

# MUSIC, LANGUAGE, INTELLIGENCE AND THE BRAIN:

## THEORY, RESEARCH FINDINGS AND PRACTICAL APPLICATIONS FOR EARLY INTERVENTION

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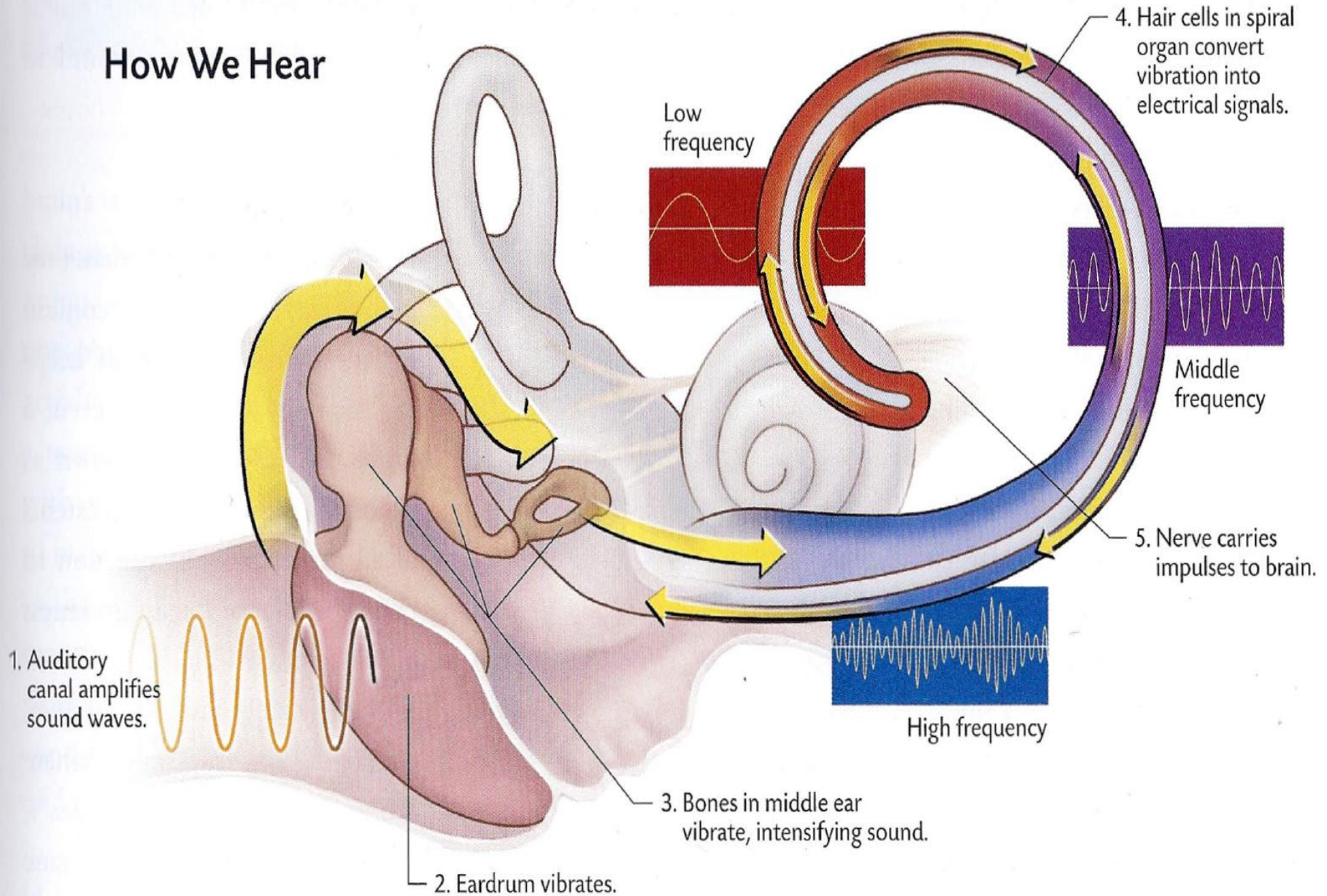
Infant Support Services

