- **The larynx and phonation**
- **VOT (voice onset time)**

Background reading and preparation:

- *V&C 13.1 "The larynx"*
- *V&C 13.2 "Voiced and voiceless sounds"*
- *V&C 13.3 "Voicing and aspiration"*
- *AAP 8.1.2, "Sound sources in stops & affricates"*
- *Optional resources about the larynx*

0. Today's objectives

After today's class, you should be able to:

- Explain the role of the **arytenoid** and **thyroid** cartilages in **adducting** / **abducting** the vocal folds
- Understand the role of **air pressure** in vocal-fold vibration (the myoelastic/aerodynamic theory)
- Explain how the **articulation** of voiced, voiceless, and (voiceless) aspirated oral stops produces negative, zero, and positive **voice onset time (VOT)**
- Use **IPA symbols** to transcribe aspirated oral stops

0. Upcoming schedule

- W Oct 15: Discussion of Lab #6, #7, and (next) #8
  - Formulating research questions and hypotheses
  - Measuring and reporting acoustic data
  - Any other content check-ins and review
  - (Time permitting) **Lab #8 work time**: Hypotheses
- M Oct 20: **Partner** lab work session (Lab #8)
- If you will miss class: check in with partner group
  - Be clear on Lab #8 instructions
  - Make plans for dividing the work

1. The structure of the larynx

- **Larynx**: a structure composed mostly of cartilages and muscles that sits on top of the trachea
  - Posterior (rear) view;
    structure names FYI here

