- **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. Upcoming schedule / Reminders

- W: First phase of final-project planning
  - Discussion: Finding research questions
  - **CITI training due** (11:55pm)

- F: Partner lab work session (Lab #08)
  - Complete your measurements **before class**
  - Reporting results
  - Creating data graphics

0. Today's plan

- The structure of the larynx
- Phonation: Myoelastic/aerodynamic theory
- Voice onset time (VOT)

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

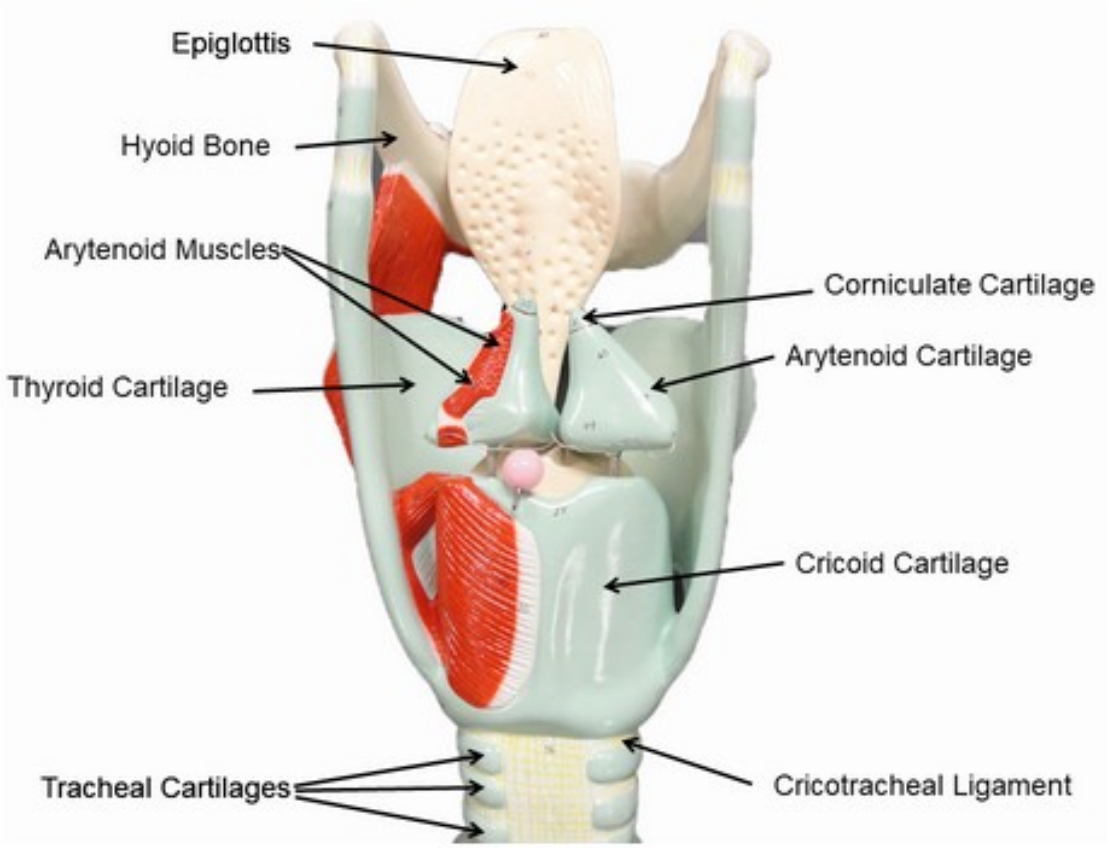
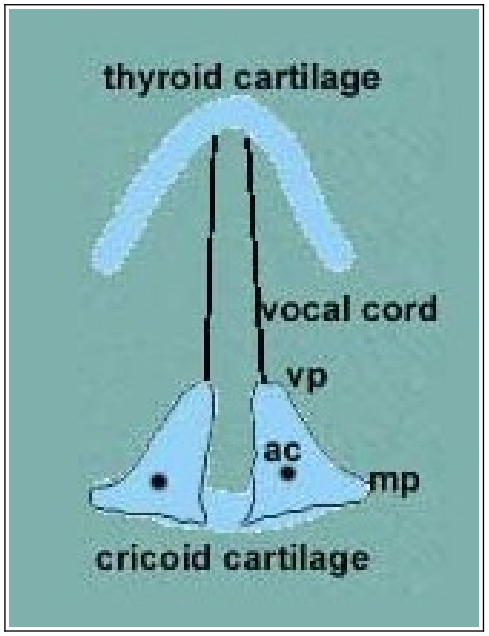


