NBASLH Praxis Review Speech Science

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Basic Human Communication

- **About 17% of the PRAXIS** exam is for basic human communication:
  - Language acquisition and learning theory
  - Language science
  - Learning theory
  - Multicultural awareness
  - **Speech science**
- Speech Science is also called **Acoustics**
  - Source: Educational Testing Service

Overview of Speech Science

- **Anatomy and Physiology** as related to speech, voice, & phoneme production
- **Speech Production**
  - Respiration, Phonation, Resonance, Articulation
- Also, know some of the basic facts about sound (Acoustics)

- Source: Educational Testing Service

Basic Acoustics

- Sound is a pressure wave produced by changes in sound pressure in air starting with and ending with…..
- Vibration of the vocal folds
- Modification of the air vibrations (thus, sound vibrations) through the vocal tract
- Expulsion of air through the
  - Oral cavity (mouth) for non-nasal (oral) sounds
  - Nose and mouth for nasal sounds

Some Other Acoustic Concepts

- Frequency = the number of "vibrations" that occur in one second
  - 1000Hz = 1000 vibrations in one second
  - Vibrations/second
- Period = the time for ONE vibration
  - Second/Vibrations (frequency)
  - Thus, the period for 1000Hz = 1/1000 second which is one millisecond
- Pitch is our perception of frequency
- Intensity is the loudness (dB) of sound (measured in dBHL = Amplitude)

Graphical Representations of Sound = Waveform

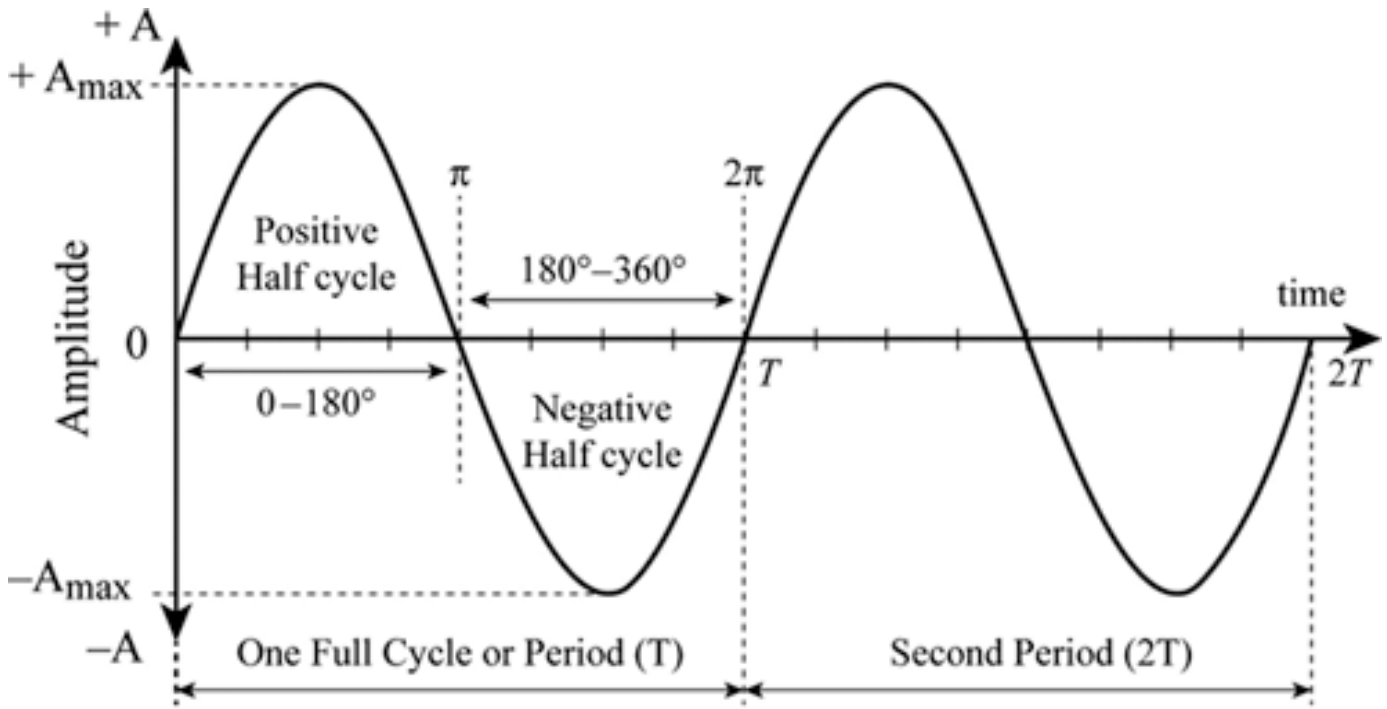
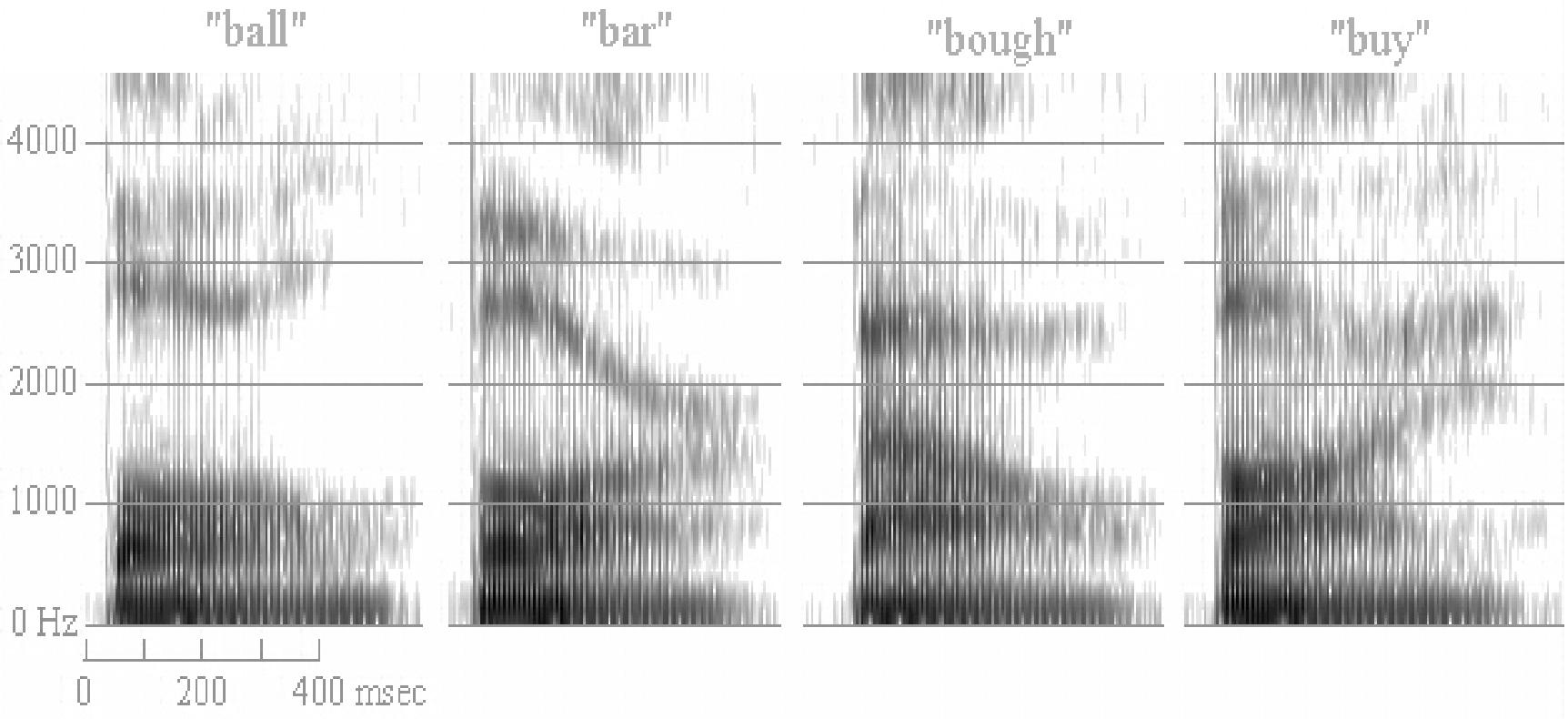