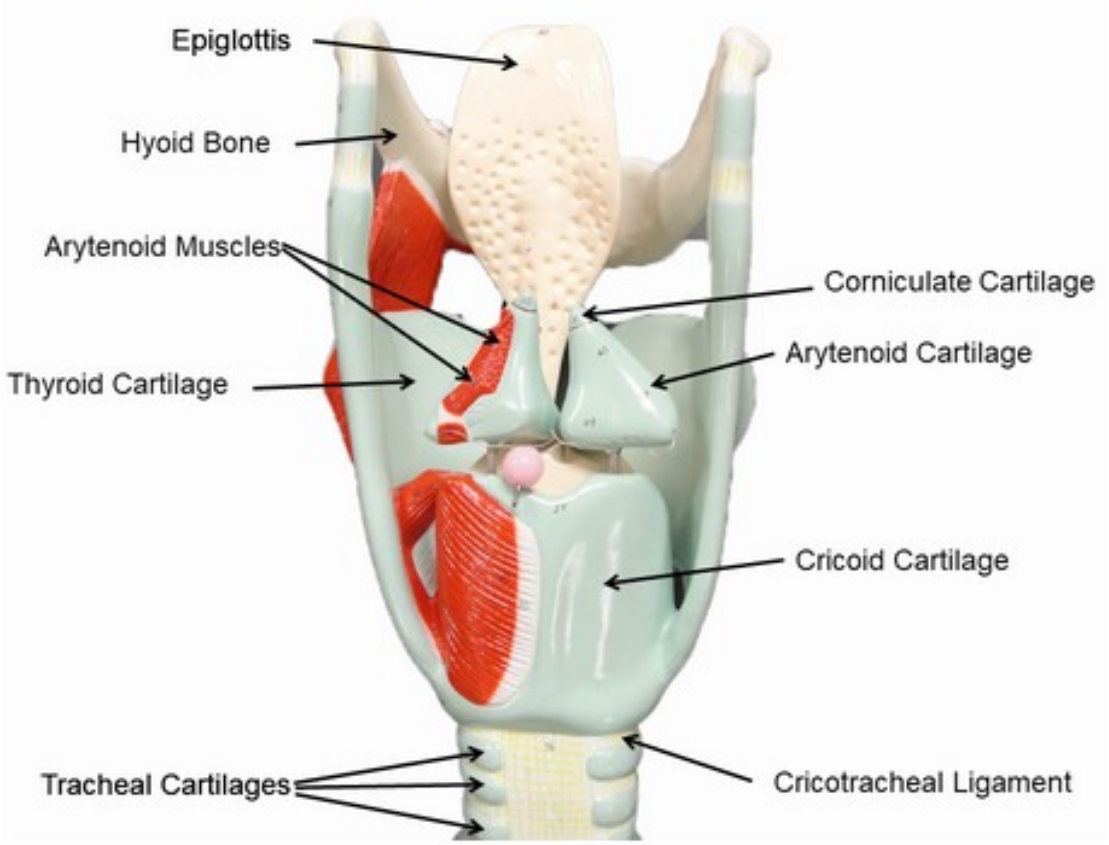


Image by Michael Mitchell, Tidewater Community College

1. The structure of the larynx

- Inside the larynx are the **vocal folds** (sometimes called "vocal cords"; they aren't really "cords")
  - Connected to the **thyroid cartilage** at the front and the **arytenoid cartilages** ("ac" in diagram) at the back
- **Arytenoid cartilages** can pivot, making vocal folds **adduct** (come together) or **abduct** (move apart)

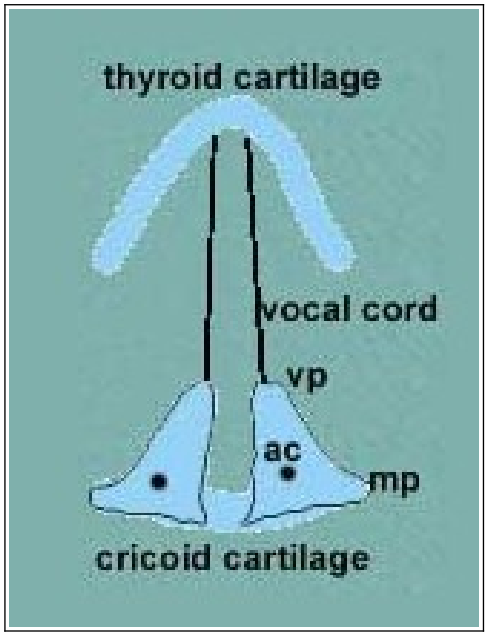


image: Wesley Norman

- Know the structures and terms in bold on this slide
- For more info, see the LING 520 "Larynx and phonation" web page

2. Phonation: Myoelastic/aerodynamic theory

- True or false?

  To increase the f_0 of the glottal source, a speaker uses the laryngeal muscles to pull the vocal folds open and push them closed at a faster rate

2. Phonation: Myoelastic/aerodynamic theory

- True or false?

  To increase the f_0 of the glottal source, a speaker uses the laryngeal muscles to pull the vocal folds open and push them closed at a faster rate

  FALSE: The vocal folds vibrate much more quickly than can be achieved by muscle-driven motion

- **Myoelastic/aerodynamic theory** of phonation:
  - muscle tension and
  - fluid dynamics in air cause vibration

2. Phonation: Myoelastic/aerodynamic theory

- What is this a picture of? How does it work?

image from Wikimedia Commons

2. Phonation: Myoelastic/aerodynamic theory

- A fireplace bellows: it blows air on the fire

image from Wikimedia Commons

- How do you get air **in**?
- How do you push air **out**?

2. Phonation: Myoelastic/aerodynamic theory

- A fireplace bellows: it blows air on the fire

image from Wikimedia Commons

- How do you get air **in**? | **Increase** volume
- How do you push air **out**? | **Decrease** volume

Remember this whenever we talk about air pressure!

2. Phonation: Myoelastic/aerodynamic theory

- **Increasing the volume** of a container of air **lowers the pressure** inside
- **Decreasing the volume** of a container of air **raises the pressure** inside
- Air pressure always tries to **equalize**

As a result:

- **Decreasing** the volume makes air **move** ___
- **Increasing** the volume makes air **move** ___

2. Phonation: Myoelastic/aerodynamic theory

- **Increasing the volume** of a container of air **lowers the pressure** inside
- **Decreasing the volume** of a container of air **raises the pressure** inside
- Air pressure always tries to **equalize**

  As a result:

