

## English Consonants & Vowels

- Phonetics: a study on speech

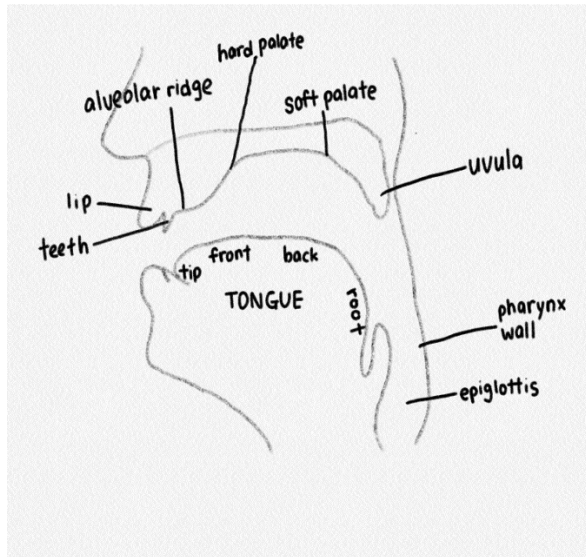
articulatory phonetics (from mouth) → how to produce speech

acoustic phonetics (through air) → how to transmit speech

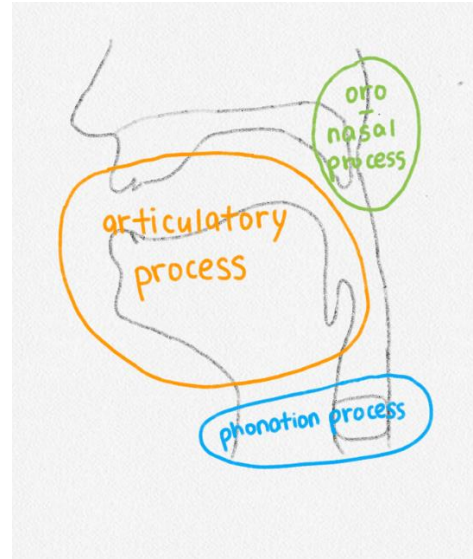
auditory phonetics (to ear) → how to hear speech

## Articulation

- Vocal tract:



- 5 speech organs = constrictors = articulators



## Phonation Process in Larynx

- larynx = voicebox: voiced → can feel vibration

ex. v, z, l, m, a, i

voiceless → can't feel vibration

ex. f, s, k, p, h

## Oro-nasal Process in Velum

- nasal: when velum lowered

ex. m, n, ng

## Articulatory Process

- lips / tongue tip / tongue body

## Control of Constrictors(Articulators)

- Each constrictor needs to be more specific in geometry

constriction location(CL) / constriction degree(CD)

- Constriction location: Lips → bilabial / labiodental

Tongue body → palatal / velar

Tongue tip → dental / alveolar / retroflex / palate-alveolar

- Constriction degree: stops > fricatives > approximants (/r, l, w, j/) > vowels

## How to Produce English Consonants and Vowels

- constrictors(lips, tongue tip, tongue body) / CD / CL / velum / larynx
  - ex) /p/: lips / bilabial / stop / velum raised / larynx open
  - /b/: lips / bilabial / stop / velum raised / larynx closed
  - /d/: tongue tip / alveolar / stop / velum raised / larynx closed
  - /z/: tongue tip / alveolar / fricative / velum raised / larynx closed
  - /n/: tongue tip / alveolar / stop / velum lowered / larynx closed
- \* 모든 모음은 constrictor로서 tongue body 만 사용(constrictor location 정의 X)
- Phonemes: individual sounds that form words
  - a combination of speech organs' actions

## Acoustics

- Praat: duration > select(click and drag on waveform or spectrogram) →
  - read a value (sec.) on the top → zoom in (if not visible)
  - intensity > show intensity → click on green → read a value (dB) on the right
  - pitch > show pitch → pitch setting > pitch range > 65-200Hz male / 145-276Hz female
    - click on blue → read a value (Hz) on the right
  - formant(모음 구별 수치) > show formants → place the cursor on one of the trajectories
    - read a value (Hz) on the left
- the number of occurrences of a repeating event per second (frequency, Hz)
  - repeating event = vibration of vocal folds / repeating > sine wave = pure tone
  - \* sine wave: frequency + magnitude(amplitude) (x 축 시간 / y 축 value, voltage)
- 모든 신호는 단순한 sine wave 들의 합으로 표현된다. (synthesis)
  - complex tone 이 반복하는 주기는 Fundamental Frequency 와 동일
  - spectrum: x 축 frequency / y 축 magnitude(amplitude)
  - spectrogram: spectrum 을 시간으로 visualize 한 것 (x 축 시간 / y 축 frequency)
  - sine wave(time-value graph)→spectrum: spectral analysis
- pure tone→spectral analysis: frequency 가 같은 sine wave 한 개
  - complex tone→spectral analysis: 일정한 간격의 sine wave 여러 개 (간격=pitch)
- (Praat: Spectrum > View Spectrum Slice)
- source: 성대에서 나는 소리 (measured by EGG)
  - human voice source consists of harmonics
  - a complex tone = sum of pure tones at integer multiples of the lowest pure tone
  - the lowest pure tone = fundamental frequency(F0) = rate of vibration of the larynx
    - = the number of opening-closing cycles of the larynx per second
  - amplitude of pure tones gradually decreases
- filter: vocal tract 에 의해서 달라지는 소리
  - filter 의 spectrum → jiggjagging with peaks and valleys (amplitude 의 패턴이 사라짐)
  - peaks/mountains: frequencies VT likes (formants)
  - valleys: frequencies VT does not like

