CH. 2: PHYSIOLOGICAL & ACOUSTIC PHONETICS

INTERNATIONAL PHONETIC ALPHABET

Table 2.1

The International Phonetic Alphabet (IPA)

IPA symbol	Examples	IPA symbol	Examples
/p/	pot	/ʃ/	shine
/b/	bat	/ʒ/	vision
/m/	mat	/θ/	thin
/n/	net	/ð/	then
/ŋ/	sing	/ʧ/	chin
/d/	dime	/ʤ/	Jane
/t/	time	/v/	van
/g/	gum	/w/	wine
/k/	Kim	/l/	lean
/f/	fun	/j/	yawn
/s/	sun	/h/	hen
/z/	Zen	/r/	run
/ɑ/	fall	/ɛ/	bet
/æ/	fat	/e/	late
/ɔ/	fought	/o/	overcoat
/ə/	atop	/ʊ/	put
/ʌ/	fun	/u/	boot
/ɪ/	infect	/ɝ/	shirt
/i/	eat	/ɚ/	later
/eɪ/	main		
/aɪ/	lime		
/oʊ/	dome		
/aʊ/	how		
/ɔɪ/	boy		
/ɪʊ/	fuse		

DIACRITICAL MARKERS

Table 2.2
Diacritical Markers

[ː] **full lengthening.** This mark, when placed to the right of a phoneme, indicates that the duration of the phoneme has been increased considerably (almost doubled); e.g., /ɛg/ becomes [ɛːg].

[ˑ] **half lengthening.** This mark, when placed to the right of a phoneme, indicates that the duration of the phoneme has been somewhat increased (not as much as for full lengthening); e.g., /tɔk/ becomes [tɔˑk].

[˜] **nasalization.** This mark, when placed above a phoneme, indicates that the phoneme, usually non-nasal, has become nasalized; e.g., /tɔp/ becomes [tɔ̃p].

[̥] **devoicing.** This mark, when placed below a phoneme, indicates that the phoneme, usually voiced, has become devoiced; e.g., /beɪbɪ/ becomes [b̥eɪb̥ɪ].

[̬] **voicing.** This mark, when placed below a phoneme, indicates that the phoneme, usually voiceless, has become voiced; e.g., /sup/ becomes [s̬up].

[ʰ] or [ʻ] **aspiration.** This mark, when placed at the top right side of a phoneme, indicates that the phoneme, usually unaspirated, becomes aspirated; e.g., /tek/ becomes [tekʻ].

[ʼ] **unaspiration.** In American English, this mark, placed at the top left side of phoneme /p/, /t/, /k/ in the word-initial position, indicates that the phoneme, usually aspirated, becomes unaspirated; e.g., /pɑt/ becomes [ʼpɑt].

[̫] **labialization.** This mark, placed directly below the phoneme, indicates that the phoneme, usually nonlabial, becomes labialized; e.g., /nouz/ becomes [n̫ouz].

[͊] **nonlabialization.** This mark, placed directly below the phoneme, indicates that the phoneme, usually labial, becomes nonlabial; e.g., /wɪθ/ becomes [w͊ɪθ].

[̪] **dentalization.** This mark, placed directly below the phoneme, indicates that the phoneme, usually not linguadental, is produced at the linguadental place of articulation; e.g., /tiʧ/ becomes [t̪iʧ].

[˙] **palatalization.** This mark, placed directly above the phoneme, indicates that the phoneme, usually nonpalatal, becomes palatalized; e.g., /zu/ becomes [żu].

[̣] **closing of vowel.** This mark, placed directly below the vowel phoneme, indicates that the phoneme is produced with greater closing than normally required for its production; e.g., /eʤ/ becomes [ẹʤ].

[̨] **opening of vowel.** This mark, when placed directly below the vowel phoneme, indicates that the phoneme is produced with greater opening than normally required for its production; e.g., /ˈeɪnˌʤəl/ becomes [ˈȩɪnˌʤəl].

