- **Phonation types**

Background reading (optional):

- *V&C* Ch 13, sec 13.4-13.7
- *AAP* Ch 8, sec 8.1.1, “Phonation types”

1. States of the glottis

- Review: What is the position of the vocal folds during modal (typical) voicing?

1. States of the glottis

- What happens when the vocal volds are wide open, or when they are tightly closed?

VF wide open	VF adducted (not too tightly)	**VF tightly closed**
	voicing/phonation	

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1. States of the glottis

- What happens when the vocal volds are wide open, or when they are tightly closed?

VF wide open	VF adducted (not too tightly)	**VF tightly closed**
voicelessness	voicing/phonation	**glottal stop** (also voiceless)

1. States of the glottis

- What predictions can we make for the acoustics of a **glottal stop** in the source-filter model?
  - What do we predict during the **closure** phase?
  - Do we predict a **stop burst**? Why or why not?
  - What do we predict about **formant transitions**?
    - Turns out, there are essentially no formant transitions for a glottal stop

1. States of the glottis

- Additional **phonation types** along this continuum

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2. Creaky phonation

- Vocal folds are **closed** during a **higher** percentage of the phonation cycle than in modal phonation
  - Creaky: VF closed for approx. 2/3 of cycle
  - Modal: VF closed for approx. 1/2 of cycle

- How creaky voicing is produced: configuration of vocal folds
  - Generally adducted more tightly
  - May be totally closed along part of their length and vibrating only along another part

2. Creaky phonation

- Used in English for sociolinguistic effects
  - Older upper-class British speakers
  - Younger American speakers

- Sometimes known as “vocal fry”
  - See various posts critiquing discussions of vocal fry in the media from Language Log

2. Creaky phonation

- Used in other languages to **distinguish phonemes** (speech sound categories)
  - How do we **transcribe** creaky phonation?
  - **Sound files** — see Mazatec (from *V&C*)
  - See also the South American Phonological Inventory Database for more languages
  - WALS map: Red symbols show languages with "glottalized resonants" (i.e., sonorants, most likely with creaky phonation)
- Creaky voice can be **phonologically** associated with either consonants or vowels (→ phonetics?)

3. Breathy phonation

- Vocal folds are **closed** during a **lower** percentage of the phonation cycle than in modal phonation
  - Modal: VF closed for approx. 1/2 of cycle
  - Breathy: VF closed for approx. 1/3 of cycle

- How breathy voicing is produced: configuration of vocal folds
  - Generally adducted more loosely
  - May be wide open along part of their length and vibrating only along another part
    - There may be a salient **aperiodic** source!

3. Breathy phonation

- In English, breathy voice may be a characteristic of individual speakers (or correlated with gender?)
- Used in other languages to **distinguish phonemes** (speech sound categories)
  - How do we **transcribe** breathy phonation?
  - **Sound files** — compare Hindi ("voiced aspirated") and Mazatec (from *V&C*)
- As with creaky voice, breathy voice can be **phonologically** associated with either consonants or vowels (→ phonetics?)

4. Acoustics of phonation types

- Two ways of looking at acoustics of phonation types
  - Open quotient and H1 relative amplitude
  - Periodicity and other cues

- The characteristics discussed here may be relied upon to different degrees in different languages!
  - Moreover, languages may use breathy or creaky voice together with other phonetic effects, complicating the picture