EHDI Conference 2011

February 21<sup>st</sup>, 2011

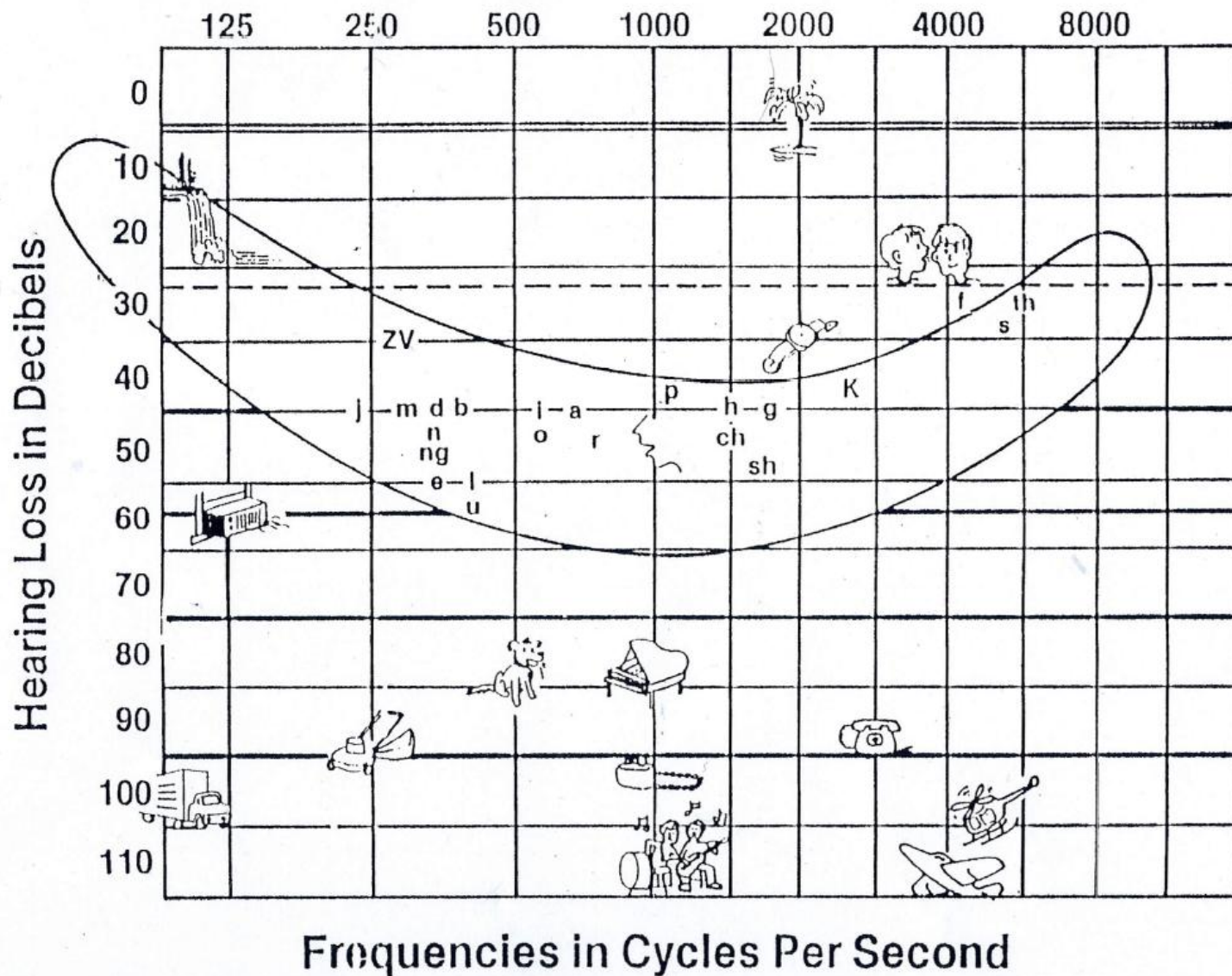
**Review**

# How We Hear