[˔] **tongue raising.** This mark, when placed to the right of the vowel phoneme, indicates that the phoneme is produced with more than usual tongue raising; e.g., /ðe/ becomes [ðe˔].

[˕] **tongue lowering.** This mark, when placed to the right of the vowel phoneme, indicates that the phoneme is produced with more than usual tongue lowering; e.g., /blu/ becomes [blu˕].

[+] or [˖] **tongue advancement.** This mark, when placed to the right of the vowel phoneme, indicates that the phoneme is produced with more than usual tongue advancement; e.g., /tu/ becomes [tu+].

[–] or [˗] **tongue retraction.** This mark, when placed to the right of the vowel phoneme, indicates that the phoneme is produced with more than usual tongue retraction; e.g., /ʧik/ becomes [ʧi–k].

Table 2.2 *(Continued)*
Diacritical Markers

[ʾ] **lip rounding.** This mark, when placed at the top right side of the vowel phoneme, indicates that the phoneme is produced with more than usual lip rounding; e.g., /ʃit/ becomes [ʃiʾt].

[ʿ] **lip spreading.** This mark, when placed at the top right side of the vowel phoneme, indicates that the phoneme is produced with more than usual lip spreading; e.g., /sun/ becomes [suʿn].

[-] **vowel centralization.** This mark, when placed across the vowel phoneme, indicates that the phoneme, usually noncentral, becomes centralized; e.g., /it/ becomes [ɨt].

[̩] **consonant syllabification.** In American English, this mark is placed below the consonants /m/, /n/, /ŋ/, /l/ when these consonants perform the function of the nucleus in a syllable; e.g., /bɑtəl/ becomes [bɑtl̩].

Note. From *Phonetics: Principles and Practices* (3rd ed.), by S. Singh & K. S. Singh, 2005, San Diego, CA: Plural. Copyright 2005 by Plural Publishing. Reprinted with permission.

CONSONANTS vs. VOWELS

Comparisons of Vowels and Consonants

Vowels	Consonants
Always voiced	May be voiced or voiceless
May stand alone	Always combined with vowel
Velum always elevated	Velum elevated or lowered
Vocal tract open	Vocal tract modified or constricted
Airflow continuous	Airflow modified or stopped
May be described by:	May be described by:
• distinctive features	• distinctive features
• tongue and lip position	• place-voice-manner
• tension vs. laxness	

CONSONANTS
DISTINCTIVE FEATURES p. 79

Table 2.4

The Chomsky-Halle Distinctive Features of English Consonants

	w	f	v	θ	ð	t	d	s	z	n	l	ʃ	ʒ	j	r	ʧ	ʤ	k	g	ŋ	h	p	b	m
Voiced	+	−	+	−	+	−	+	−	+	+	+	−	+	+	+	−	+	−	+	+	−	−	+	+
Consonantal	−	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	+	+	+	−	+	+	+
Anterior	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	+	+	+
Coronal	−	−	−	+	+	+	+	+	+	+	+	+	+	−	+	+	+	−	−	−	−	−	−	−
Continuant	+	+	+	+	+	−	−	+	+	−	+	+	+	+	+	−	−	−	−	−	+	−	−	−
High	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	+	+	+	+	+	−	−	−	−
Low	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−
Back	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	−	−
Nasal	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	+	−	−	−	+
Strident	−	+	+	−	−	−	−	+	+	−	−	+	+	−	−	+	+	−	−	−	−	−	−	−
Vocalic	−	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−

Note. From *Introduction to Communicative Disorders* (4th ed., p. 146), by M. N. Hegde, 2010, Austin, TX: PRO-ED. Copyright 2010 by PRO-ED, Inc. Reprinted with permission.