5. Open quotient and H1 relative amplitude

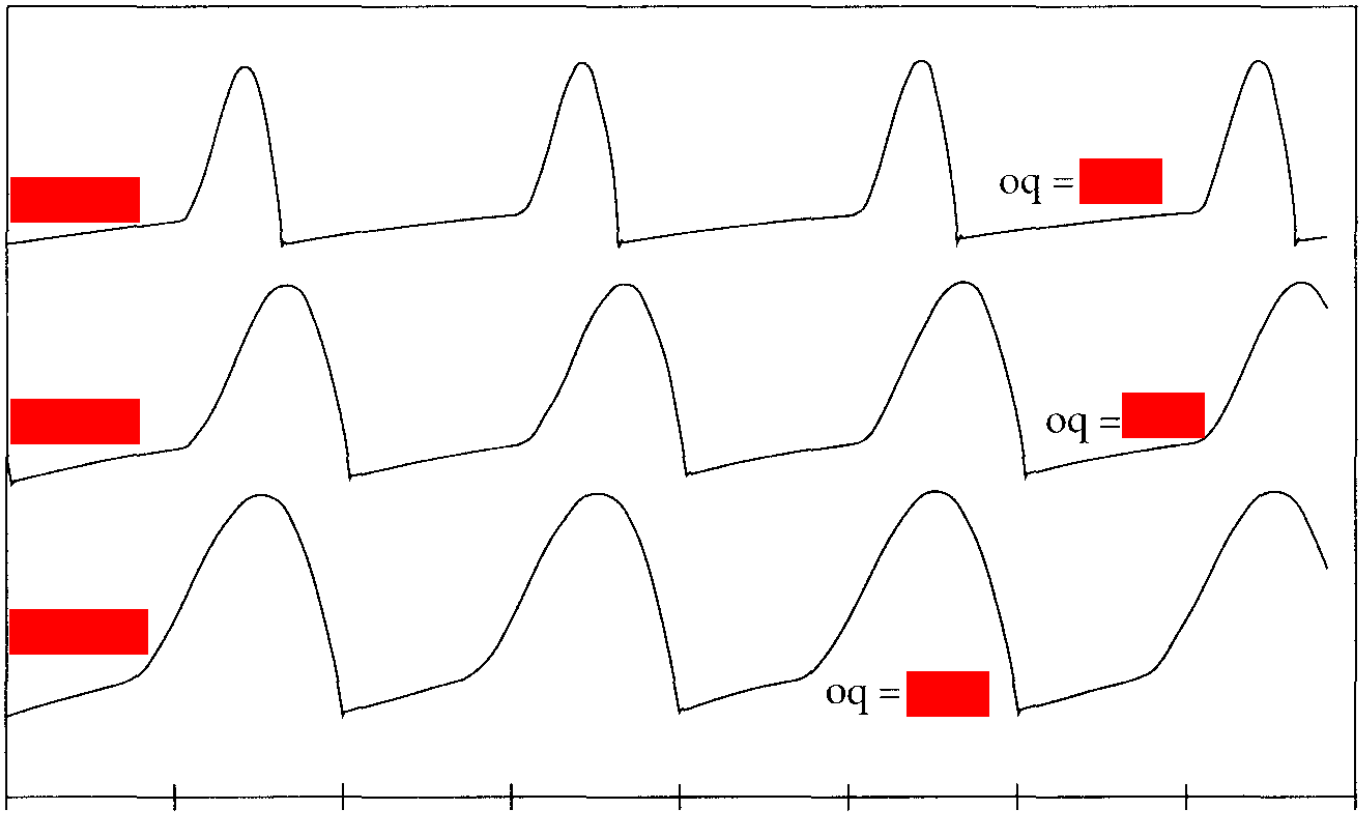
- One articulatory difference among phonation types is the **open quotient** — the proportion of each cycle of VF vibration during which the glottis is open
  - Breathy: VF open for approx. 2/3 of cycle
  - Modal: VF open for approx. 1/2 of cycle
  - Creaky: VF open for approx. 1/3 of cycle

- This difference has acoustic consequences for the **spectrum** of the **glottal source wave**