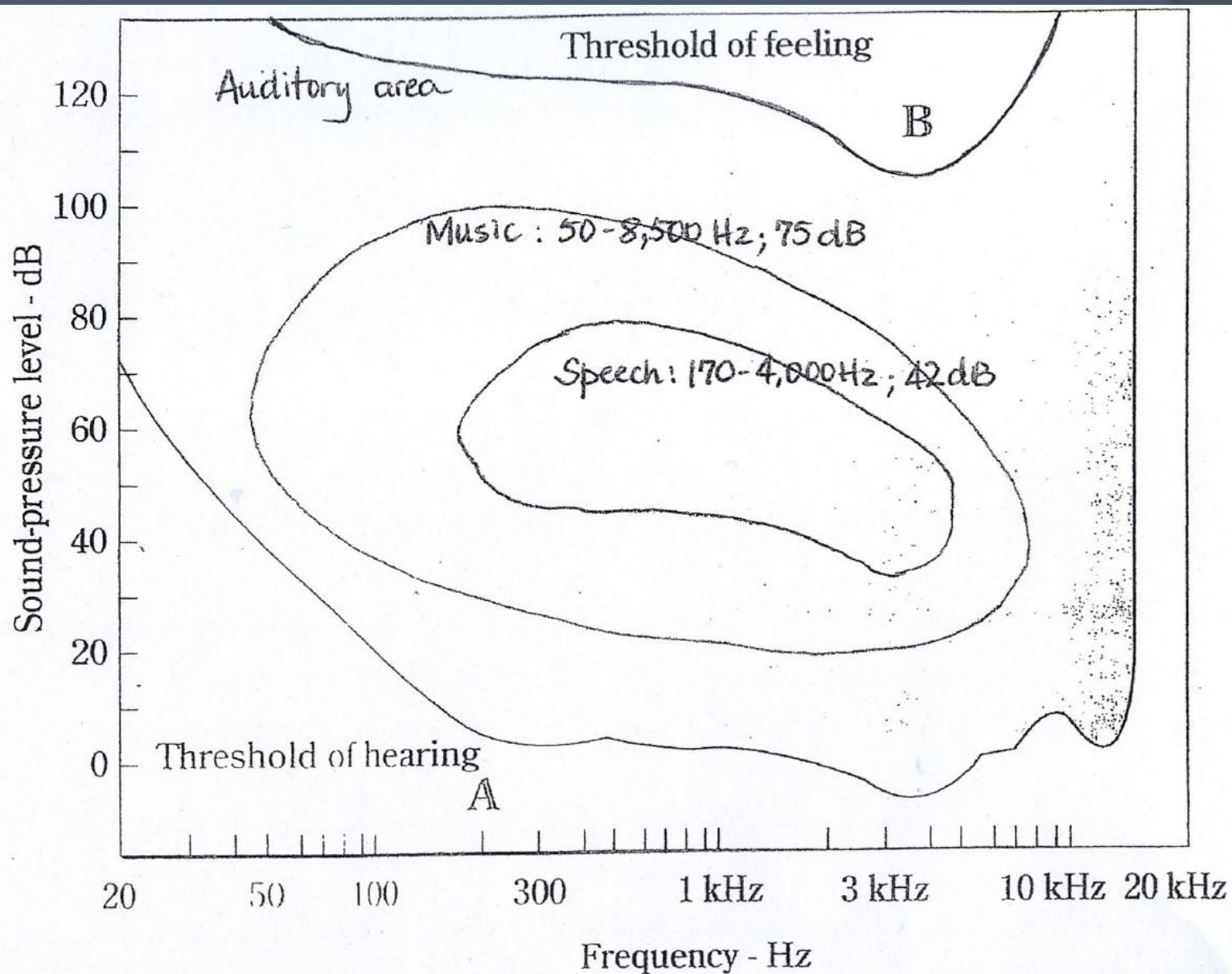


Sound waves are converted in the ear to nerve impulses that are carried to the brain's auditory center.

