- **Airstream mechanisms: Ejectives, implosives, clicks**

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*Optional reading for more information:*

- V&C Ch 13, sec 13.8-13.9 (ejectives, implosives)
- V&C Ch 14, sec 14.5 (clicks)
- AAP Ch 8, pp 175-6 (ejectives, implosives clicks)

# 0. Today's plan

- Final-project information
- Brief check-in on Lab #07
  - **Centroid** and **dispersion** for distinguishing among the voiceless fricatives of German: Individually? Together?
  - How do these relate to the **source/filter model**?
- Intro to **airstream mechanisms** with a focus on **ejectives** — prepare to discuss research article
  - **articulation**, esp. volume and pressure in moving air
  - **acoustics**, esp. characteristics that distinguish ejectives/implosives/clicks from each other and from plosives (pulmonic egressive oral stops)

# 1. Airstream mechanisms

Review from last week (fireplace bellows!)

- What conditions are necessary to cause a **gas to move** from one container into another?

- Assuming a flexible container, what **change to the container's volume** will cause a gas to move?

# 1. Airstream mechanisms

Review from last week (fireplace bellows!)

- What conditions are necessary to cause a **gas to move** from one container into another?
  - Gas moves from high pressure to low pressure

- Assuming a flexible container, what **change to the container's volume** will cause a gas to move?
  - Volume **up** → pressure **down** → gas moves **in**
  - Volume **down** → pressure **up** → gas moves **out**

# 1. Airstream mechanisms

- In order for there to be sound, there must be **moving air** (or other medium: water, helium, …)
- In speech, something must set the air in motion

  → This is known as an **airstream mechanism**

- So far, all the speech sounds we have discussed have had air moving **outward**, initiated by the **lungs**
  - This is the **pulmonic egressive** airstream mechanism
- There are three other possibilities…

# 1. Airstream mechanisms

- Terminology for **airstream mechanisms**

| ***Air set in motion by*** | ***Adjectival form*** | ***Direction of airstream*** | ***Name for this class*** |
|---|---|---|---|
| lungs | pulmonic | egressive | **plosives** (*if oral stop*[1]) |
| glottis | glottalic | egressive | **ejectives** |
| glottis | glottalic | ingressive | **implosives** |
| velum | velaric | ingressive | **clicks** |

[1]Most non-oral-stop consonants, all vowels are also pulmonic egressive

# 2. Pulmonic airstream mechanisms

- **Pulmonic egressive** — most common airstream mechanism
  - Most speech sounds are pulmonic egressive
  - This includes all sounds of (standard) English

- How to get air to move **out** using the **lungs**?
  - Compress their volume → higher pressure → air moves out

# 2. Pulmonic airstream mechanisms

- **Pulmonic ingressive** airstream mechanism?
  - Physically possible (try talking while breathing in!)
  - Sometimes used for expressions of surprise, affirmation, etc. in different cultures
    [examples from Wikipedia]
  - Extremely rare or nonexistent in speech sounds

# 3. Glottalic airstream mechanisms

- The starting point for producing a **glottalic** airstream mechanism
  - Close the glottis (as if producing a glottal stop [ʔ])
  - Form another stop constriction in the oral tract
  - Air is now trapped between the glottis and the other constriction
    - You should be *unable to breathe through your nose* while holding the two closures — why?

# 3. Glottalic airstream mechanisms

## Ejectives

- Language examples:
  - WALS map (ejectives in red or purple)
  - Sound file examples from *V&C*: see especially Quechua

- Most ejectives are (oral) **stops** or **affricates**, but **fricatives** are also possible

- There is a systematic convention for **transcribing** ejectives in the IPA — what is it? (see *V&C*)

# 3. Glottalic airstream mechanisms

## Ejectives

- An **ejective** is **glottalic egressive**
  - What do we need to do with the glottis to cause air to move **out of** the mouth when the oral closure is released?

# 3. Glottalic airstream mechanisms

## Ejectives

- An **ejective** is **glottalic egressive**
  - What do we need to do with the glottis to cause air to move **out of** the mouth when the oral closure is released?
    - Volume between glottal and oral closures must get *smaller* → pressure **up** → air **out**
  - Raise the larynx!
    - Then, release oral closure
    - Last, release glottal closure

# 3. Glottalic airstream mechanisms

## Ejectives

- In an ejective, the glottis remains tightly closed until just after the oral closure is released
  - Can an ejective be **voiced**? Why or why not?

# 3. Glottalic airstream mechanisms

## Ejectives

- In an ejective, the glottis remains tightly closed until just after the oral closure is released
  - Can an ejective be **voiced**? Why or why not?
  - **Impossible**: vocal folds can't vibrate while glottis is tightly closed

# 3. Glottalic airstream mechanisms

## Ejectives

- What should an ejective stop look like on a waveform/spectrogram?
  - The **burst** is usually **more salient** than in a plosive — why?
  - If the sequence of events is *oral release — glottal release — (vowel),* what do we expect this to look like on the **waveform**?

