and consonant–vowel combinations are presented and discussed. A short film is shown to illustrate certain features of the data.

MRI

- Magnetic Resonance Imaging
- Creates a strong magnetic field and emanating radio waves
- Hydrogen atoms in the body align with the radio waves
- Provides soft tissue contrast

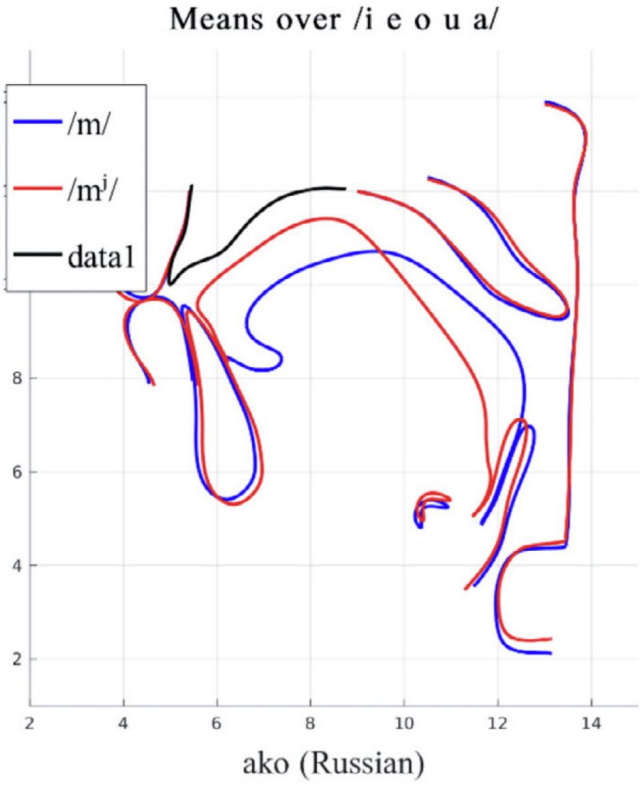
- Early MRI required sustained speech
- Real time MRI allows for the capture of continuous speech
- Drawback to the latter is reduced spatial resolution

MRI

- Subject is lying on their back
- Noisy

- “How it works”
- Video 1
- Video 2

MRI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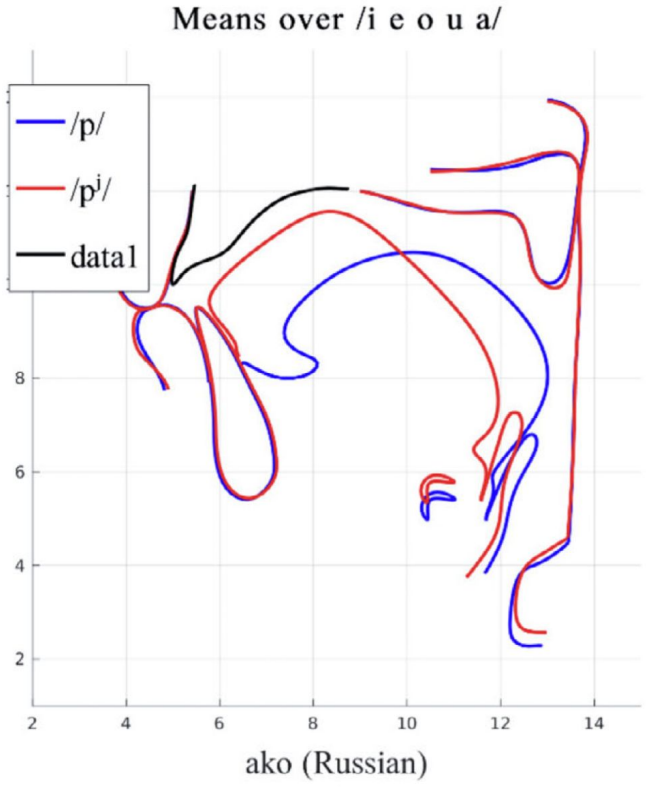
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MRI