5. Open quotient and H1 relative amplitude

- Glottal-source **waveforms** (synthesized) | *AAP* Fig 8.2

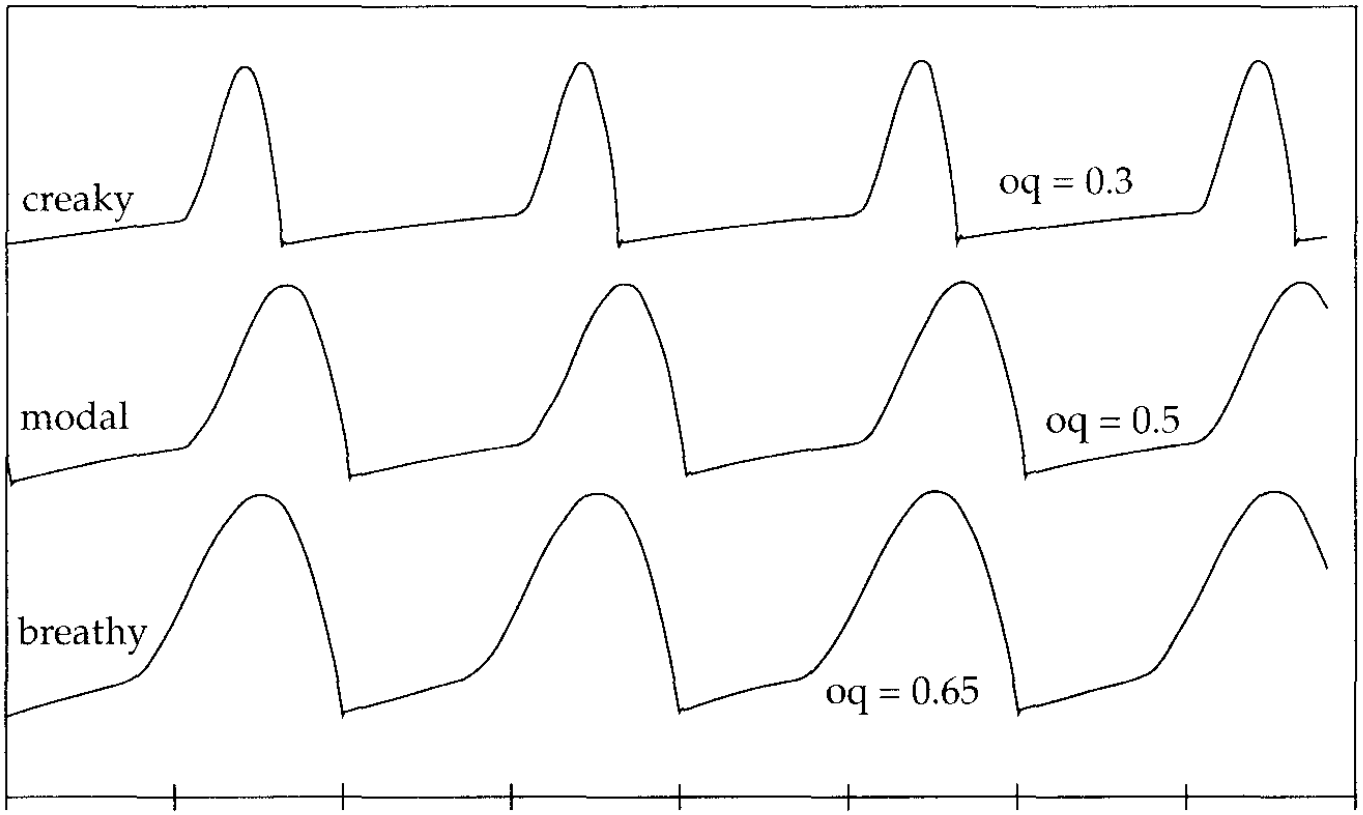
  Which phonation type matches which diagram?