Figure 1

Figure 1 is the fundamental sine wave.

Graphic Representation = Spectrogram



Overview of Speech Science
(Source: ETS)

- Identify the functional anatomical components of the speech and voice mechanisms
- Describe the actions of the speech musculature as they relate to the processes of respiration, phonation, resonance, & articulation
  - Neural innervation of these muscles innervated?
- What parts of the brain are responsible for:
  - Motor speech production?
  - For sensations from the articulatory, phonation, & breathing mechanism?
  - For auditory processing of speech

Overview of Speech Science

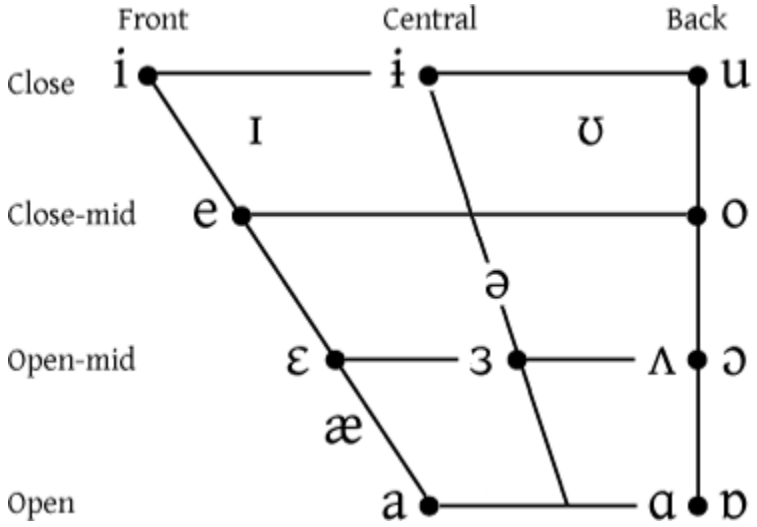
- Describe the source-filter theory of speech sound production
- Define the terms
  - Waveform
  - Spectrum
  - Harmonic
  - Formant
  - Sound spectrogram

- How do modifications in the vocal tract affect the acoustic properties of speech?