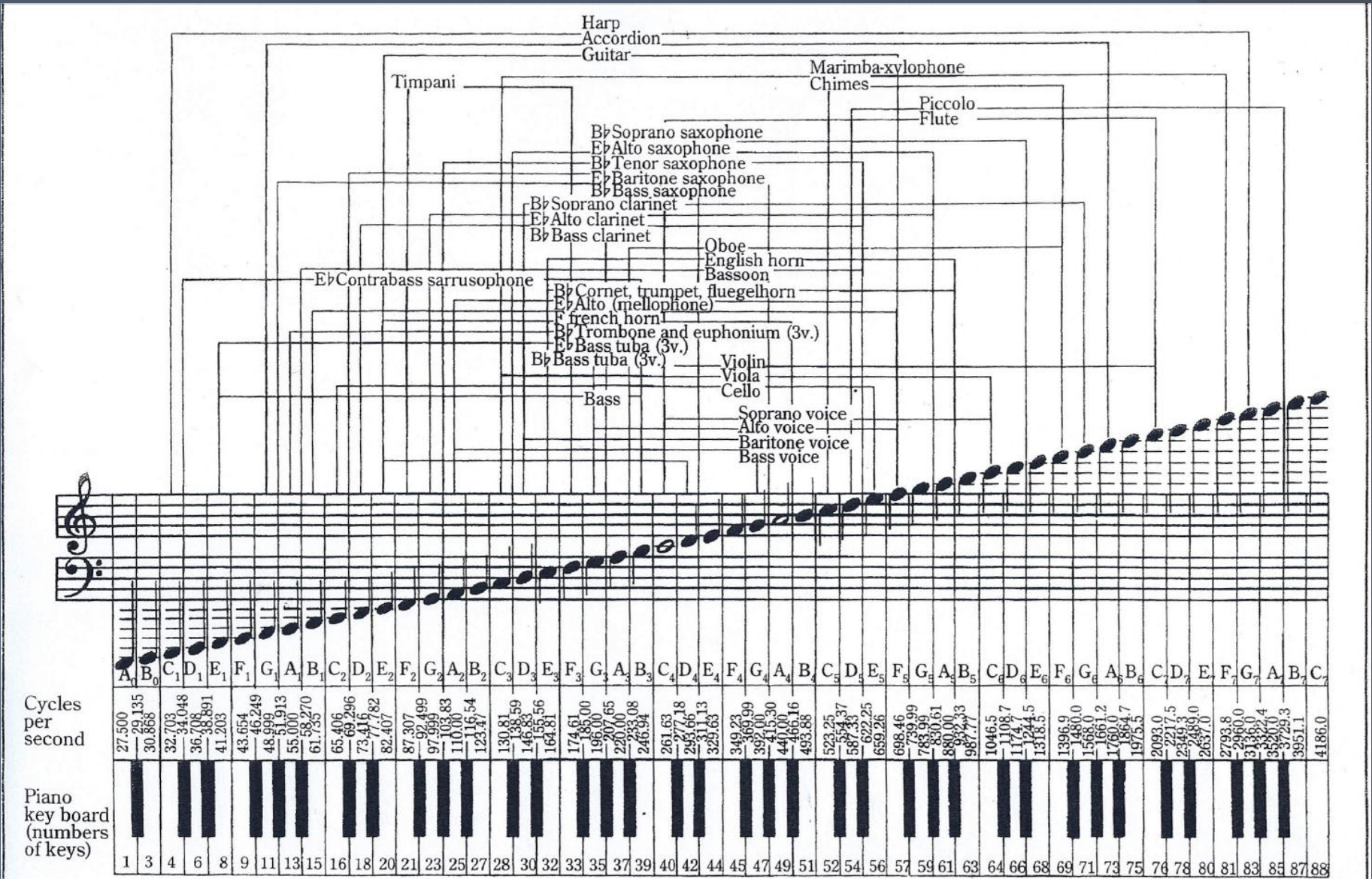
# Comparison of the Frequency and Intensity of Various Environmental and Speech Sounds



# Area of Audibility



# Audible frequency range of various instruments & voices



Language  
&  
Music

# Language & Music: Similarities 101

- A. Characteristic to human species that seem to be universal to all humans and specific to humans:
  1. Universal: humans have a general capacity to acquire linguistic and musical competence
  2. Specific: no parallel in animal world
- B. Capable of generating an unlimited number of novel sequences