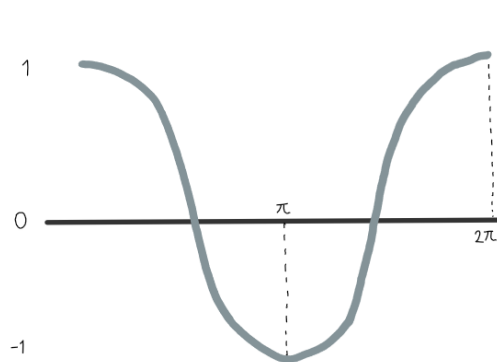


**행렬과 벡터**

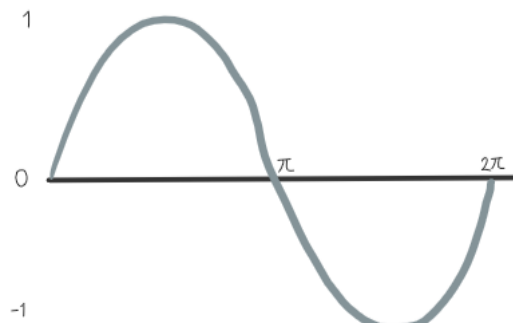
- 이미지, 소리, 텍스트 > 벡터  
모든 데이터는 벡터로 나타낼 수 있음
- 흑백 이미지 > 2 차원 / 컬러 이미지 > 3 차원 / 영상 > 4 차원

**Sound**

- Sinusoidal: cos 이나 sin 과 같은 곡선  
Phasor: sinusoidal 의 function 을 만드는 것
- $\pi$  (무리수)  
 $0 \sim \pi \sim 2\pi$  (radians - sin/cos 의 입력값 /  $\theta$ )  
 $0^\circ \sim 180^\circ \sim 360^\circ$  (degree)
- Phasor:

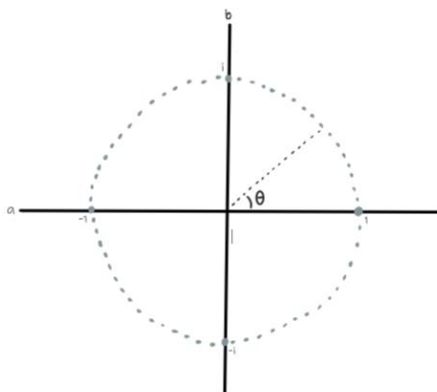


cos 함수



sin 함수

- 오일러 공식:  $f(\theta) = e^{i\theta} = \cos(\theta) + \sin(\theta)i$   
 $e = 2.71...$  (무리수)  
 $i = \text{imaginary}$  (허수,  $\sqrt{-1}$ )  
복소수 =  $a + bi$  (모든 수 표현 가능) >  $f(\theta)$   
 $\theta = 0 > f(0) = e^0 = 1$   
 $\theta = \frac{\pi}{2} > f(\frac{\pi}{2}) = \cos(\frac{\pi}{2}) + \sin(\frac{\pi}{2})i = i$   
 $\theta = \pi > f(\pi) = \cos(\pi) + \sin(\pi)i = -1$   
 $\theta = \frac{3\pi}{2} > f(\frac{3\pi}{2}) = \cos(\frac{3\pi}{2}) + \sin(\frac{3\pi}{2})i = -i$



복소평면 (complex plane): a 실수 / b 허수

Projection: x 축(a)에서 볼 때 > 허수(sin 그래프)

y 축(b)에서 볼 때 > 실수(cos 그래프)

- sin 과 cos 음의 같음 (sin 그래프와 cos 그래프는  $\frac{\pi}{2}$ 의 차이)

인간의 귀는 phasor shift 는 구별하지 못함 / frequency 의 차이만 구별

## Linear Algebra

- 인공지능: 데이터(vector) > 기계(행렬) > 데이터(vector) / 행렬의 곱

$$\begin{array}{ccccccc} & & -1 & 0 & 2 & & \\ -5 & 3 & 0 & 1 & \times & \begin{bmatrix} 0 & 1 & 3 \\ 3 & -5 & 7 \\ 2 & 3 & 4 \end{bmatrix} & = & \begin{bmatrix} -3 & 6 & 23 \end{bmatrix} \end{array}$$