FEATURE	DESCRIPTION	SOUNDS
Vocalic	Have little constriction and are associated with spontaneous voicing	
Consonantal	Have marked constriction along the midline region of the vocal tract	
Lateral	Produced by placing the front of the tongue against the alveolar ridge (midline closure) and lowering the midsection of the tongue bilaterally (lateral opening)	
Voiced	When the sounds are produced, the vocal folds vibrate	
Back	Produced with the tongue retracted from the neutral schwa position	
Low	Tongue is lowered from the neutral schwa position	
Continuant	Produced with an incomplete point of constriction. For this reason, the airflow is not entirely stopped at any time, and the sounds may be produced continuously until the person runs out of breath	
Nasal	These sounds are produced by lowering the velum so that there is coupling of the oral and nasal cavities and sounds are resonated in the oral cavity	
Anterior	These sounds are produced with a point of constriction located more anteriorly than that of "sh." The production of "sh" defines the boundary between anterior and non-anterior sounds.	
Coronal	Produced with the tongue blade raised above the neutral schwa position	
Round	Produced with the lips protruded or rounded	
Tense	These sounds are produced with a relatively greater degree of contraction or muscle tension at the root of the tongue	
High	Produced with the tongue elevated above the neutral schwa position	
Strident	Produced by forcing the air-stream through a small, constricted opening; the result is strident or intense noise	
Sonorant	Produced by allowing the airstream to pass relatively uninterrupted through the nasal or oral cavity; there is no stoppage or point of constriction	
Interrupted	May be thought of as the opposites of sonorants because the interrupted sounds are produced by complete blockage of the airstream at the point of constriction	
Syllabics	Syllabics serve as the nucleus for a syllable	
Obstruents	Made with a notable amount of air obstruction in the vocal tract; obstruents are made with a narrow constriction or complete closure of the oral cavity, so a friction noise is produced or the airstream is stopped completely	
Sibilants	High-frequency sounds that have longer duration and more stridency than most other consonants	
Approximants	Named as such because of the approximating nature of the contact between the two articulators that help form them. That is, the degree of contact is approximate, not nearly as firm or closed as it is for fricatives, affricates, and stops.	

Rhotic	A term sometimes used to describe /r/ and its allophones	

PLACE-VOICE-MANNER OF PRODUCTION p. 80

Table 2.3

Manner of Production

Place of articulation	Nasals	Stops	Fricatives	Affricates	Liquids	Glides	Laterals
Bilabial	(m)	p (b)				(w)	
Labiodental			f (v)				
Linguadental			θ (ð)				
Lingua-alveolar	(n)	t (d)	s (z)		(l)		(l)
Linguapalatal			ʃ (ʒ)	ʧ (ʤ)	(r)	(j)	
Linguavelar	(ŋ)	k (g)					
Glottal			h				

Note. Voiced sounds are circled. Place-Voice-Manner Classification of English Consonants. From *Introduction to Communicative Disorders* (4th ed., p. 142), by M. N. Hegde, 2010, Austin, TX: PRO-ED. Copyright 2010 by PRO-ED, Inc. Reprinted

PLACE		
FEATURE	*DESCRIPTION*	*SOUNDS*
Linguavelars (velars)	Produced when the dorsum of the tongue contacts the velum	
Lingua-palatals	Produced when the tongue blade is pressed against the hard palate to form the point of constriction just posterior to the alveolar ridge	
Lingua-alveolars	Produced by contact of the tip of tongue with the alveolar ridge	
Linguadentals (interdentals)	Produced by protruding the tongue tip slightly between the cutting edge of the lower and upper front teeth, forming a narrow constriction. Airflow is directed through this constriction, and contact between the tongue and teeth is light	
Bilabials	Produced by mutual contact of the upper and lower lips	
Labiodentals	Produced by placing the lower edge of the upper central incisors on the upper portion of the lower lip. A narrow point of constriction is formed from this light contact of the incisors and lip	
Glottals	Produced at the level of the glottis. The vocal folds are open, and the air passes through them.	
VOICING		
FEATURE	*DESCRIPTION*	*SOUNDS*
Voiced	Vocal folds vibrate during consonant production	
Voiceless	Vocal folds do not vibrate during consonant production	
Cognate pairs	Sounds that are identical in every way except voicing	
MANNER		
FEATURE	*DESCRIPTION*	*SOUNDS*
Nasals	• Produced by lowering the velum to keep the velopharyngeal port open	