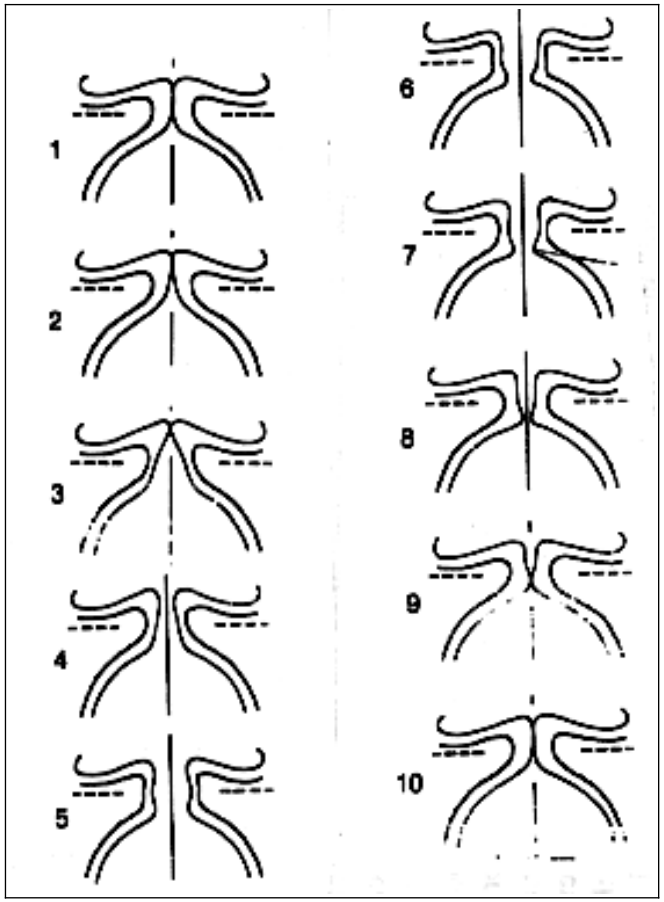
  - **Decreasing** the volume makes air **move out**
  - **Increasing** the volume makes air **move in**

2. Phonation: Myoelastic/aerodynamic theory

- The relationship between **air pressure** and **moving air** is important for **phonation** in several ways
  - Getting air to move out from the lungs
  - Getting air to push past the adducted (closed) vocal folds

2. Phonation: Myoelastic/aerodynamic theory

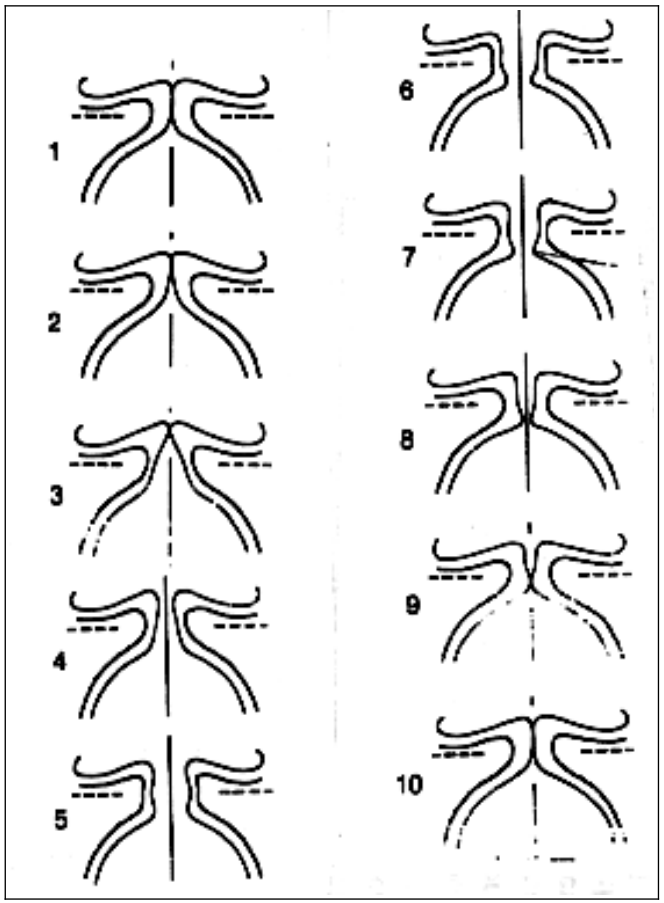
- Schematic cross-sectional diagram of the vocal folds during phonation (from a web page by John Coleman, Oxford U.)