The Source-Filter Theory

- Definition: Speech is produced by passing a basic sound through a series of filters with modify the sound to produce the specific sounds we hear
- This relates to how we modify the basic sound (vocal fold vibrations) through the vocal tract and the oral cavity (and nasal cavity)
- Know the different places where modifications take place (we will go over this)

Physiological Phonetics



- **Vowels**
  - Front, central, back
  - High, mid, low
  - Tense, lax
  - Rounded, unrounded
- **Diphthongs**
  - Know the movement from “a” to “b”
  - What primary vowels make up diphthongs?

Physiological Phonetics

- Understand the traditional classification system of **consonants**
- Manner
- Place
- Voicing

	stop	fricative	affricate	nasal	liquid	glide
bilabial	p, b			m		w
labio-dental		f, v				
dental		θ, ð				
alveolar	t, d	s, z		n	l, r	
palatal		ʃ, ʒ	ʧ, ʤ			j
velar	k, g			**ŋ**		
glottal		h				
Sounds that are **bold** are voiced.						

Consonants

- **Place**: bilabial, labial/velar, labiodental, linguadental (interdental), lingua-alveolar, linguapalatal, linguavelar, glottal
- **Manner**: stop, nasal, glide, fricative, stop, lateral, flap, affricate, rhotic
- **Voicing**: voiced, voiceless

Distinctive Features (Chomsky & Halle)

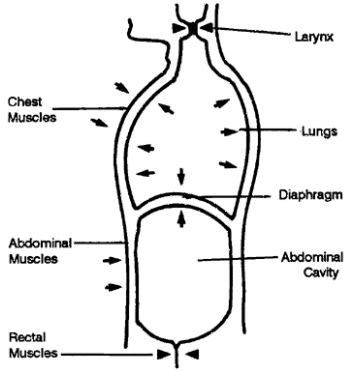
- Sonorant = made with voice and continuous sound such as a vowel, glide, nasal, liquid = musical
- Vocalic = vowel sounds
- Consonantal = consonant sounds
- Strident = harsh sounds made with a large spread of acoustic energy
- Lateral = air escapes to the sides
- Nasal = air escapes through the nose
- Voiced = made with vocal fold vibration
- Interrupted = consonants that are not continuants know what interrupts the flow of air/sound

Distinctive Features (Chomsky & Halle)

- High = vowels in which tongue is high in mouth
- Low = vowels in which tongue is low in mouth
- Back = vowels produced using back of tongue
- Front = vowels produced using front of tongue
- Coronal = consonants formed with tip of tongue
- Rounded = vowels made with rounded lips

Respiratory System (from Ferrand)

- Know the anatomy and physiology of the respiratory system
- Understand how lungs work for breathing
- Understand different lung volumes and capacities (next slide)
- Explain differences between life breathing and breathing for speech
  - Time Factors of this cycle
    - Life breathing cycle is about 50/50 (in/out)
    - Speech breathing cycle is short (in)/long (out)



A VALSALVA MANEUVER

Breathing for Life

- Less volume
- Air intake via nose
- Volume = 10% of VC

- Diaphragm and intercostal muscles
- Automatic
- Inspiration takes 40% – 50% of respiratory cycle

Breathing for Speech

- More volume
- Air intake via mouth
- Volume may reach 25% of VC
- MORE ACTIVITY of these muscles
- Voluntary control
- Inspiration takes 10% – 20% of respiratory cycle

Lung volumes and capacities (Measured with a spirometer)

- Tidal breathing = normal breathing or breathing for life
- Tidal volume (TV) = amt. of air on a single breath of normal breathing
- Inspiratory reserve volume (IRV) = extra air you take in after normal inhalation of breath
- Expiratory reserve volume (ERV) = air you can let out after normal expiration of breath
- Residual volume (RV) = air left over after you have exhaled EVERYTHING

Lung volumes and capacities (Measured with a spirometer)

- Vital capacity (VC)
  - IRV + TV + ERV
- Functional Residual Capacity (FRC)
  - ERV + RV
- Total lung capacity (TLC)
  - TV + IRV + ERV + RV

Phonatory System

- Know structures of the larynx
- Explain ***myoelastic-aerodynamic theory of phonation***
- Explain the sound wave of the human voice
- Explain sources and measurement of jitter and shimmer
- Explain physiologic bases of vocal registers