# Language & Music: Similarities 102

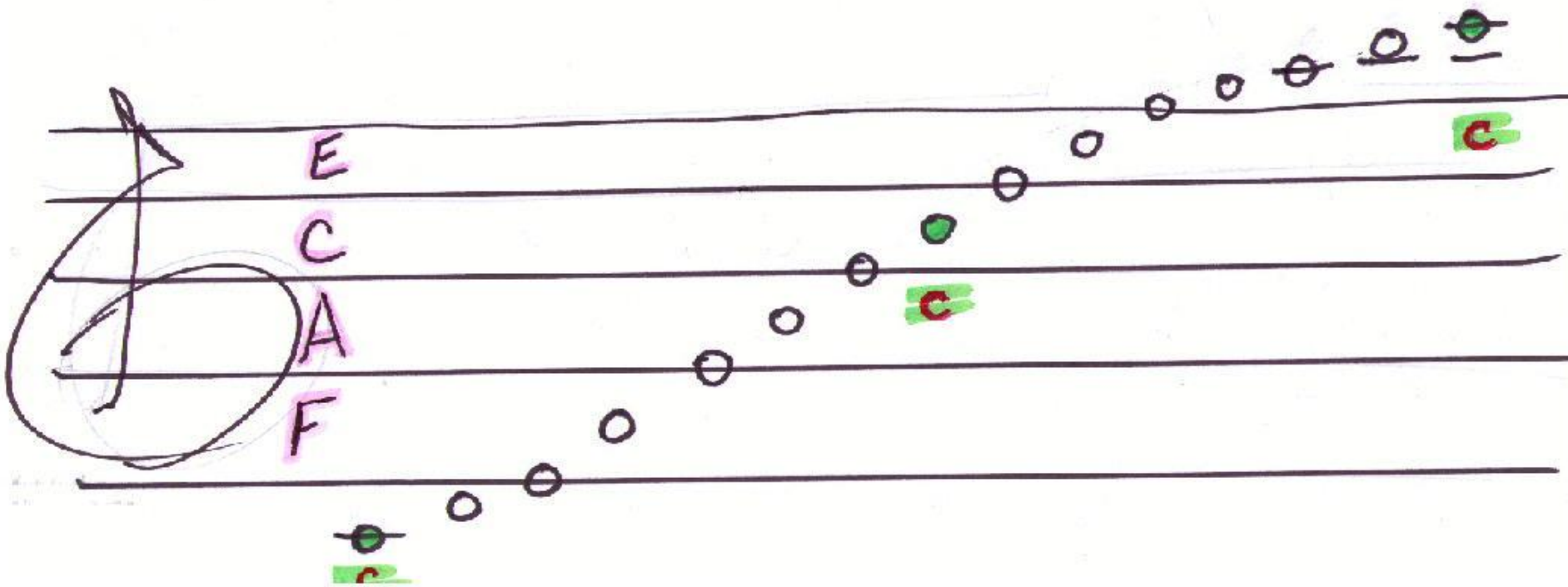
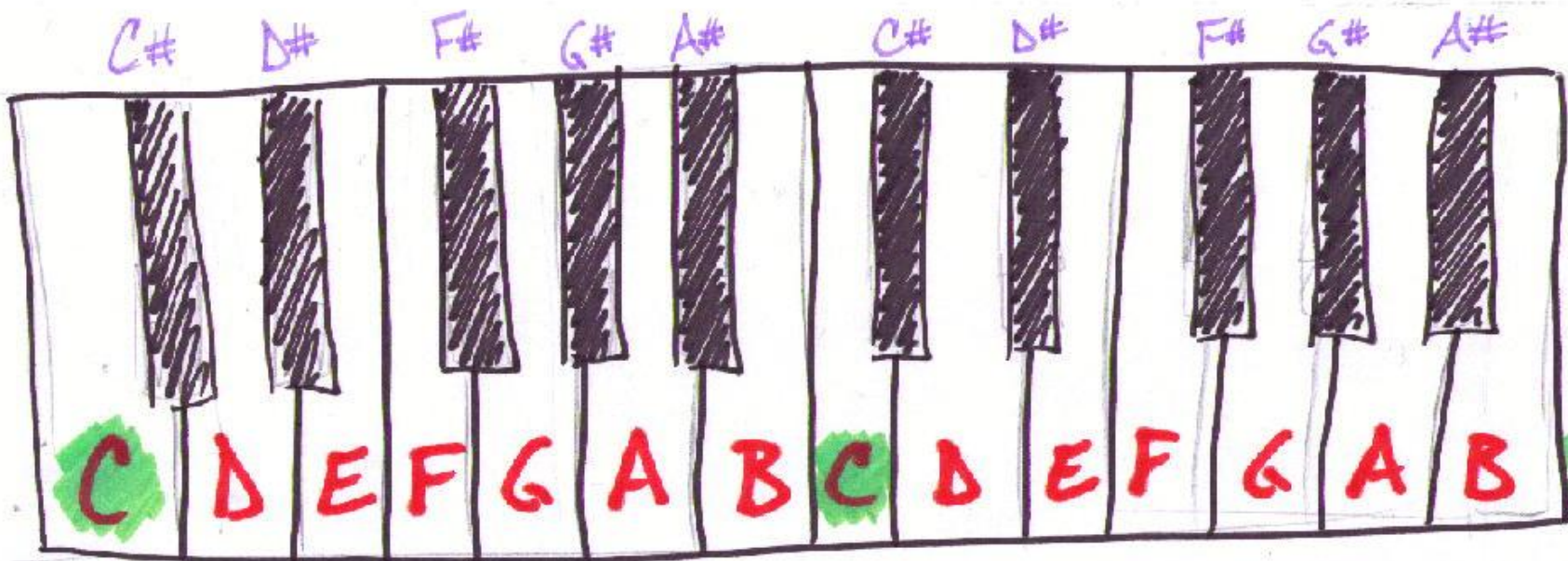
- c. Children seem to have a natural ability to learn the rules of language & music through exposure to examples
  1.  $\pm 1$  to  $\pm 2$  years of age: Spontaneous speech and spontaneous singing are first exhibited around the same age
  2.  $\pm 2$  to  $\pm 5$  years of age: Language develops through intermediate forms of grammar
  3.  $\pm 5$  years of age: Adult grammar

