• Airstream mechanisms: Ejectives, implosives, clicks

Background reading:
• 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)
Overview

• These slides present basic phonetic and typological facts about consonants with non-pulmonic airstream mechanisms
  - ejectives, implosives, clicks

• Discussion covers
  - articulation, with attention to the role of volume and pressure in moving air
  - acoustics, especially characteristics that distinguish each of these classes of consonants from each other and from plosives (pulmonic egressive oral stops)
1. Airstream mechanisms

Review from last time (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?
Review from last time (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**

<table>
<thead>
<tr>
<th>Air set in motion by</th>
<th>Adjectival form</th>
<th>Direction of airstream</th>
<th>Name for this class</th>
</tr>
</thead>
<tbody>
<tr>
<td>lungs</td>
<td>pulmonic</td>
<td>egressive</td>
<td>plosives</td>
</tr>
<tr>
<td>glottis</td>
<td>glottalic</td>
<td>egressive</td>
<td>ejectives</td>
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<tr>
<td>glottis</td>
<td>glottalic</td>
<td>ingressive</td>
<td>implosives</td>
</tr>
<tr>
<td>velum</td>
<td>velaric</td>
<td>ingressive</td>
<td>clicks</td>
</tr>
</tbody>
</table>

¹Most 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!
  
  • Then, 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
  - 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? | 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 ɡ ɳ]
  - 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**?