	• The open velopharyngeal port allows the sound produced by the vibrating vocal folds to pass through the nasal cavity • The vocal tract is lengthened, and there is an overall increase in the area for resonance	
Fricatives	• Derive their name from the friction—a hissing-type quality—that results from the continuous forcing of air through a narrow constriction • Two closely approximating articulators form a constriction through which a continuous airstream must pass • The constrictions in the vocal tract generate aperiodic noise as the airflow passes through them • The constrictions must be narrow enough and the airflow strong enough to create a turbulent airflow • The turbulent airflow creates noisy random vibrations, or frication • Firm velopharyngeal closure is necessary	
Affricates	• Have both a fricative and stop component • Begin as stops and are released as fricatives	
Stops	• Produced by complete constriction or closure of the vocal tract at some point, so the airflow is totally stopped. • Formed at three basic places: alveolar (closure between the tip of the tongue & the alveolar ridge), velar (closure between the tongue blade & roof of the mouth), and labial (closure of the lips) • When airflow is stopped, pressure builds up behind the point of contact • When the build-up air is released, there is a short audible burst of noise	
Glides	• Produced by a quick transition of the articulators as they move from a partially constricted state to a more open state for the vowels that follow them “onglide” term used to describe this movement • Formed by a relatively transitory and unrestricted point of constriction	
Liquids	• Produced with the least oral cavity restriction of all the consonants • Vocal tract is obstructed only slightly more than vowels • R called a “rhotic;” produced in two ways: o Retroflex: made with the tongue tip retracted & approximating the hard palate o Bunched: dorsum of tongue is bunched or retracted & elevated toward the hard palate • L	

<table>
<tr><td></td><td>o Midsection portion of the tongue is relaxed and open, and thus air is directed through the sides of the tongue</td><td></td></tr>
<tr><th colspan="3">CONSONANT CLUSTERS/BLENDS</th></tr>
<tr><td colspan="3">● Consonants that are produced adjacent to other consonants
● Occur in initial, medial, and final positions of words
● Most blends consists of two consonants; however, some three-consonant clusters do occur
o 2 □ mosquito, bless, silk
o 3 □ burst, straw, burnt</td></tr>
</table>

VOWELS

DISTINCTIVE FEATURES p. 84

FEATURE	*DESCRIPTION*	*SOUNDS*
Vocalics	Produced without a marked constriction of the vocal tract	All vowels
Sonorants	Produced by an airstream that passes unconstructed through the oral or nasal cavity	All vowels
Voiced	Produced with vocal fold vibration	All vowels
Rounded	Produced with the lips rounded or protruded	
Tense	Produced with muscle contraction or tension at the root of the tongue	
Front	Tongue is in a position anterior to the neutral schwa position	
Back	Made with the tongue retracted from the neutral schwa position	
High	Made with the tongue elevated above the neutral schwa position	
Low	Made with the tongue lowered from the neutral schwa position	
Rhotic	Sounds made with an /r/ coloring	

POSITION CHARACTERISTICS p. 84

Vowels can be characterized according to four dimensions:

<table>
<tr><td>Lip position</td><td>● Rounded or unrounded</td></tr>
<tr><td>Tense/lax qualities</td><td>● Tense:
o longer duration
o produced with increase tension
● Lax:
o shorter duration
o relatively less muscular tension</td></tr>
<tr><td>Tongue height</td><td>● High, mid, or low</td></tr>
<tr><td>Tongue forwardness or retraction</td><td>● Front, central, or back</td></tr>
</table>

<table>
<tr><th colspan="3">FRONT VOWELS</th></tr>
<tr><td>Vowel</td><td>Characteristics</td><td>Words</td></tr>
<tr><td></td><td>● high, lax, unround</td><td>bit, sick, tin</td></tr>
<tr><td></td><td>● high, tense, unround, tongue is in high & forward position</td><td>head, meet, see</td></tr>
</table>