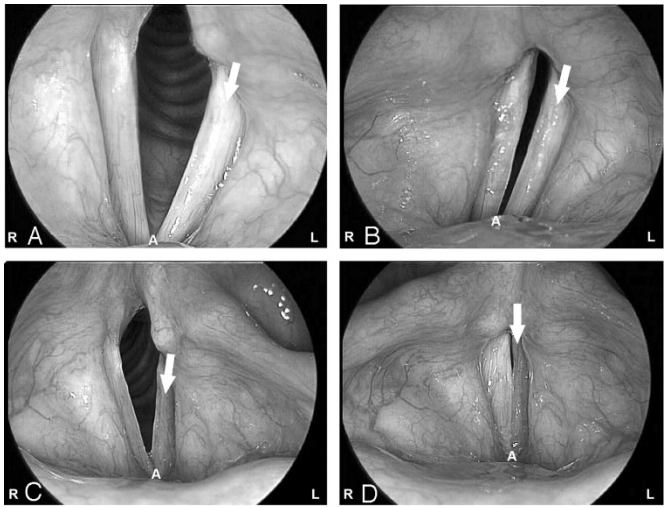
Myoelastic Aerodynamic Theory of Phonation

- Myoelastic
  - How the muscles change their elasticity and tension to make changes in the frequency of vibration
- Aerodynamic
  - Vocal folds are activated by the airstream from the lungs (not by individual nerve impulses)
  - The air pressure from the lungs blows the vocal folds apart
  - The vocal folds come back together because of the elasticity of the vocal folds and the sudden drop in air pressure between the folds (Bernoulli principle)

Biomechanics of Voice Production

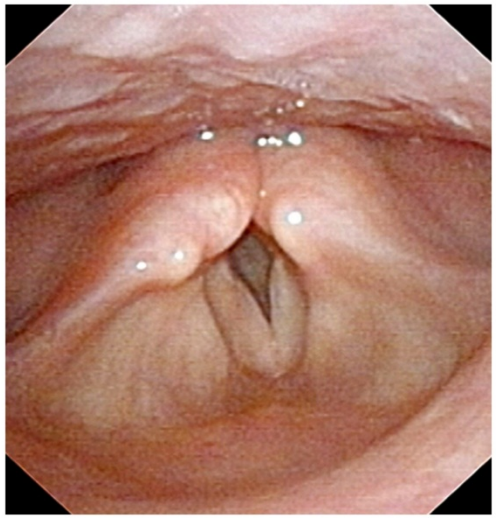
Caution: don't confuse

- ***Abduction/Adduction*** of the vocal folds by movement of the cricoarytenoid joints, and
- ***Opening/Closing*** of the vocal folds during vibration achieved by passive coupling of the aerodynamic forces & the biomechanical characteristics of the vocal folds.



Cover-Body Theory of Phonation

- Vocal adjustments in speaking and singing are regulated by changing the mechanical properties of the different layers of tissue of the vocal folds
- Cover layer – near the surface
- Body layer – deeper in the fold



Jitter and Shimmer

- Jitter is variation in PITCH (frequency) of voice
- Shimmer is variation in VOLUME (intensity) of voice
- Normal ranges are known and can be measured
- Abnormalities relate to poor vocal quality and voice use

Fundamental Frequency

- F_0 = fundamental frequency
  - Determined by tension of vocal folds rather than actual length
    - Adult males: 80 – 150 Hz
    - Adult females: 180 – 250 Hz
    - Children: 250 – 400 Hz
- Intensity
  - Controlled by subglottal air pressure
  - Thus, related to amount of air and amount of air pressurereleased during speaking

Human Voice

- F_0 + harmonics = complex tone we call speech
- Glottal spectrum shows that as harmonic frequencies increase – amplitude decreases at a rate of 12 dB/octave for each doubling of frequency
- F_0 is loudest, next doubling of frequency is 12dB lower in volume,etc.

Vocal Perturbations

- Vocal Folds do **not** vibrate evenly
  - Variability in timing of the vibration = frequency perturbation = **jitter**
  - Variability in amplitude of vibration = amplitude perturbation or **shimmer**
- Perturbation = variation

Vocal Registers and Vocal Quality

- Registers
  - **Falsetto** – vocal folds long and stiff
  - **Pulse** – low F_0, "vocal/glottal fry," vocal folds tightly closed
  - **Modal** – normal conversational speech
- Quality
  - **Breathiness** – inadequate vocal fold closure
  - **Roughness/Hoarseness** – vocal folds vibrate in less periodic pattern

Articulatory and Resonance System

- Know the structure and function of the articulators
- Explain the resonating characteristics of the vocal tract
- Describe the source-filter theory of vowel production
- Understand acoustic and spectrographic analysis of vowels and consonants
- Explain the role of suprasegmentals and coarticulation in connected speech