Nasalization and glottal stops in Thai	Johnson et al., 2019
Phonemic and phonetic vowel nasalization Brazilian Portuguese	Barlaz et al., 2018
Velarization and retroflexion in /l/ and /n/ in Basque	Iribar et al., 2019
Prosodic effects on coronal consonant reduction in English and Spanish	Parrell & Narayanan, 2018
Lingual and pharyngeal differences between French nasal and oral vowels	Carignan et al., 2015
Gestural targets and the production of schwa in English	Lammert, Goldstein, Ramanarayanan, & Narayanan, 2014
Palatalization and coarticulation in Korean	Kim, 2012
Laryngeal & supralaryngeal correlates of the laryngeal contrasts in Korean fricatives	Kim et al., 2011
Pharyngeal volume differences between voiceless and voiced fricatives in English	Proctor et al., 2010
Prosodic effects and gestural timing in the production of English /n/	Byrd et al., 2009

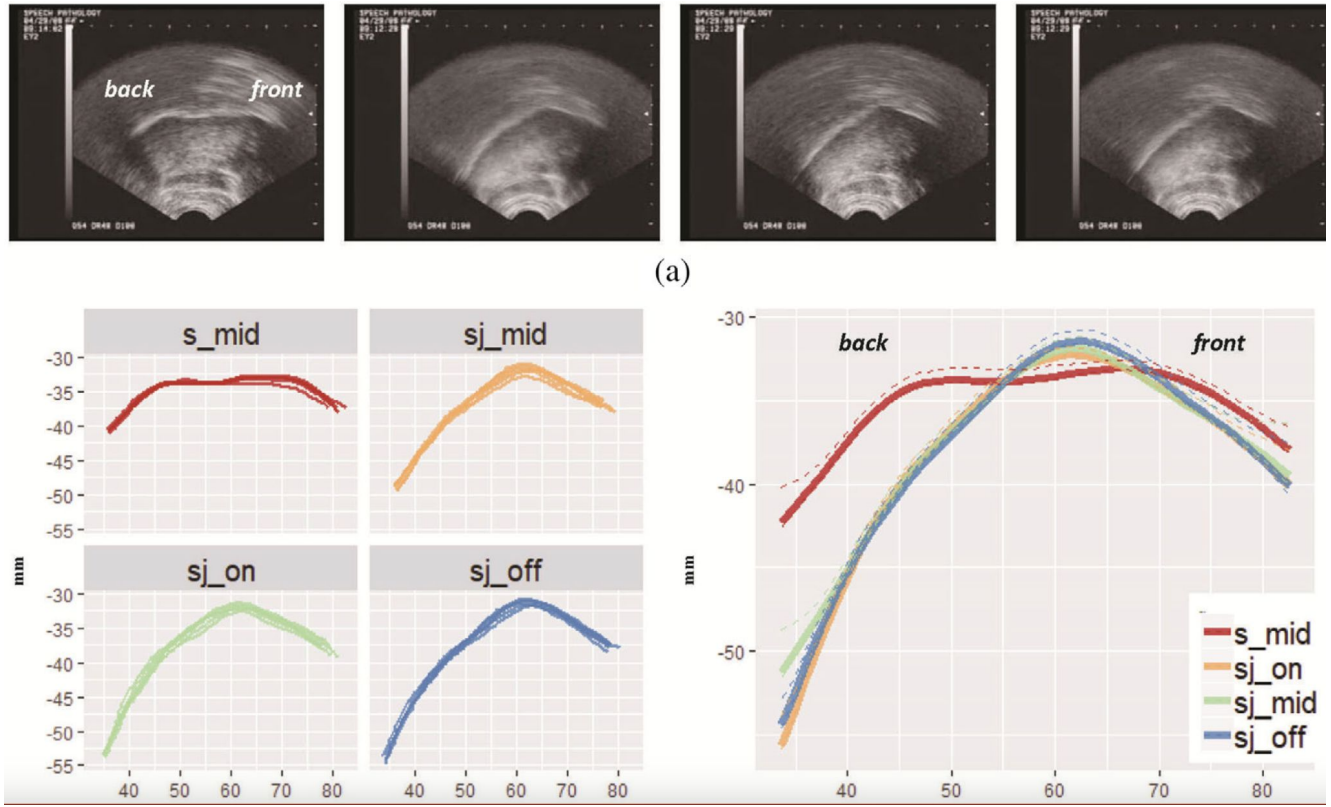
Ultrasound

- Ultra-high frequency sound wave projected as a thin beam that travels through tissue and is reflected from its surface
- When placed under the chin, it produces an image of the tongue
  - Sagitally (front to back)
  - Coronally (left to right)
- This method has been used in speech science since the 1960’s and is still used today
- Has become increasingly portable over time!