Image by Michael Mitchell, Tidewater Community College

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 by Wesley Norman

- 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

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  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** ___

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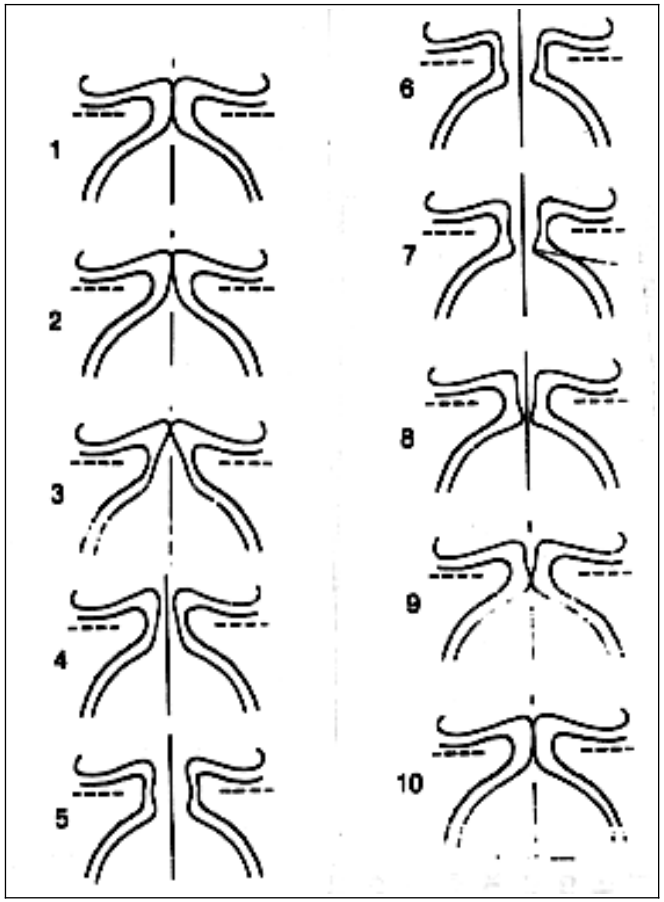
2. Phonation: Myoelastic/aerodynamic theory

- 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

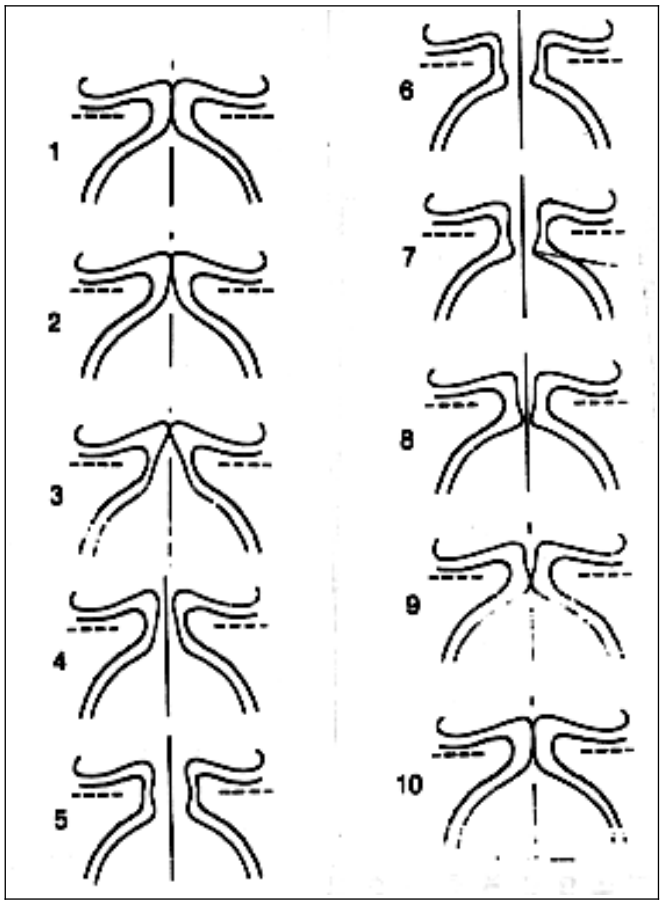
- Schematic cross-sectional diagram of the vocal folds during phonation (from a web page by John Coleman, Oxford U.)