Production of Vowels

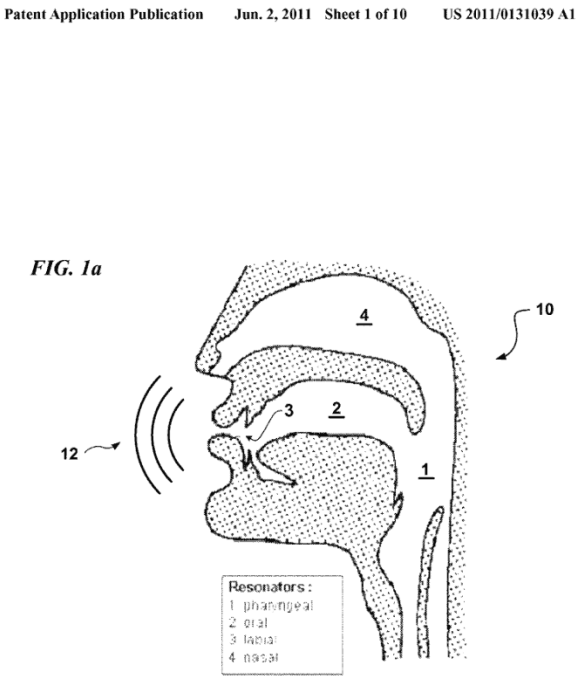
- Related to the modifications in RESONANCE as the F_0 is changed or modified by the resonance of sound in the different parts of the vocal tract (source)
- We all have a F_0
- As the sound wave travels up the vocal tract, it resonates along the walls of the
  - Pharynx
  - Back of mouth
  - Inside mouth (and for nasals in nose)
  - Front of mouth

Resonance Regions

- F_0 Larynx
- F_1 Pharynx
- F_2 Back of Mouth
- F_3 Middle of Mouth
- F_4 Front of Mouth
- Complex sound called Vowels

F_{0+} F_{1+} F_{2+} F_{3+} F_4

For Vowels we focus on F_{1+} F_2



Vocal Tract as a Resonator

- Tube that is closed at one end (glottis) and open at the other
- Complex shape – series of air-filled containers, each with own **resonating frequency** (RF)
- Result: Vocal tract resonates at numerous RFs
- Variable resonator – changing shape changes RF
  - Can change the shape with the
  - **Tongue**
  - **Shape of lips (affect shape of mouth**

Formants

- Resonant frequencies of the vocal tract
  - F1 – related to volume of pharyngeal cavity
  - F2 – related to length of oral cavity
- Modified by moving tongue
  - F1 – lower with /i/= greater volume in pharyngeal cavity + less volume in oral cavity
  - F 1 – higher with /a/= less volume in pharyngeal cavity + more volume in oral cavity

Formants

- F2 – higher with /i/ – shorter length of oral cavity
- F2 – lower with /a/ – longer length of oral cavity

- Each vowel has a distinct pattern of formants
  - This enables us to perceive different vowels

Spectrographic Analysis of Phonemes

- Vowels – characterized by relationship of F1, F2, F3
- Diphthongs – characterized by ***formant transitions*** for F1, F2, and F3
- Glides – characterized by rapid formant transitions
- Liquids – steady-state formants
  - /r/ characteristically brings F3 closer to F2

Formants of Vowels

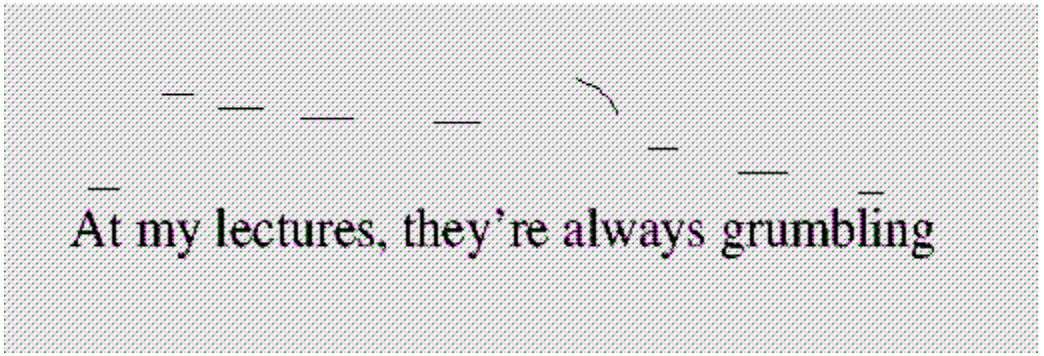
Phonetic Symbol	Example Word	F_1 (Hz)	F_2 (Hz)	F_3 (Hz)
/ow/	bought	570	840	2410
/oo/	boot	300	870	2240
/u/	foot	440	1020	2240
/a/	hot	730	1090	2440
/uh/	but	520	1190	2390
/er/	bird	490	1350	1690
/ae/	bat	660	1720	2410
/e/	bet	530	1840	2480
/i/	bit	390	1990	2550
/iy/	beet	270	2290	3010