Ultrasound

- Generally has much poorer temporal resolution
- Requires the probe (that projects the beam) to be stable
- Can also be used to measure laryngeal activity
  - Ultrasound probe is held up to the larynx to measure the relative height
  - Used simultaneously with a laryngoscope
- Unlike other methods, it is extremely non-invasive
- Video

Ultrasound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Ultrasound

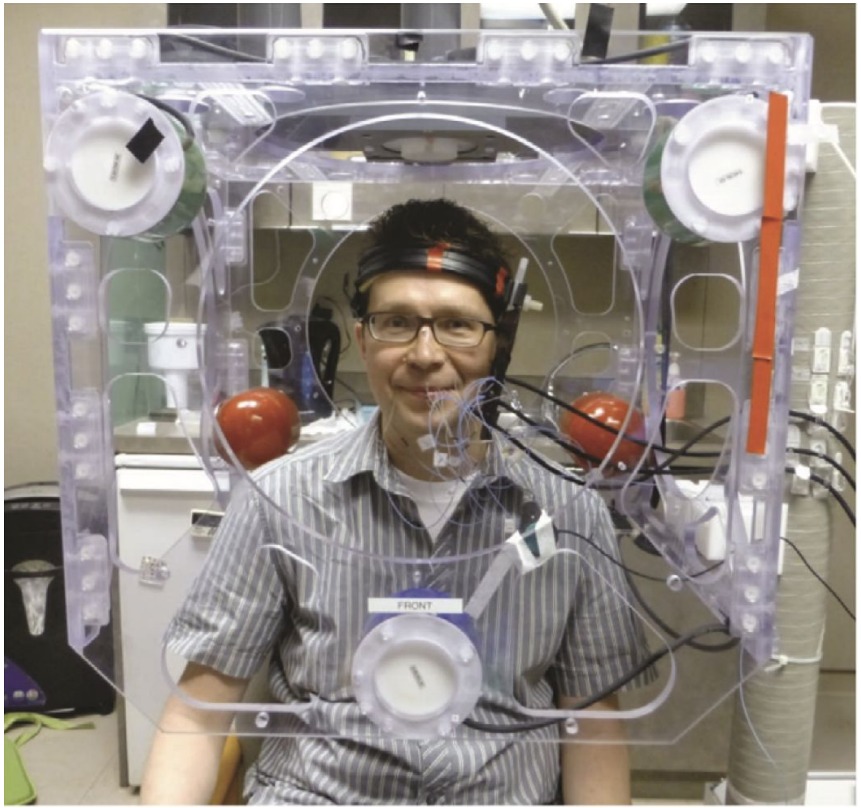
Phenomena investigated	Study
The nasal substitution process in Sasak and Javanese	Archangeli et al. (2017)
Secondary palatalization and velarization in Irish	Bennett et al. (2018)
Sociophonetic variation in the production of /l/ in Newfoundland English	De Decker & Mackenzie (2017)
Inaudible vowels in Oneida and Blackfoot	Gick, Bliss, Michelson, & Radanov (2012)
ATR and tense-lax in Twi-English bilinguals	Kirkham & Nance (2017)
Retroflex stops in Kannada	Kochetov, Sreedevi, Kasim, & Manjula (2014)
Whistled fricatives in Xitsonga	Lee-Kim, Kawahara, & Lee (2014)
/æ/ allophony in North American English	Mielke et al. (2017)
Several types of clicks in Mangetti Dune!Xung	Miller (2016)
Lingual C-V coarticulation in Catalan	Recasens & Rodriguez (2017)
The rhotic degemination process in Dutch	Strycharczuk & Sebregts (2018)
A 4-way coronal place contrast in Arrernte	Tabain & Beare (2018)