- **Length** of vertical lines indicates **magnitude of air pressure**
- Horizontal dashed lines indicate **muscle tension**

2. Phonation: Myoelastic/aerodynamic theory

- How **one cycle** of vocal-fold vibration happens, according to the myoelastic/aerodynamic theory



- Vocal folds loosely adducted (1)
- Air pressure builds up below until the pressure difference overcomes the muscle tension (2–3)
- Vocal folds forced open; air passes through (4–5)
- Pressure equalizes; muscle tension + 'sucking' effect of moving air (Bernoulli effect) pulls v.f. back together (6–10)

2. Phonation: Myoelastic/aerodynamic theory

- Some observations from linguistic typology:
  - If a language is missing one of the voiced oral stops [b d g], it is most likely to be **missing [g]**
    - WALS map: Languages missing [g] or [p]
      (blue and purple dots are missing [g])
  - In some languages, there is a tendency for the duration of voicing to be **longer** for oral stops further **forward** in the vocal tract ([b]>[d]>[g])

- The myoelastic/aerodynamic theory of phonation can help explain these facts — how?

2. Phonation: Myoelastic/aerodynamic theory

- Ease of voicing in oral stops: [b]>[d]>[g]

- The myoelastic/aerodynamic theory of phonation can help explain these facts — how?
  - Why is **supraglottal pressure** (air pressure in the vocal tract above the larynx) a crucial factor in phonation?
  - Why is it more **difficult** to maintain voicing in [g] than in [b] or [d]?

** We will return to this discussion next class **

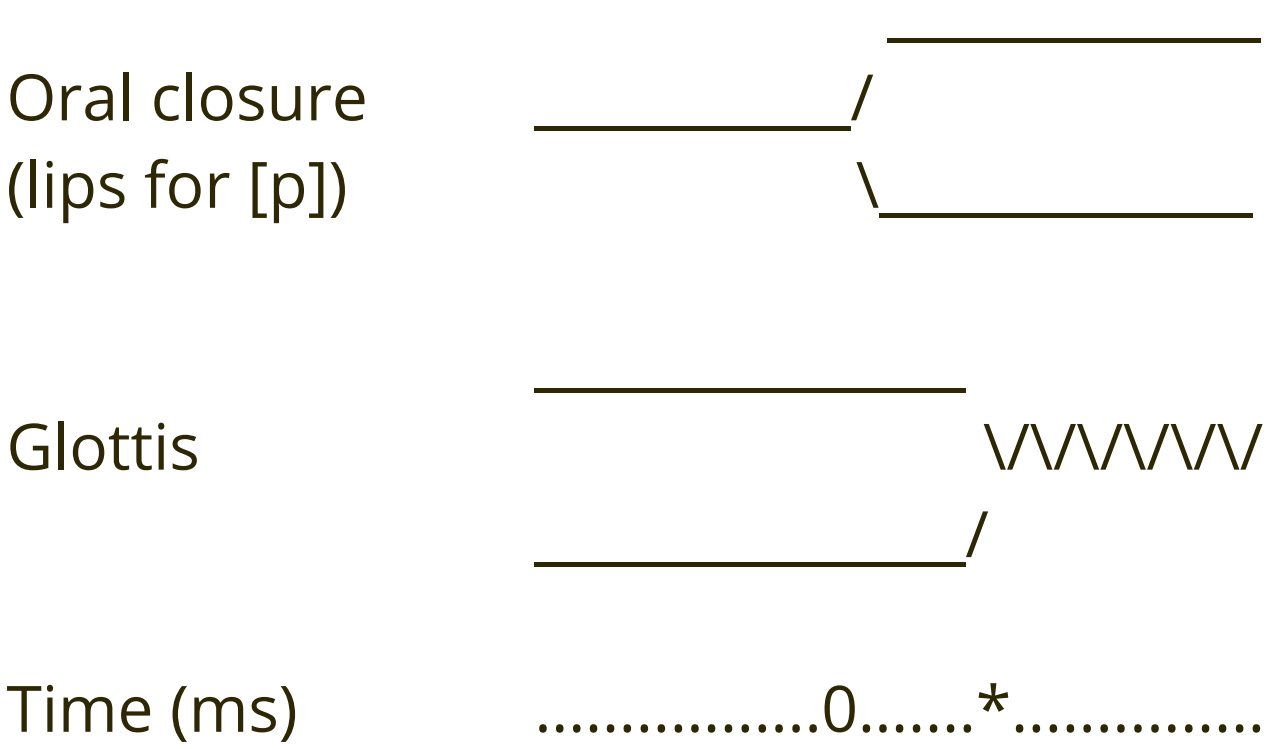
3. Voice onset time (VOT)

Goals of this discussion:

- What is **VOT**? How do we measure it in oral stops?
  - What is **aspiration**? How does it relate to VOT? What does it look like on a spectrogram?
  - What kinds of stops have (near) zero VOT?