# Language & Music: Similarities 103

- D. Natural medium for both is Auditory-Vocal (Aud-Voc)
  1. Both are primarily received as sequences of sounds and produced as sequences of vocal movements which create sounds
  2. Many neural mechanisms for analyzing input and producing output must be shared
  3. Most universal of all musical forms is the SONG: words & music are intimately combined

# Language & Music: Similarities 104

- E. Although Aud-Voc mode is primary, many cultures have developed written form
  1. Notational system using written symbols in visual form to convey message
  2. Message is retrieved and decoded by receiver
  3. Reading & writing is usually taught *after* person is competent user of Aud-Voc mode
  4. Acquisition of literacy profoundly alters cognitive functioning



## 小燕子 Xiǎo yàn zi

小燕子 穿花衣 年年春天 来这里 我问燕子你  
xiǎo yàn zi chuān huā yī nián nián chūn tiān lái zhè lǐ wǒ wèn yàn zi nǐ

为啥来 燕子说 这里的春天 最美丽 小燕子  
wèi shá lái yàn zi shuō zhè lǐ de chūn tiān zuì měi lì xiǎo yàn zi

告诉你 今年这里 更美丽 我们盖起了大工厂  
gào su nǐ jīn nián zhè lǐ gèng měi lì wǒ men gài qǐ le dà gōng chǎng

装上了新机器 欢迎你 长期 住在这里  
zhuāng shàng le xīn jī qì huān yíng nǐ cháng qī zhù zài zhè lǐ

## 小燕子

3̣5̣ 1̣6̣5̣ - | 3̣5̣ 6̣1̣5̣ - | 1̣. 3̣2̣1̣ | 2̣1̣ 6̣1̣5̣ - | 3̣. 5̣6̣5̣6̣ | 1̣2̣5̣6̣ - |

小燕子，穿花衣，年年春天来这里，我问燕子你为啥来。

3̣2̣1̣2̣ - | 2̣2̣3̣5̣5̣ | 1̣2̣3̣5̣ - | 3̣5̣ 1̣6̣5̣ - | 3̣5̣ 6̣1̣5̣ - | 1̣. 3̣2̣1̣ |

燕子说，这里的春天最美丽。小燕子，告诉你，今年这里

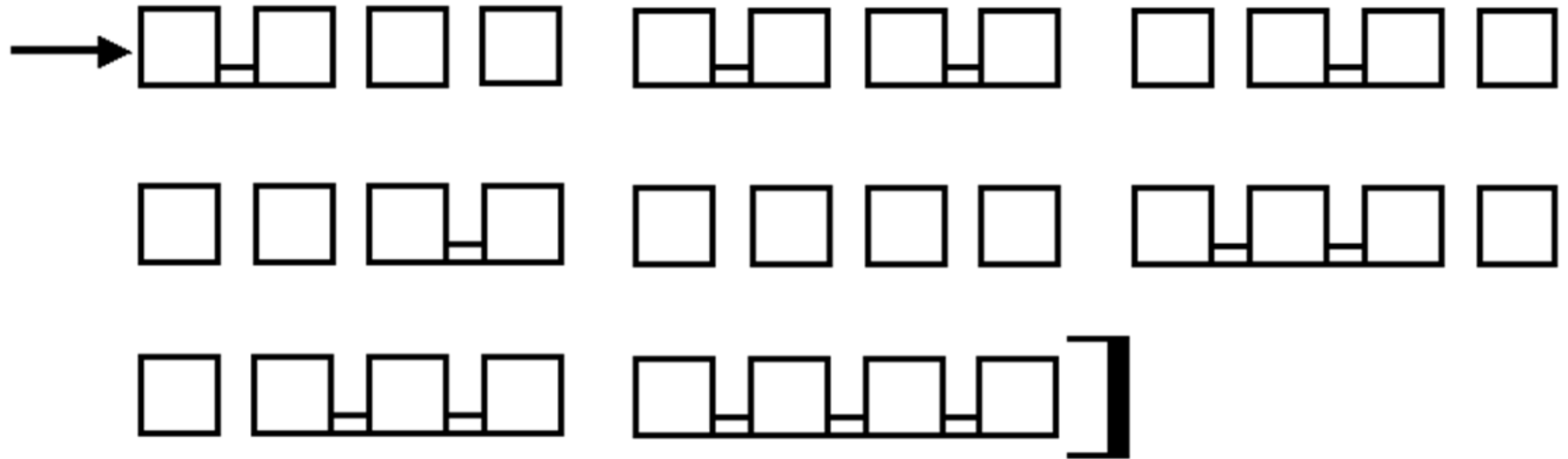
2̣1̣ 6̣1̣5̣ - | 3̣. 5̣6̣5̣6̣ | 1̣2̣5̣6̣ - | 3̣. 1̣6̣5̣ | 3̣2̣1̣2̣ - | 2̣. 3̣5̣ -<sup>6</sup><sub>3</sub>