Coarticulation

- Coarticulation – individual phonemes influence one another, modifying the acoustic characteristics

Suprasegmentals (prosody)

- Stress
- Intonation
- Loudness (amplitude)
- Pitch (from fundamental frequency)
- Juncture
- Duration
- Rate
- Vowel Reduction



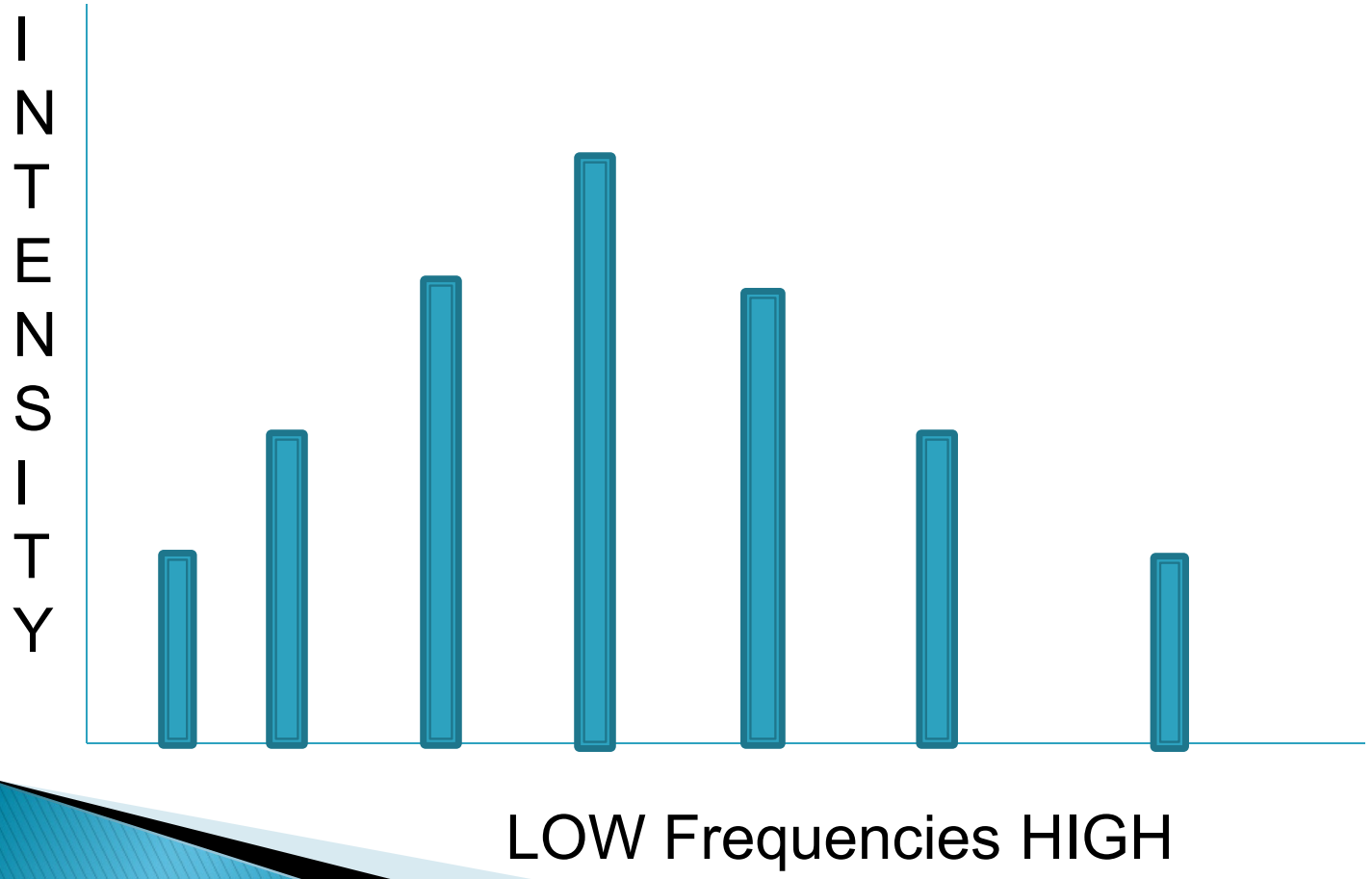
Suprasegmentals

- **Intonation**
  - **Variation of F_0**
    - Dropped at end of phrases/sentences due to drop in subglottal air pressure
- **Stress**
  - Variation of frequency, intensity and duration of syllable/word
  - Greater stress = higher F_0
- **Duration**
  - Length of phoneme
    - Varies with stress