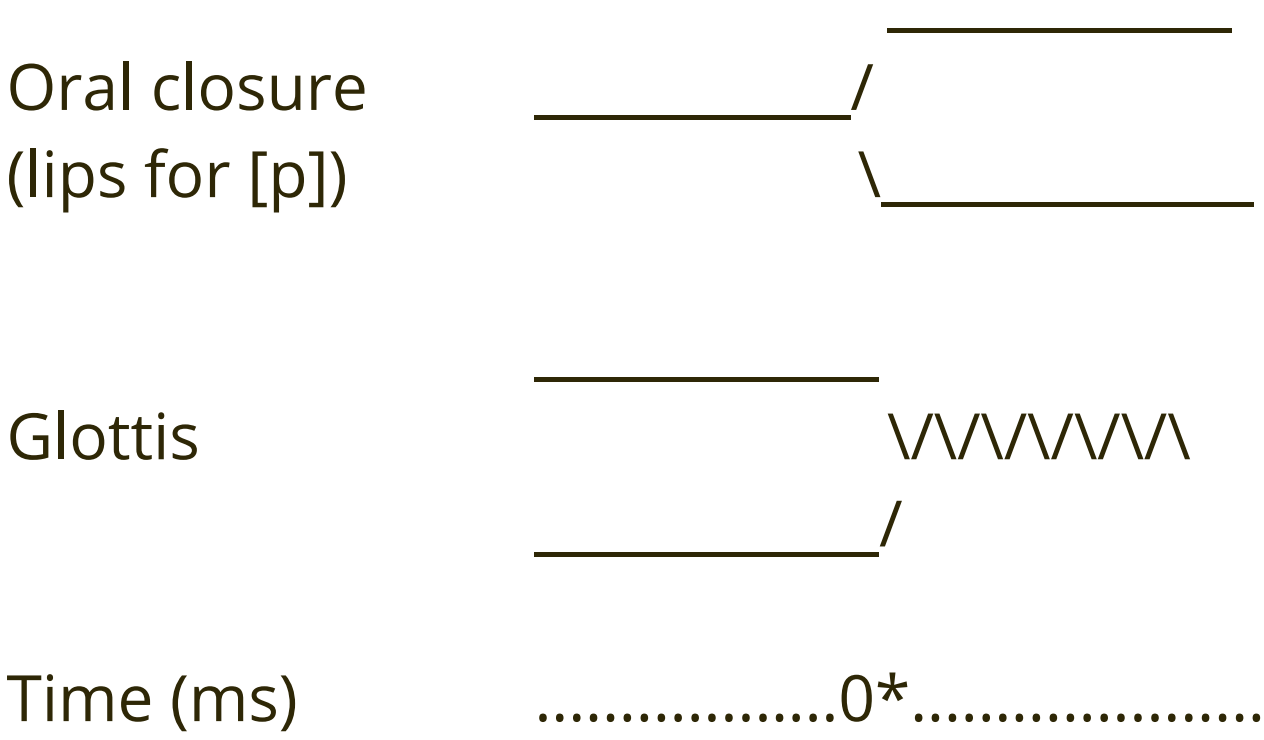
3. Voice onset time (VOT)

- **Voiceless aspirated stops** (as in English *pa* [pʰɑː])



3. Voice onset time (VOT)

- **Voiceless unaspirated stops** (as in French *pas* [pa]), English *spa* [spɑː]



(* = onset of voicing)

3. Voice onset time (VOT)

- What are the **timepoints** we are concerned with when measuring VOT in stops?

- Which class of oral stops has…
  - VOT of (near) **zero**?
  - **Positive** VOT?

3. Voice onset time (VOT)

- What are the **timepoints** we are concerned with when measuring VOT in stops?
  - Stop release and beginning of phonation
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  - **Positive** VOT? | Voiceless aspirated
- If we extend the concept of VOT to **voiced** oral stops, and we measure with the same landmarks, what kind of VOT will the voiced stops have?