# 3. Glottalic airstream mechanisms

## Implosives

- Language examples
  - WALS map (implosives in blue or purple)
  - Sound file examples from *V&C*: see especially Sindhi, Owerri Igbo

- Implosives are nearly always (oral) **stops**

- What characteristic do IPA symbols for **transcribing** implosives have in common? (see *V&C*)

# 3. Glottalic airstream mechanisms

## Implosives

- An **implosive** is **glottalic ingressive**
  - What do we need to do with the glottis to cause air to move **into** the mouth when the oral closure is released?

# 3. Glottalic airstream mechanisms

## Implosives

- An **implosive** is **glottalic ingressive**
  - What do we need to do with the glottis to cause air to move **into** the mouth when the oral closure is released?
    - Volume between glottal and oral closures must get *larger* → pressure **down** → air **in**
  - Lower the larynx!
    - Timing of release of oral and glottal closures probably less critical than in ejectives

# 3. Glottalic airstream mechanisms

## Implosives

- An implosive is almost always **voiced**
  - What happens to supraglottal air pressure if the glottis is vibrating while it is lowered?

# 3. Glottalic airstream mechanisms

## Implosives

- An implosive is almost always **voiced**
  - What happens to supraglottal air pressure if the glottis is vibrating while it is lowered?
- Consequences:
  - Air pressure may not be lower than zero (atmospheric pressure) in oral cavity when larynx is lowered
  - Air may not actually rush into mouth when oral closure is released

# 3. Glottalic airstream mechanisms

## Implosives

- What should an implosive look like on a waveform/spectogram?
  - Should the stop have a burst? If so, should it be weak or strong? Why?

# 3. Glottalic airstream mechanisms

## Implosives

- A difference between implosives and voiced plosives visible on the waveform
  - In an implosive, the amplitude of the voicing during closure generally *increases* (or at least does not decrease) leading up to the stop release
  - This indicates: it is **easier to maintain voicing** in an implosive, compared to a voiced plosive
  - Think about our discussion of voicing in plosives: **Why** might implosives be easier to voice?

# 4. Velaric airstream mechanisms

- The starting point for producing a **velaric** airstream mechanism
  - Form a closure at the **velum**

    (just as for a velar stop)
  - Form another closure **forward** of the velum
    - Labial, dental, alveolar, postalveolar

- What effect does forming this configuration have on the ability to produce…
  - voicing?
  - nasality?

# 4. Velaric airstream mechanisms

- The starting point for producing a **velaric** airstream mechanism
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  - Form another closure **forward** of the velum
    - Labial, dental, alveolar, postalveolar

- What effect does forming this configuration have on the ability to produce…
  - voicing? | no effect! voiceless/voiced possible
  - nasality? | no effect! oral/nasal possible

# 4. Velaric airstream mechanisms

## Clicks

- Clicks are possible at various places of articulation (see IPA chart for symbols)
  - bilabial click (like a flat-lipped 'kiss' sound)
  - dental click (like the sound that indicates disapproval)
  - (central) alveolar click
  - lateral alveolar click (like the noise made to get a horse to move)
  - palatoalveolar click

# 4. Velaric airstream mechanisms

## Clicks

- To indicate whether a click is produced with **nasality**, or whether it is **voiced** or **voiceless**, it can be written together with a velar stop [k g ŋ]
  - By convention, the click sound is understood to be simultaneous with the preceding velar stop

- Language examples
  - WALS map (clicks in red)
  - Sound file examples from *V&C*: see especially Nama, Zulu, Xhosa

# 4. Velaric airstream mechanisms

## Clicks

- A **click** is a **velaric ingressive** sound
  - What do we need to do for air to move **into** the mouth when the oral closure is released?

# 4. Velaric airstream mechanisms

## Clicks

- A **click** is a **velaric ingressive** sound
  - What do we need to do for air to move **into** the mouth when the oral closure is released?
    - Volume between closures must get *larger* → pressure **down** → air **in**
  - Slide the tongue body down/back while maintaining the velar closure!
    - Then release forward closure, then velar
  - X-ray of a click, from V&C

# 4. Velaric airstream mechanisms

- What might we predict about the acoustics of **bursts** in clicks? Why?
  - Note that the **change in volume** of the space between closures (before the forward closure is released) is proportionally **large** because the space itself is relatively small

# 4. Velaric airstream mechanisms

- A **velaric egressive** sound is physically possible, but they are not known to occur as speech sounds
  - What would you have to do with a velaric airstream configuration to get the air to move **out**?