更美丽。我们盖起了大工厂，装上了新机器。欢迎你

1̣. 3̣2̣1̣ | 2̣1̣5̣6̣1̣ - ||

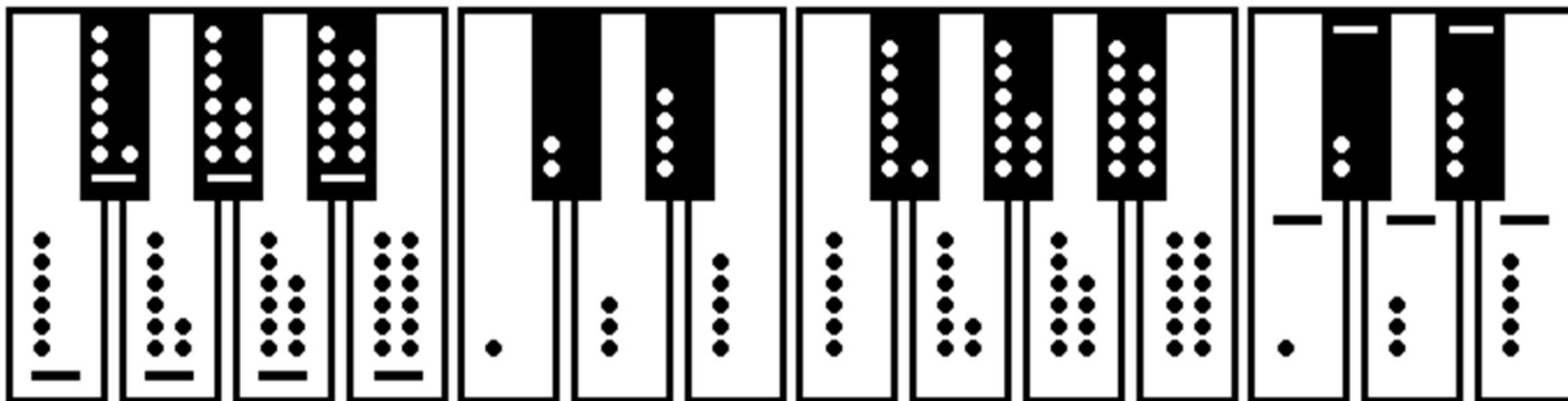
长期住在这里

# Numerofonía 3



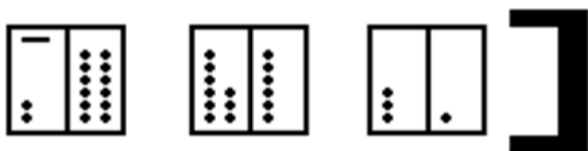
(mantener un pulso regular y constante)  
(no cortar la emisión del sonido anexado)

# Teclado en relieve



# Tactofonía de Aschero para ciegos:

## Escritura en relieve



Los puntos indican la altura del sonido



# Language & Music: Similarities 105

- F. Receptive skills precede productive skills in development
- G. Forms taken by natural language & natural music differ across cultures, but some universal features constrain these forms
  1. Native English speaker cannot understand Chinese
  2. Role of Language: to express thought

# Language & Music: Similarities 106

- H. Language & Music are both comprised of 3 components:
1. Phonology: way of characterizing the basic 'sound' units
  2. Syntax: rules governing the way in which 'sound' units are combined
  3. Semantics: way in which meaning is assigned to 'sound' sequences