1x4

4x3

1x3

행렬의 곱 계산법:  $5*(-1) + 3*0 + 0*3 + 1*2 = -3$

$$5*0 + 3*-1 + 0*-5 + 1*3 = 6$$

$$5*2 + 3*3 + 0*7 + 1*4 = 23$$

- Matrices:  $\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}$  (m 행 n 열 / m by n 행렬)

- Vector:  $\begin{bmatrix} a_1 \\ \vdots \\ a_m \end{bmatrix}$  (m by 1 행렬 / column vector)

$a_m$

$[a_1 \dots a_n]$  (1 by n 행렬)

- Vector Spaces: linear combinations still stay in the space

Linear Combinations:  $c*v + d*w$  (c, d: scalars / v, w: vectors)

$R^n$  space consists of all vectors with n components (차원의 모든 공간 / 일부분 X)

- Column Space:  $A = \begin{bmatrix} 2 & -1 \\ 1 & 3 \end{bmatrix}$  > (2, 1) (-1, 3)을 linear combination 하면 모든 공간을 채움  
column vector 가 column space 를 채움

col1 & 2 not on a line > independent

: Whole Space(vector 가 속해있는 space) = Column Space = 2 차원

$$A = \begin{bmatrix} 2 & -1 \\ 1 & -0.5 \end{bmatrix} > (2, 1) (-1, -0.5)$$

col1 & 2 on a line > dependent

: Whole Space = 2 차원 / Column Space = 1 차원

dim(whole space) = n rows / dim(column space) = n of independent columns

$$A = \begin{bmatrix} 1 & 3 & -2 \\ 2 & 3 & 0 \\ 4 & 1 & 5 \\ 1 & 2 & -2 \end{bmatrix}$$

> Whole Space = Column Space = 3 차원

$$A = \begin{bmatrix} 2 & 4 & 0 \\ 4 & 8 & 5 \end{bmatrix}$$

> Whole Space = 3 차원 / Column Space = 2 차원

$$(2*Col1 = Col2)$$

$$A = \begin{bmatrix} 1 & 1 & 2 \\ 2 & 1 & 3 \\ 4 & 1 & 5 \end{bmatrix}$$

> Whole Space = 3 차원 / Column Space = 2 차원

$$(Col1 + Col2 = Col3)$$

$$A = \begin{bmatrix} 1 & 2 & 4 \\ 2 & 4 & 8 \\ 4 & 8 & 16 \end{bmatrix}$$

> Whole Space = 3 차원 / Column Space = 1 차원

$$(2*Col1 = Col2 / 2*Col2 = Col3)$$

$$A = \begin{pmatrix} 1 & 3 \\ 2 & 3 \\ 4 & 1 \end{pmatrix} > \text{Whole Space} = 3 \text{ 차원} / \text{Column Space} = 2 \text{ 차원}$$

(independent 한 column 2 개)

$$A^T = \begin{pmatrix} 1 & 2 & 4 \\ 3 & 3 & 1 \end{pmatrix} \text{ (transpose)} > \text{Whole Space} = 2 \text{ 차원} / \text{Column Space} = 2 \text{ 차원}$$

(Column Space 는 Whole Space 보다 차원이 클 수 없음)

- Four spaces in a matrix: two whole spaces  $R^m / R^n$

$$A = \begin{pmatrix} 1 & 2 \\ 2 & 3 \\ 4 & 6 \end{pmatrix} > \text{Whole Space(column)} = 3 \text{ 차원} / \text{Whole Space(row)} = 2 \text{ 차원}$$

Column Space = 1 차원 / Row Space = 1 차원

Independent 한 column/row 의 개수: rank (column 과 row 의 rank 는 같음)

Null Space: Whole Space 에서 사용하지 않는 차원

$$A_x = \begin{pmatrix} 1 & 2 \\ 2 & 3 \\ 4 & 6 \end{pmatrix} * \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} > \text{null space} \begin{pmatrix} 0 & 2 & -2 & 1 \\ 0 & -1 & 1 & -\frac{1}{2} \end{pmatrix} \dots$$

- Linear Transformation:  $A * x = b$  (기계 \* 출력 = 입력)

- Detransformation: Inverse matrix

$$A^{-1} * b = x$$

dependent column &gt; not invertible

- Eigenvector: transformation 후 원점과 일직선 상에 있는 vector

$$Av = b \text{ (A transforms v to b)}$$

among all v, some v is parallel to Av &gt; That v is eigenvector

- 상관 관계(correlation): 두 개의 변수가 비례하는 관계

$$-1 \leq r \leq 1$$

$$\cos \Theta = r$$

- inner product: 벡터 A, B >  $A * B$  를 모두 더한 값