	• mid, tense, unround	make, later, fate
	• mid, lax, unround	let, ten, sent
	• low, lax, unround; one of the lowest vowels in English	tan, matter, sat

CENTRAL VOWELS		
Vowel	*Characteristics*	*Words*
	• tense, half-round, retroflexed • tongue blade I bunched & elevated toward the hard palate • transcribed to represent /r/ production in syllables receiving primary stress	curtain, hurt, dirty
	• lax, half-round, retroflexed • transcribed to represent /r/ production in unstressed syllables such as butter	letter, color, letter

BACK VOWELS		
Vowel	*Characteristics*	*Words*
	• high, tense, round • tongue in the highest, most retracted position	spoon, fruit, bruise
	• high, lax, round	took, put, foot
	• mid, lax, round	fought, caught, shawl
	• mid, tense, round	coat, lower, soapy
	• low, lax, unround • lowest, most retracted tongue position	calm, pocket, father

DIPHTHONGS: produced as a slow, gliding movement from one vowel (the onglide) to the adjacent vowel (the offglide)		
Vowel	*Characteristics*	*Words*
Phonemic diphthongs	• cannot be reduced to pure vowels without changing word meaning	type vs. top
Non-phonemic diphthongs	• do not change word meanings	

DYNAMICS OF SPEECH PRODUCTION, p. 88

Sounds may influence each other in 3 ways:

Type	Description	Example
Adaptation	● Comprise two types of variations according to the preceding & following sounds: o Variations in the way the articulators move o The extent to which vocal tract configuration change shape	The /m/ in meek is produced with more lip retraction than the /m/ in moo, which is produced with slight lip protrusion
Assimilation	● Modified due to the influence of adjacent sounds ● Modifications are so extensive that there are perceptible changes in sounds	In the phrase “great zoo,” the /z/ in zoo is de-voiced because of the voiceless /t/ in the preceding word
Coarticulation	● The influence of one phoneme upon another phoneme in production or perception ● Two different articulators move simultaneously to produce two different speech sounds ● Creates both adaptation & assimilation	

ACOUSTICS: BASIC DEFINITIONS, p. 90

Term	Definition
Acoustics	● a branch of physics ● the study of the physical properties of sound and how sound is generated and propagated
Psychoacoustics	● a study of how humans respond to sound as a physical phenomenon ● a branch of both psychology and acoustics
Sound	● may be defined both physically and psychologically (perceptually) ● physically defined as the result of a vibration or disturbance in the molecules of a medium (air, gas, or liquid) ● perceptually defined as a vibration or disturbance in the air that is potentially audible, although instruments can measure inaudible sound
Sound waves	● movements of particles in a medium containing expansions & contractions of molecules
Compression (condensation)	● a phase of sound in which the vibratory movements of an object increase the density of air molecules because the molecules are compressed or condensed ● opposite of rarefaction
Rarefaction	● the thinning of air molecules when the vibrating object returns to equilibrium ● opposite of condensation
Simple harmonic motion	● refers to the back and forth movement of particles when the movement is symmetrical and periodic ● AKA a sine wave
Sinusoidal motion	● a wave with horizontal and vertical symmetry because it contains one peak or crest and one valley or trough ● a sinusoidal wave contains a single frequency and is a result of simple harmonic motion
Aperiodic waves	● those that do not repeat themselves at regular intervals ● their vibratory patterns are random and difficult to predict from one time interval to the next