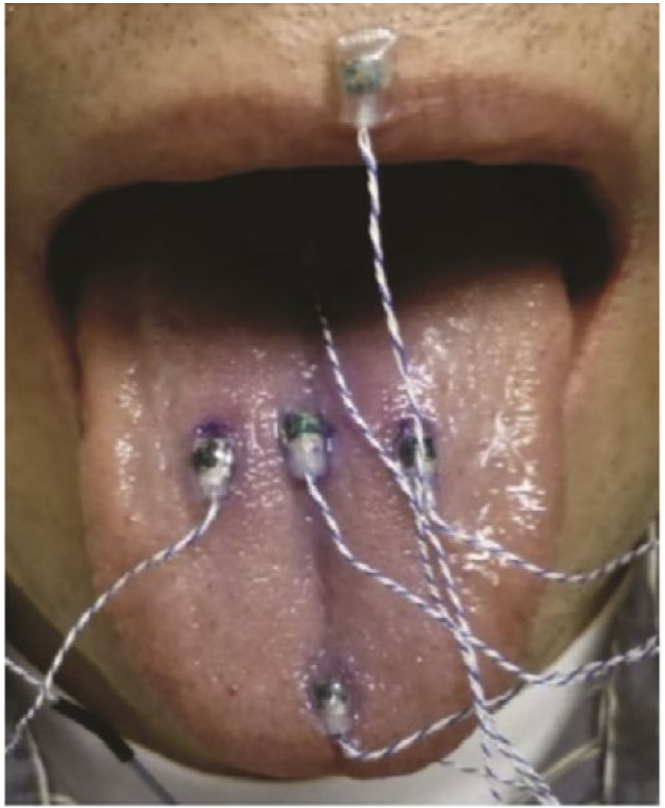
EMA

- Electromagnetic Articulography
- Small sensors are attached to articulators
- A magnetic field is projected and the sensors create an opposing magnetic field
- This allows for the tracking of the articulators in real time
- Video

- One downside is that it only provides position of a single point and not the entire articulator

EMA





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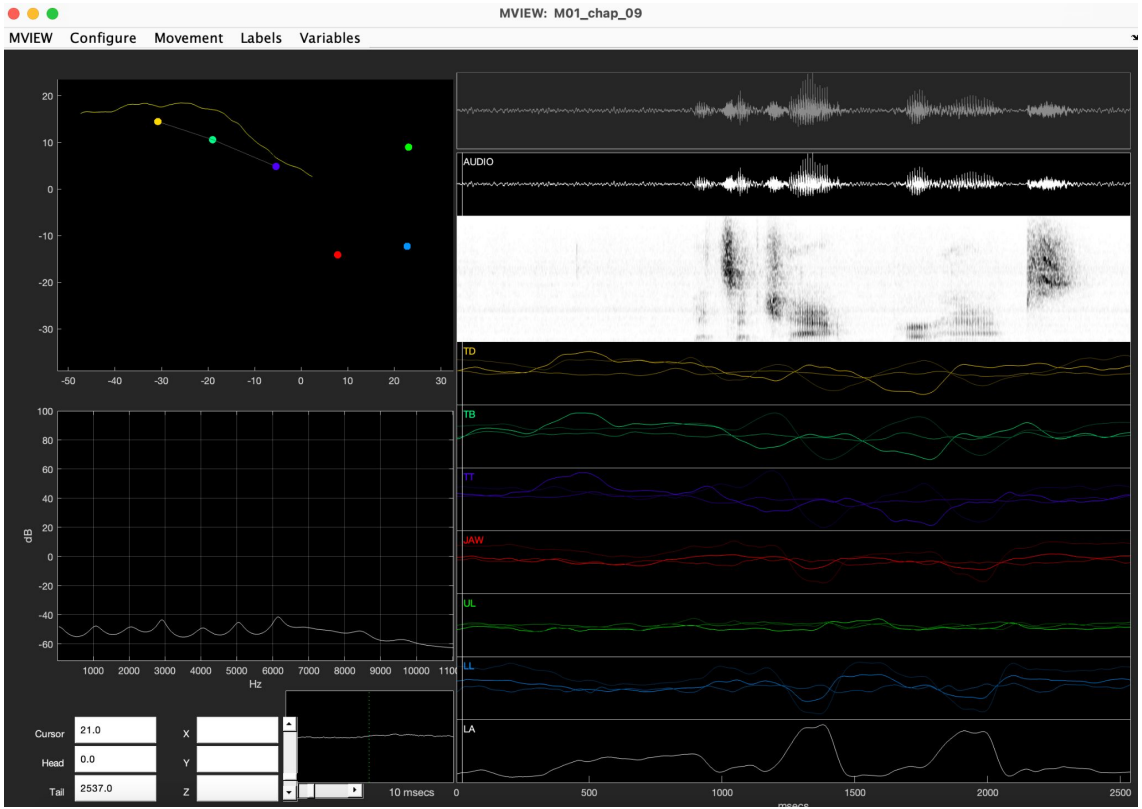
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EMA