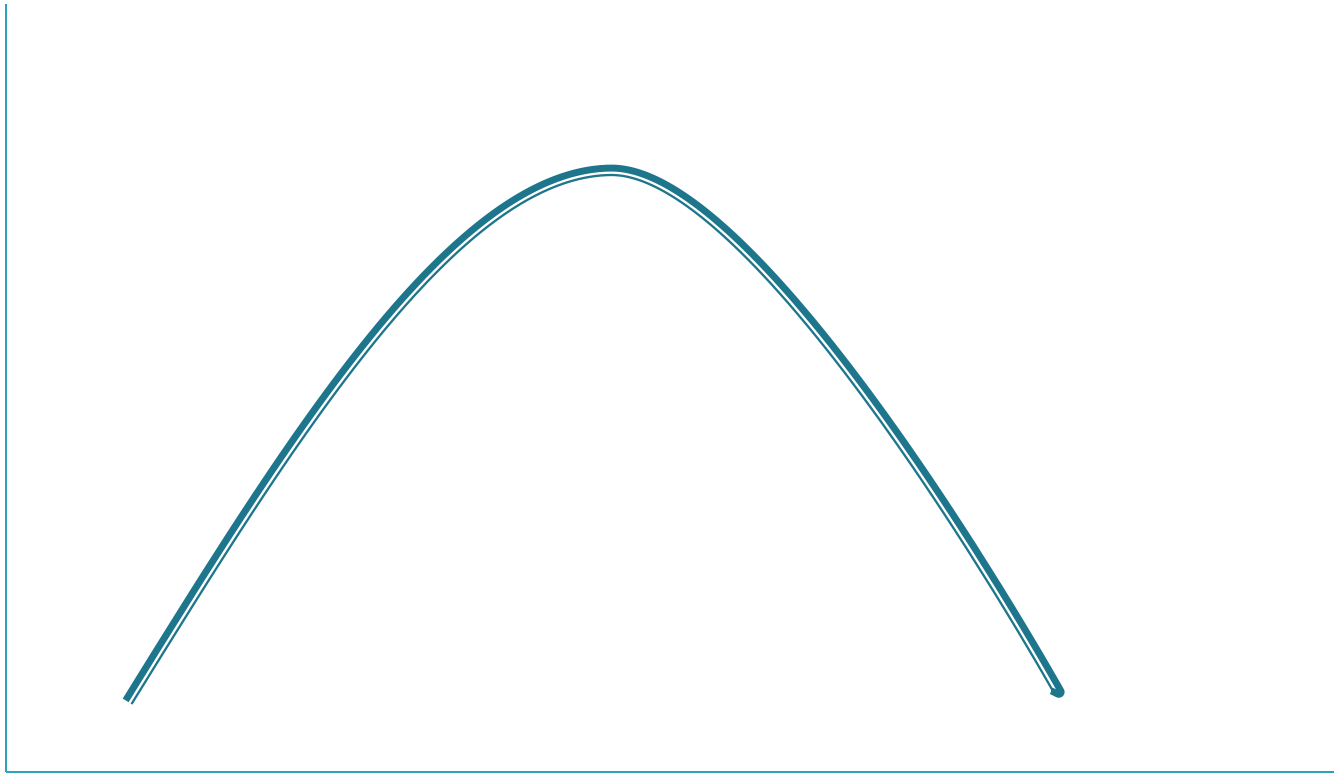
Major Acoustic Properties (Bankson & Bernthal)

Sound class	Intensity	Spectrum	Duration
Vowels	Very strong	Low frequency	Moderate to long
Glides & liquids	Strong	Low frequency	Short to moderate
Strident fricatives & affricates	Moderate	High Frequency	Moderate
Nasals	Moderate	Very low frequency	Short to moderate
Stops	Weak	Varies by place	Short
Nonstrident fricatives	Weak	Flat	Short to moderate