5. Open quotient and H1 relative amplitude

- Glottal-source **waveforms** (synthesized) | *AAP* Fig 8.2

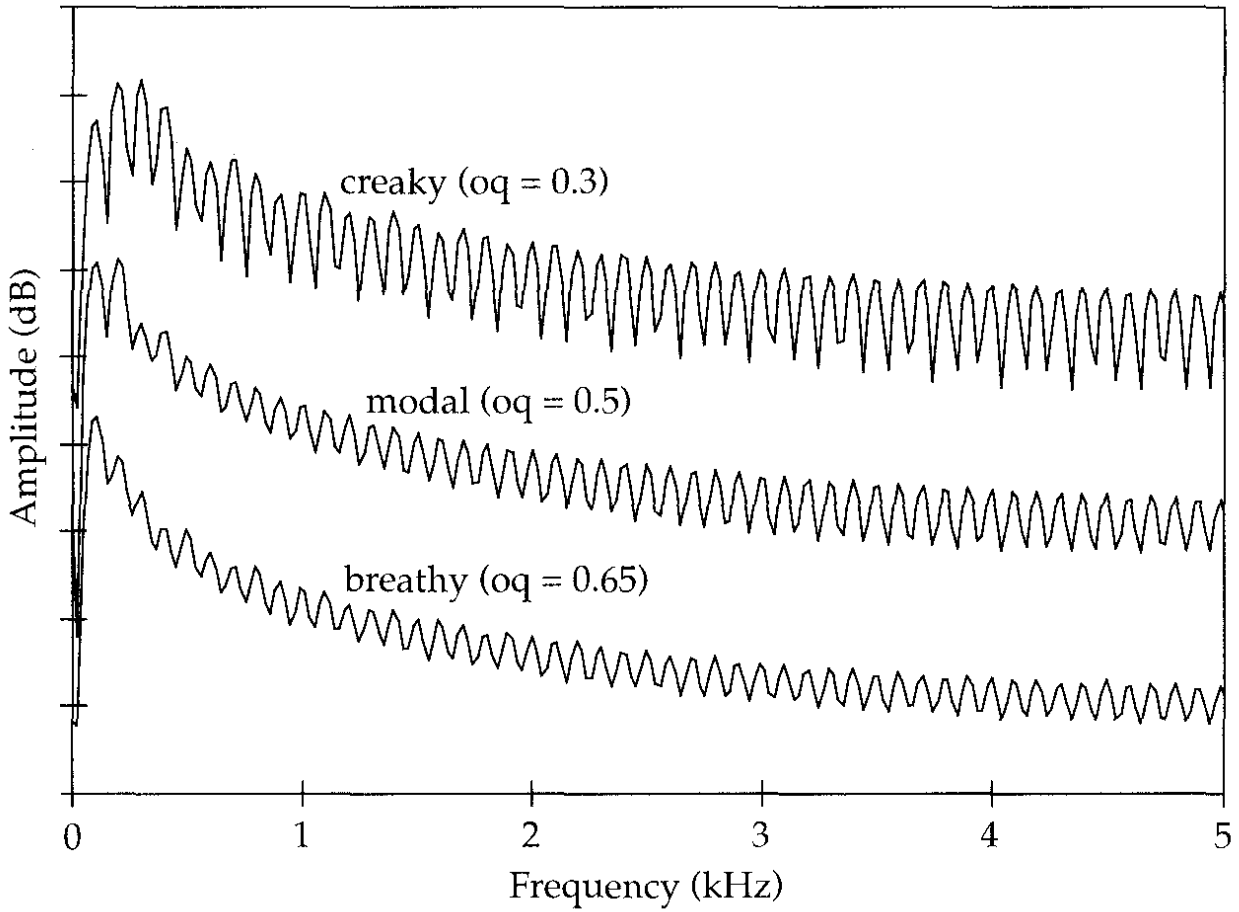
  Which diagram is most like a **sine wave**?



5. Open quotient and H1 relative amplitude

- Glottal-source **spectra** (synthesized) | *AAP* Fig 8.3

  Which diagram is most like a **sine wave**? How?



5. Open quotient and H1 relative amplitude

- Breathy phonation: Most like a sine wave
  - **First glottal harmonic (H1)** has **highest** amplitude
  - **Spectral slope:** Relative amplitudes of harmonics drop off most quickly

- Note: These characteristics might not be visible for cases of breathy phonation where the **aperiodic** sound source is predominant
  - See Mazatec example above

5. Open quotient and H1 relative amplitude

- Modal, creaky phonation get progressively more different from breathy
  - **First glottal harmonic (H1)** has amplitude **similar** to second in modal phonation
  - **First glottal harmonic (H1)** has amplitude **lower** than next few in creaky phonation
  - **Spectral slope:** Relative amplitudes of harmonics drop off less quickly in modal phonation and least quickly in creaky phonation

5. Open quotient and H1 relative amplitude

- Reminder: We've been talking about properties of the **glottal-source** waveform
  - What do we need to be careful about in inferring properties of the glottal-source spectrum in **speech sounds**?

    → What else might affect the **relative amplitude of glottal harmonics** besides differences in phonation type?

6. Periodicity and other cues

- **Creaky voice**: Waveform/spectrogram
  - Stiff vocal folds often vibrate more slowly and irregularly, leading to **lower** fundamental frequency and glottal pulses that are visibly **further apart** (possibly also irregularly spaced)
  - On waveform, component corresponding to F1 may be very salient
  - “Arrowhead” effect often visible in waveform

6. Periodicity and other cues

- **Breathy voice**: Waveform/spectrogram
  - Longer open quotient may lead to portions of the phonation cycle that are similar to aspiration
    → as noted above, may have a considerable **aperiodic** component
  - Often has **lower amplitude** than modal voice
  - Waveform may show **less well-defined** effect of formants (because breathy phonation doesn't excite vocal-tract resonances as well)

7. Summary: Phonation types

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