3. Voice onset time (VOT)

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  - Stop release and beginning of phonation
- Which class of oral stops has…
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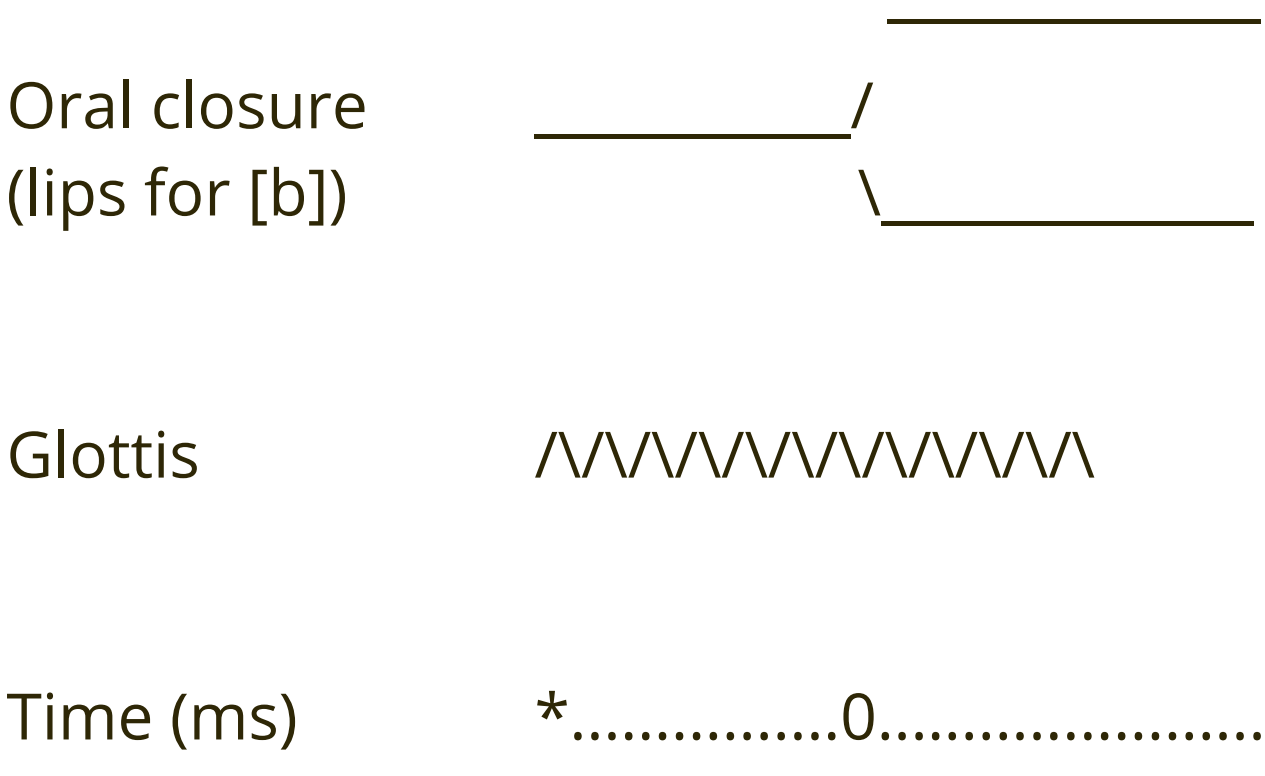
  - **Positive** VOT? | Voiceless aspirated
- If we extend the concept of VOT to **voiced** oral stops, and we measure with the same landmarks, what kind of VOT will the voiced stops have?
  - **Negative** VOT (voicing begins *before* stop release)

3. Voice onset time (VOT)

- **Voiced stops** (as in English *about* [ə<u>b</u>aʊt])



3. Voice onset time (VOT)

- Three categories of VOT

negative VOT	**(near) zero VOT**	**positive VOT**
"voicing lead"		"voicing lag"
voiced	*voiceless unaspirated*	*voiceless aspirated*

- Not all languages use all categories contrastively
- Some languages use only one or two categories, even phonetically
  - Examples: English vs. Spanish | Hindi (*V&C* web site)

3. Voice onset time (VOT)

To think about…

- What do we have to think about when measuring VOT for consonants other than stops?
  - See Salgado, Slavic, and Ye (2013) on aspirated [s] in S'gaw Karen
    (This publication began as a LING 520 final project!)

4. For next time

- Prepare an answer for the discussion question on slide 17 about voicing and place of articulation
- Preview the Lab #08 instructions (available Mon evening)