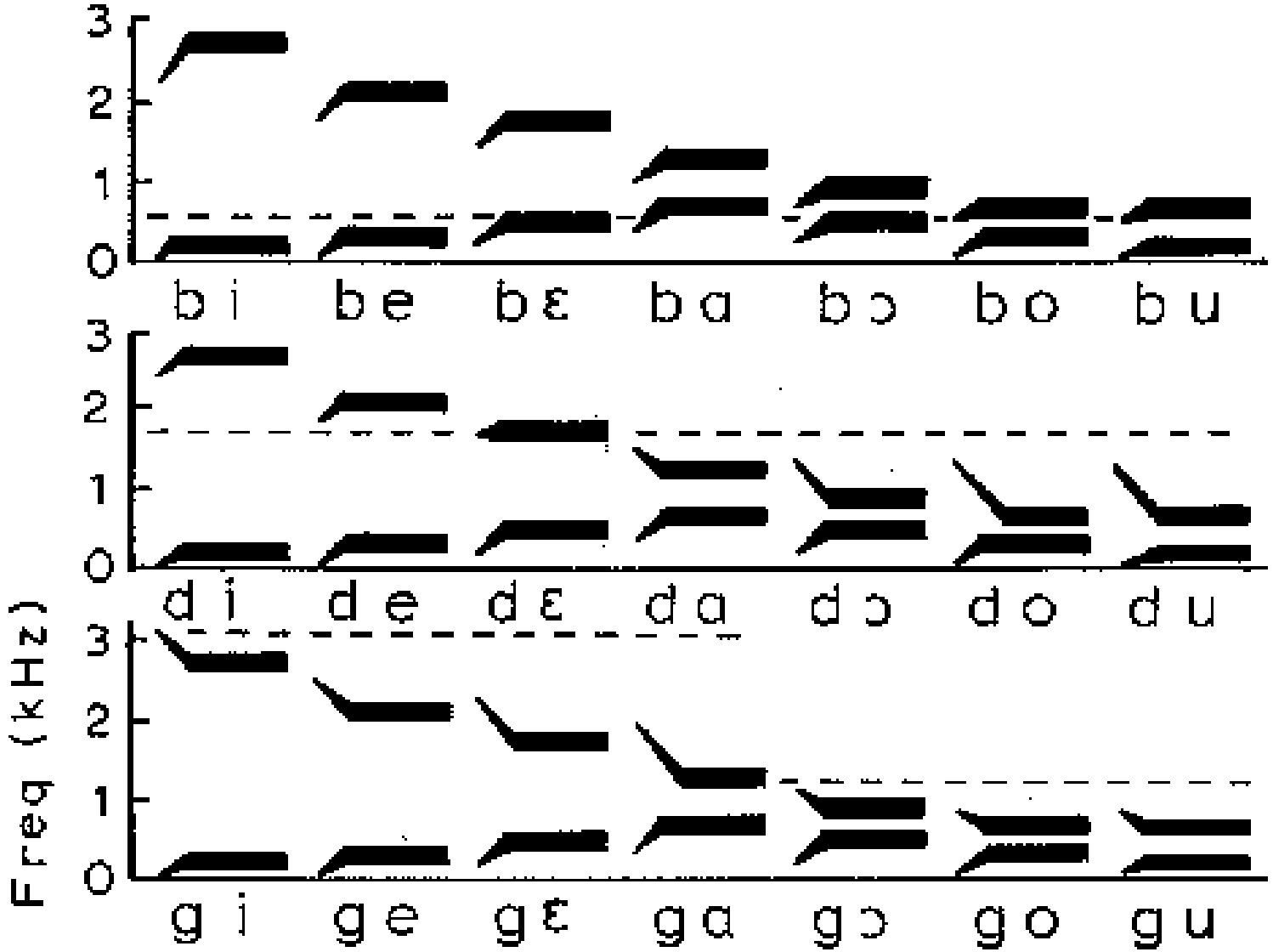
Bar Spectrogram



Line Spectrogram



Spectrographic Analysis



Let's Take a Quick Look at Spectrograms

- Go to the following slide's free website
- Play with it and get used to spectrograms
- Practice spectrographic analysis
- Wide but narrow plots = plosive consonants
- Plots with formants at the bottom = voice consonants
- Plots with no formants at the bottom = voiceless consonants
- Flat formants = vowels
- Formant Transitions = consonants

More on Spectrograms

- Wide spread of energy up and down = fricatives and sibilants
- Empty spaces or mostly white spaces left to right = pauses or no voice
- Here is the free website link called WASP-2

- https://www.speechandhearing.net/laboratory/wasp/

Auditory Perception of Speech

- We perceive acoustic features of sound (frequencies, intensities, time (temporal) differences)
- We learn to classify these by their **distinctive features**
- We then learn that these have names (phonemes) and things like vowels and consonants

Theories of the Auditory Perception of Speech

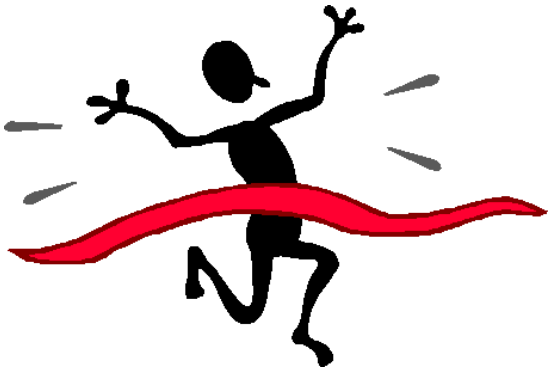
- ***Motor Theory***– we perceive speech because we produce speech
  - Evidence: during the auditory perception of speech there is activity in Broca's area
  - Research demonstrates that infants can perceive different phonemes prior to production (e.g., Voice Onset Time (VOT) experiments

Theories of Speech Perception or Auditory Processing of Speech

- Auditory Theories – acoustic features for each phoneme, regardless of co-articulation and context are detected by specific neural regions in central auditory pathway
  - Called the ***Feature Detection Theory***
    - Time = stop/plosives vs. continuants
    - Low frequency buzz = nasals

We Are Finished

- This **review** should help you know what you really understand and what you need to study before you take the Praxis exam
- This was not intended to teach you this information but to review the information
- If you are weak in an area, review the key points covered in this review
- Good luck and do your best on the Praxis exam! ! !



The End

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