- **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?

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  - Why is it more **difficult** to maintain voicing in [g] than in [b] or [d]?

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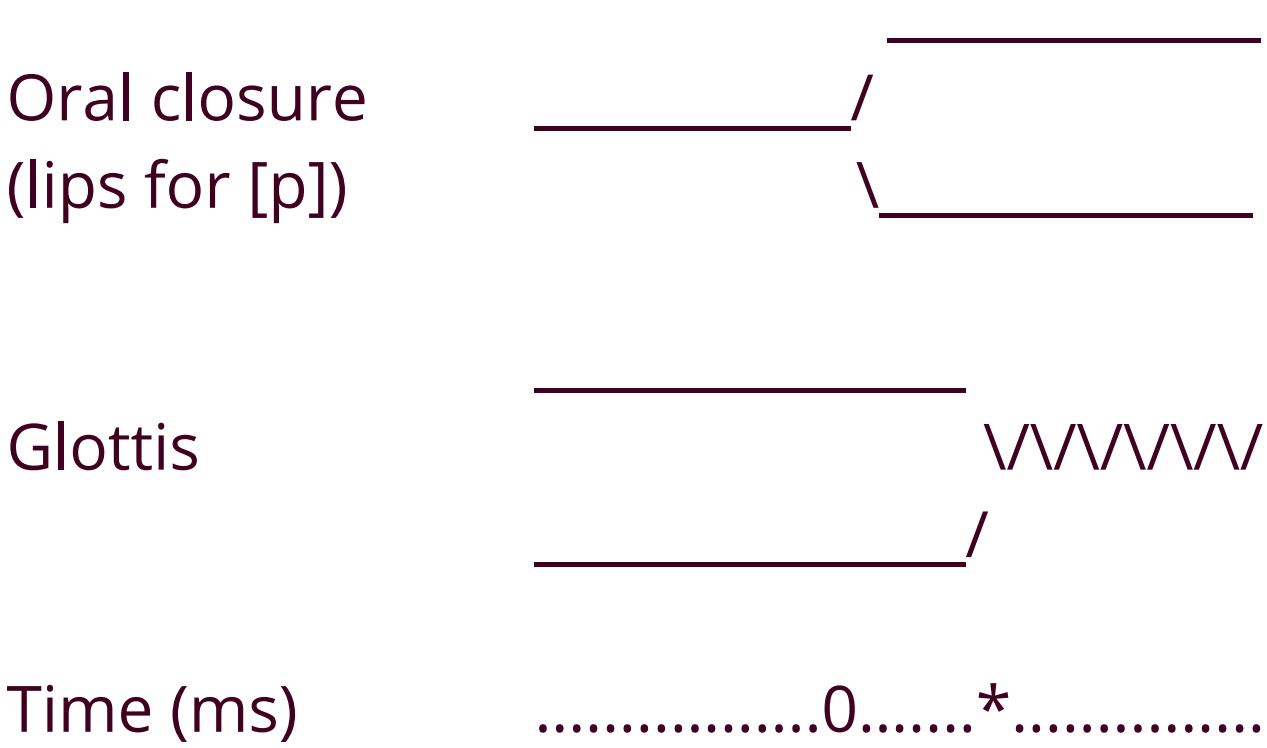
- The myoelastic/aerodynamic theory of phonation can help explain these facts — how?
  - Why is **supraglottal pressure** (air pressure in the vocal tract above the larynx) a crucial factor in phonation? | How does pressure relate to **moving air**?
  - Why is it more **difficult** to maintain voicing in [g] than in [b] or [d]? | What is the **volume** of the area between the glottis and the stop closure? Why does this matter?