	• aperiodic waves are equated with noise
Periodic waves	• sound waves that repeat themselves at regular intervals and are predictable
Intensity	• physically the amount of energy transmitted per second over an area of one square meter • measured in terms of watt per square meter OR in decibels
Bel	• a logarithmic unit of measure of sound intensity • it is a basic & relative reference measure that helps express the wide range of sound intensities to which the human ear is sensitive by means of a compressed, logarithmic scale
Decibel	• a measure of sound intensity that equals one tenth of a bel
csg system	• a metric system of measuring length in centimeters (cm), time in seconds (sec), and mass in grams (g) • can be contrasted with the MKS system a metric system of measuring length in meters (m), mass in kilograms (kg), and time in seconds
Dyne	• a measure of force in the csg metric system • 1 dyne is the force required to accelerate a mass of 1 gram from a velocity of 0 cm per second to a velocity of 1 cm per second in 1 second
Density	• the amount of mass per unit volume • density of matter serves as a medium for sound and affects sound transmission
Displacement	• change in position • air molecules are said to be displaced because of the vibratory action of an object
Oscillation	• refers to the back & forth movement of the air molecules because of a vibrating object
Force	• a vector quantity that produces an acceleration of a body in the direction of its application • the product of mass & acceleration • measured in terms of Nt (newton) • 1 newton = the force required to accelerate a mass of 1 kg from a velocity of 0 m per second to a velocity of 1 m per second in 1 second
Elasticity	• a property that makes it possible for matter to recover its form & volume when subjected to distortion • all matter is subjected to distortion when force is applied to it
Velocity	• a change in position of air molecules when an object is set to vibration • measured in terms of the distance an object moves per the time & the direction it takes as it moves
Frequency	• one of the two characteristics of vibratory motion • the rate of vibratory motion that is measured in terms of the number of cycles completed per second or, more recently, in terms of hertz (Hz) • Hertz in the unit of measure for frequency and is the same as the cycle per second • 1 cycle per second = 1 Hz
Natural frequency	• the frequency with which a source of sound normally vibrates • determined by the source's mass & stiffness • INCREASED MASS = DECREASED FREQUENCY • INCREASED STIFFNESS = INCREASED FREQUENCY
Formant frequency	• a frequency region with concentrated acoustic energy • the center frequency of a formant, which is a resonance
Fundamental frequency	• the lowest frequency of a period wave • principle component of a sound wave • has the greatest wavelength • the first harmonic
Harmonics (overtones)	• the tones in a periodic complex sound, in which all frequencies can be characterized as whole-number multiples of the fundamental frequency
Octave	• an indication of the interval between two frequencies • the intervals always maintain a ratio of 1:2 each octave doubles a particular frequency
Impedance	• acoustic, mechanical, or electrical resistance
Newton's Law of Motion	• explains motion & its characteristics

	● sound involves motion
Law of inertia	● states that all bodies remain at rest or in a state of uniform motion unless another force acts in opposition
Law of reaction forces	● every force is associated with a reaction force of opposite direction
Pressure	● the amount of force per unit area ● measured either as dynes or as newtons ● important in understand the amount of force sound waves exert on the eardrum
Reflection	● the phenomenon of sound waves traveling back after hitting an obstacle, with no change in the speed of propagation
Refraction	● the bending of sound wave due to change in the speed of propagation ● Example □ when sound waves move from one medium to another
Resonance	● the modification of sound by other sources □ modification of the laryngeal tone predominantly by the nasal and oral cavities
Transmitting medium	● any matter that carries or transmits sound ● air, liquids, & solids can all transmit sound ● the mass and elasticity of a transmitting media affect sound

INTRO TO THE STUDY OF SOUND & ACOUSTIC ANALYSIS OF SPEECH

<u>SOUND WAVE GENERATION & PROPAGATION, p. 93</u>

- Sound propagation needs a medium
- Air, liquid, or gas can serve as a medium
- Two main properties that affect the transmission of sound: mass (density) & elasticity
- Vibratory motion is possible because of elasticity
    - elastic objects get distorted when a force is applied to them, then recover their original form or position
    - as they change form or position, they create waves (vibratory motion)