Phenomena investigated	Study
Speech errors and effects of syllable/word position in English	Mooshammer, Tiede, Shattuck-Hufnagel, & Goldstein (2019)
Vowel devoicing and its effect on lingual gestures in Japanese	Shaw & Kawahara (2018b)
Articulatory settings in Dutch dialects	Wieling (2018)
Inter-gestural timing in Tashlhiyt Berber and Polish clusters	Hermes, Mücke, & Auris (2017)
Inter-gestural timing, speech rate, and frequency in Russian clusters	Pouplier, Marin, Hoole, & Kochetov (2017)
Gestural characteristics of a 3-way quantity contrast in Estonian consonants	Türk, Lippus, & Šimko (2017)
Articulatory correlates of syllable structure in Moroccan Arabic	Shaw, Gafos, Hoole, & Zeroual (2011)
Domain-initial strengthening and the Korean 3-way laryngeal contrast	Cho, Son, & Kim (2016)
Vowel coarticulation and aggression in Mandarin	Chen, Chang, & Iskarous (2015)

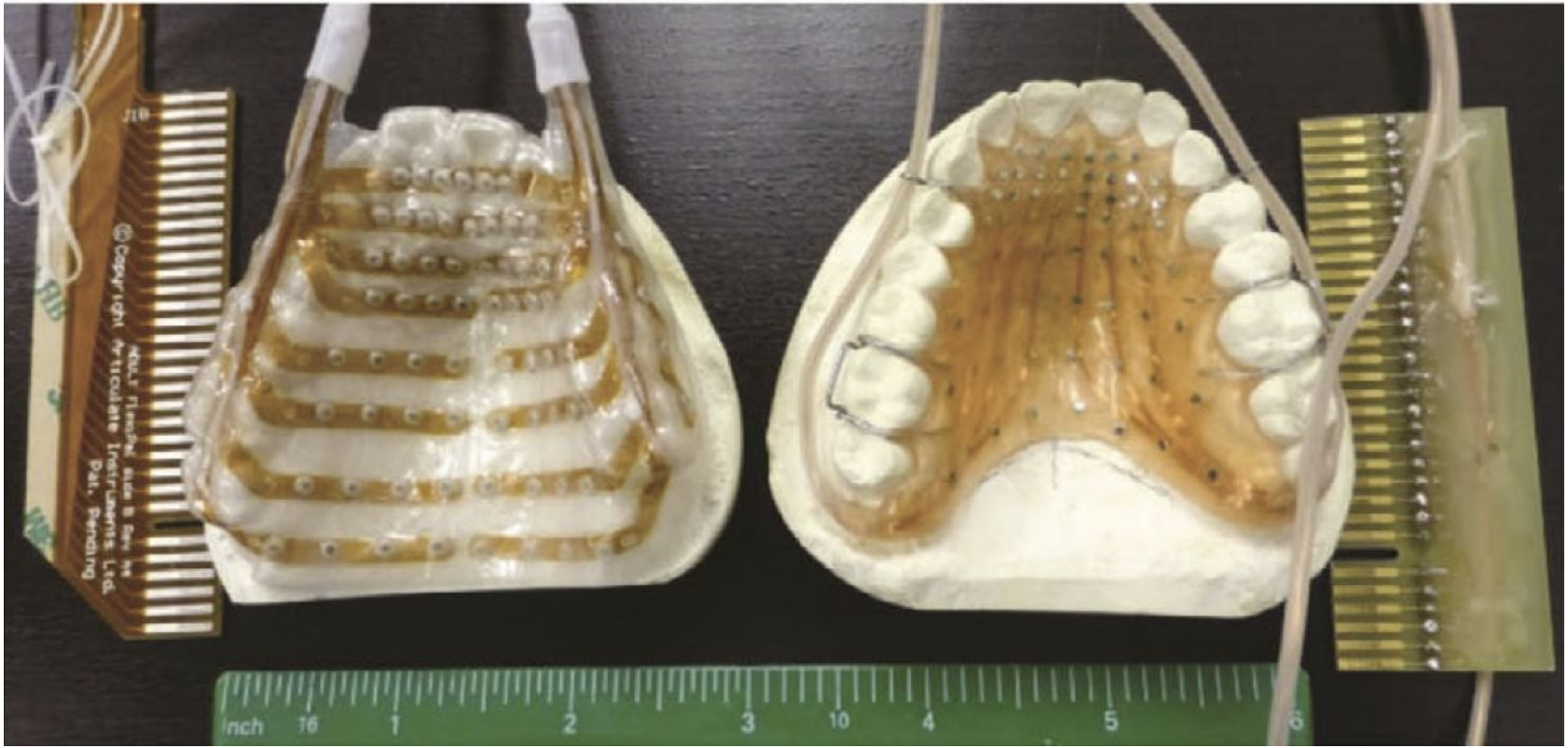
Palatography

- A static measurement of where the tongue makes contact with the palate can be measure
- Originally this was done using a combination of charcoal and olive oil that would then be painted onto a speaker’s tongue or palate
- Now, we have artificial palates with electrodes that fit into speaker’s mouths

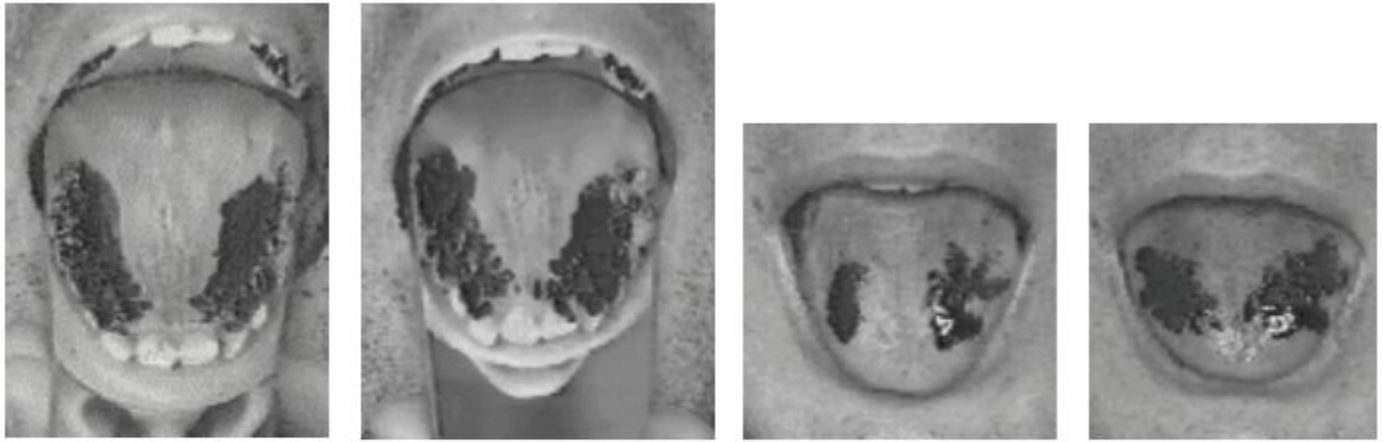
- This allows for insight into exactly where articulations are being made