3. Voice onset time (VOT)

- 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)

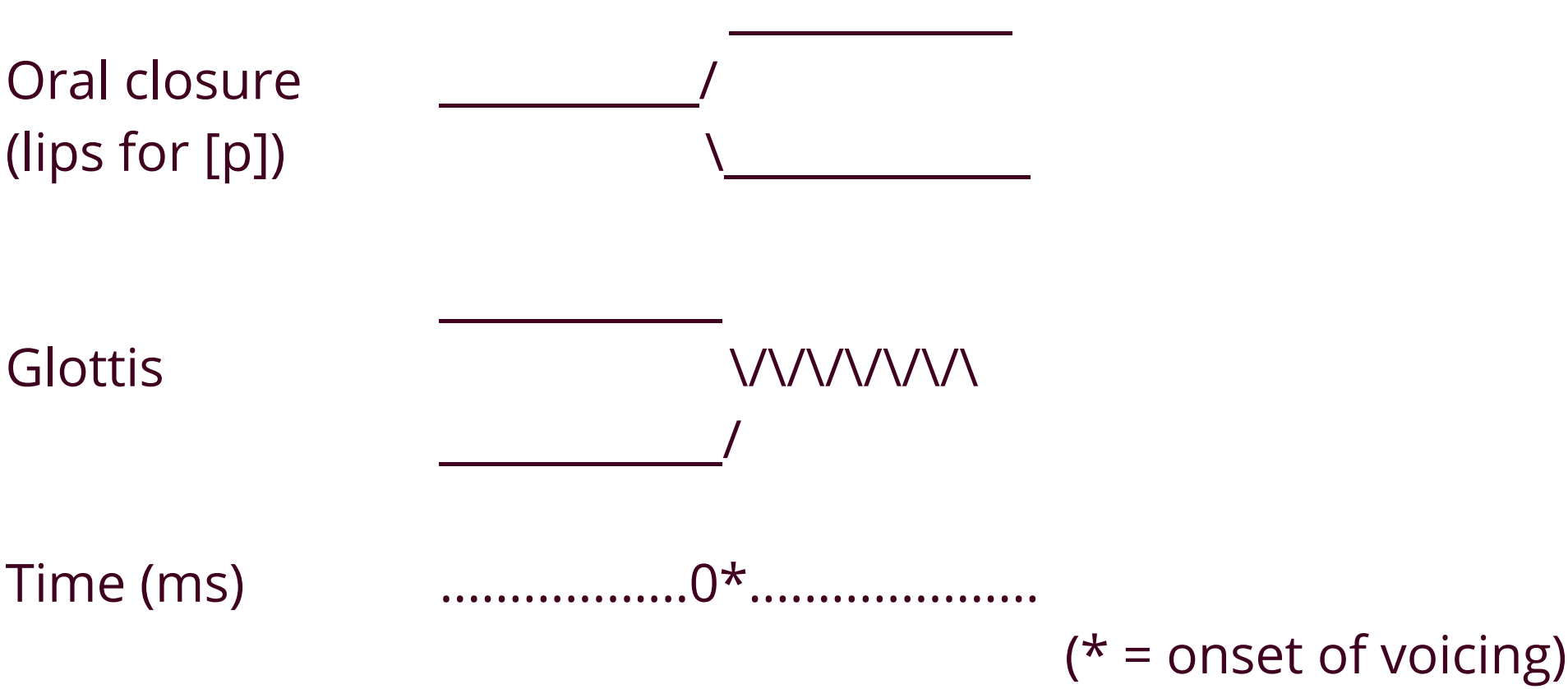
- **Voiceless aspirated stops** (as in English *pa* [pʰɑː])



(* = onset of voicing)

3. Voice onset time (VOT)

- **Voiceless unaspirated stops** (as in French *pas* [pa])



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  - **Negative** VOT (voicing begins *before* stop release)

3. Voice onset time (VOT)

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

Oral closure _____/
(lips for [b]) _____

Glottis /\/\/\/\/\/\/\/\/\/\

Time (ms) *.....0.....

(* = onset of voicing)

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)

- 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!)