Term	Definition
Frequency of vibration	● number of times a cycle of vibration repeats itself within a second
Pure tone	● when a tone contains a single frequency
Simple harmonic motion	● results in a tone of single frequency that repeats itself ● AKA sinusoidal motion
Complex tone	● created when two or more single frequency tones of differing frequencies are combined ● the vibrations that make up a complex tone are period or aperiodic ● aperiodic waves are equated with noise
Velocity	● amount of molecular displacement per unit time
Acceleration/deceleration	● change in velocity ● acceleration is also related to direction of movement; when direction changes, velocity changes also
Period	● the amount of time needed for a cycle to be completed
Amplitude	● a measure of the magnitude (intensity, strength) of the sound signal ● in most cases, a measure of amplitude refers to sound pressure ● sound pressure □ amount per unit area, measured in dynes or newtons ● logarithmic scale used to express the intensity range to which the human ear is sensitive□ decibels

<u>FREQUENCY & PITCH, p. 93</u>

- Frequency of vibration is a function of the properties of the vibrating object
- The medium that transmits the sound does not affect the frequency of sound. but it DOES affect the speed of sound
- A more dense medium □ retard the speed of sound transmission more than a less dense medium
- A less dense medium □ propagate sound faster
- A more elastic medium (even if it is more dense) will propagate a sound faster than a less elastic (even if it is less dense) medium

- Variations in frequency of vibration variations in pitch
    - Pitch is a sensory experience related to changes in frequency
    - A sound of higher frequency is perceived as a sound of higher pitch
- The normal human ear of a young adult can respond to 20 Hz-20,000 Hz.

AMPLITUDE & LOUDNESS, p. 94

- Amplitude extent of molecular displacement
- The greater the degree of molecular displacement, the higher the amplitude or intensity of sound
- The higher the amplitude, the greater the perceived loudness of sound
- Human ear sensitive to 130 decibels

SOUND PRESSURE & HEARING LEVEL, p. 94

- Intensity of sound is expressed in terms of decibels at a certain *sound pressure level* (dB SPL)
    - Sound pressure is the sq. root of a power measured in watts
    - Pressure itself is measured in terms of pascals (pa)
- Sounds should reach a certain minimum intensity to stimulate the human auditory system
    - Minimum level Hearing level (HL)
- Intensity of normal conversational speech varies between 50-70 dB SPL
- Very intense sounds exceed 100 dB SPL

INTRO TO ACOUSTIC ANALYSIS OF SPEECH, p. 95

Term	Definition
Sound spectrograph	• an electronic instrument that graphically records the changing intensity levels of the frequency components in a complex sound wave
Spectrogram	• a 3 dimensional display of the running of short-term spectrum • includes time, intensity, & frequency • intensity represented on the "gray scale" (blackness of pattern) • time appears on horizontal axis, from left to right
Process of using a spectrograph to create a spectrogram	• person speaks into a microphone, which transduces the speech sample so that air pressure variations of the acoustic signal are put into the form of voltage variation • the electrical signal is converted to an electromagnetic signal for storage on the magnetic drum of the spectrograph • the stored magnetic pattern is converted back into an electrical signal for analysis as a spectrogram • the signal is then filtered so that one can determine energy in various frequency regions • the current of the electrical signal is amplified and fed to a marking stylus • as the current flows from the stylus to the paper, there is localized burning of the paper; the burning produces a blackening of the paper in proportion to the current
Voice onset time	• the time between the release of the stop consonant and the beginning of the vowel
Voice termination time	• the time required to cease vocal activity

- Vowels are generally easier to analyze acoustically than consonants
    - In normal speakers, vowels are associated with a steady-state acoustic pattern and a steady-state articulatory configuration
    - Vowels often described easily according to the frequencies of the first three formants (F1, F2, F3 frequencies)
    - Fundamental frequency of vowels vary with their height
        - High vowels higher fundamental frequency than low vowels
    - All vowels can be described w/ basically the same acoustic characteristics, such as formant pattern duration
- Consonants are more complex
    - Analyzed according to parameters such as voice onset, time, formant transition (when a vowel follows the consonant), turbulent airflow, etc.