Palatography

Palatography

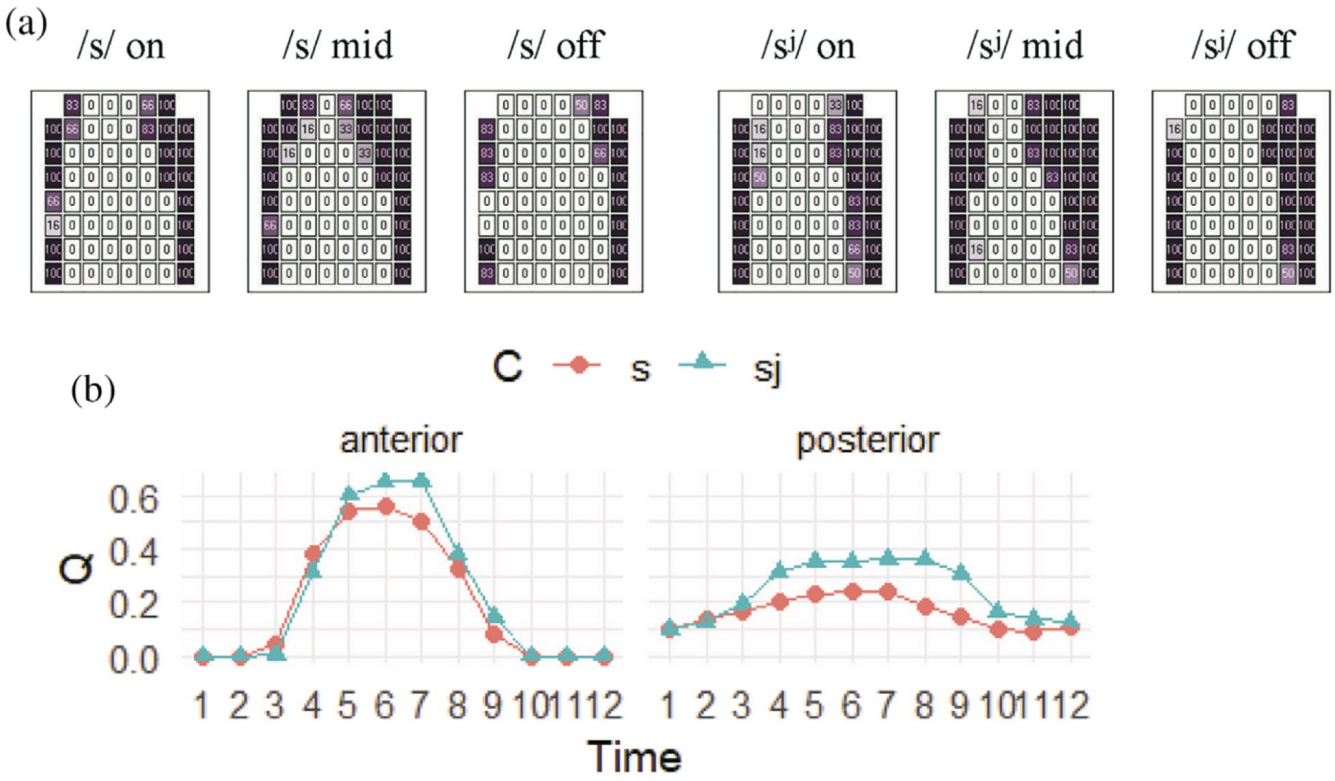


Palatography



10.2 Samples of palatograms of Bagwalal /sim/ 'lip' (far left) and /s̄im/ 'bile' (center left), and linguograms of the same words from a different speaker (from Maddieson 1999b).

Palatography



Palatography

Phenomena investigated	Study
Nasal place assimilation in Italian	Celata, Calamai, Ricci, & Bertini (2013)
Prosodic strengthening and boundary effects in English	Cho & Keating (2009)
Acquisition of Russian phonemic palatalization by English speakers	Hacking et al. (2016)
Voicing differences in Croatian sibilant fricatives	Liker & Gibbon (2013)
Inter-gestural timing in German fricative clusters	Pouplier & Hoole (2016)
C-C coarticulation in Catalan consonant clusters	Recasens & Mira (2015)
Initial geminates in Tashlhiyt Berber	Ridouane (2010)
Vocalization and re-syllabification of /l/ across word boundaries in Southern British English	Scobbie & Pouplier (2010)
The palatal nasal production in Brazilian Portuguese and Spanish	Shosted, Hualde, & Scarpace (2012)
The alveolar-retroflex contrast in Norwegian	Simonsen, Moen, & Cowen (2008)
Overlap and gradient assimilation in French nasals+stop sequences	Steele, Colantoni, & Kochetov (2019)

Nasal Airflow

- Nasal airflow can be measured using a “nasometer”
- A plate divides the nose from the mouth, and two microphones measure the amplitude of the nasal cavity and the oral cavity

- It can be also measured directly with a specialized mask or by sticking tubes into the nostrils, but these methods are much more invasive and alter the acoustic signal in ways that the nasometer does not.

Nasal Airflow

That’s all for now!

- There are some other methods as well, but these are the major ones used to measure articulatory properties!
- These slides are heavily based off of:
  - Kochetov, A. (2020). Research methods in articulatory phonetics I: Introduction and studying oral gestures. *Language and Linguistics Compass*, *14*(4), e12368.
  - Kochetov, A. (2020). Research methods in articulatory phonetics II: Studying other gestures and recent trends. *Language and Linguistics Compass*, *14*(6), e12371.