# Phonology

## Language

- ◎ Phonemes: c-a-t
  - Can be thought of certain sound patterns, with certain frequency and duration parameters
  - Specific cultures have specific sound patterns
  - Produced by characteristic combination of lip, tongue and vocal chord motion

## Music

- ◎ Note: do-re-mi or C-D-E
  - Characterized by frequency and duration parameters – these parameters tend to be broader in music than language
  - Different cultures choose different subsets of possible notes for their music (ie. Pentatonic scale)
  - Produced by vocal, body or instruments

# Syntax

## Language

- ⦿ Grammar
  - Structural unit: ie. Agent + active verb + recipient
  - Prominence contour: assign stress, timing, intonation to a sentence
- ⦿ Recipient/Listener can sort utterance into acceptable & unacceptable categories: culture & period specific

## Music

- ⦿ Grammar
  - Structural unit: Musical phrase
  - Prominence contour: chords and duration
    - Harmony, tonality
    - Rhythm, meter
    - Melody
    - Repetition
- ⦿ Acceptable & unacceptable music: culture & period specific

# Semantics

## Language

- ◉ Individual word meanings: lexical semantics
- ◉ Word meanings in combination: compositional semantics

## Music

- ◉ Musical meaning – 4 aspects:
  - Emerging from mimicry
  - Arising from suggestion of a particular mood
  - Resulting from extra-musical associations (ie. national anthem)
  - Attributed to interplay of formal structures in creating patterns of tension and resolution

# Developmental Sequence

## Language

- Turns towards source of sound
- Babbling
- Use of suprasegmentals to convey meaning (ie. displeasure, question, etc)
- Syllabic approximation
- Jargoning & 1<sup>st</sup> words: made-up or approx. of true words

## Music

- Turns towards source of sound
- 1<sup>st</sup> signs of intentional music-like behavior: mimic the intonational contours of speech – microtonal pitch glides
- ±18 mos: discrete pitch intervals; beginnings of spontaneous singing

# Mary Had a Little Lamb

---

Mary had a little lamb,  
Little lamb,  
Little lamb,  
Mary had a little lamb  
It's fleece as white as snow



# Fundamental Building Blocks

## Language

- ◉ Duration (rhythm)
- ◉ Intensity (stress)
- ◉ Pitch (Intonation)

## D.I.P.

## Music

- ◉ Tone (what you hear) or Note (what you see written in musical score)
- ◉ Pitch
- ◉ Rhythm: duration of notes/pauses
- ◉ Tempo: speed
- ◉ Contour: shape of melody – “up” or “down”
- ◉ Timbre: piano vs. saxophone
- ◉ Loudness/dynamics
- ◉ Spatial location: direction of sound source
- ◉ Reverberation



# John Jacob Jingleheimer Schmidt

---

John Jacob Jingleheimer Schmidt

His name is my name, too

Whenever we go out, the people always shout

There goes John Jacob Jingleheimer Schmidt

DA-DA-DA DA-DA-DA-DA

## Suggestions:

- repeat softer each time, with very loud DA-DA-DA
  - Hunch down a little bit more as song grows softer; stand straight again for DA-DA-DA
- 



# Ô Man Chê Chê

---

Ô man chê chê (echo)

Chê chê co lê (echo)

Che co lisa (echo)

Lisa lisa manga (echo)

Suggestion:

- Every person that goes to the center of the circle sings in a different way and does different motions while all others imitate.



# The Grammars of Music and Language

## Language

- Phoneme: d-o
- Morpheme: smallest linguistic unit that has semantic meaning (ie. un-; dis-; -s/-es;)
- Word
- Clause
- Sentence
- Piece

## Music

- Note
- Motif: short rhythmic or melodic passage that is repeated or evoked in various parts of a composition
- Phrase
- Section
- Movement
- Piece

# A Whole New World

From Walt Disney's *Aladdin*



Music by ALAN MENKEN  
Lyrics by TIM RICE

Sweetly  
D  
ALADDIN:

I can show you the world,  
shin - ing, shim - mer - ing,

splen - did. Tell me prin - cess, now when did you last

let your heart de - cide? I can o - pen your

eyes take you won - der by won - der o - ver, side - ways and

un - der on a mag - ic car - pet ride. A whole new

world a new fan - tas - tic point of view.

No - one to tell us no or where to go or

# Nesta Rua

---

Nesta rua, nesta rua tem um bosque  
Que se chama, que se chama Solidão  
Dentro dele, dentro dele mora um anjo  
Que roubou, que roubou meu coração

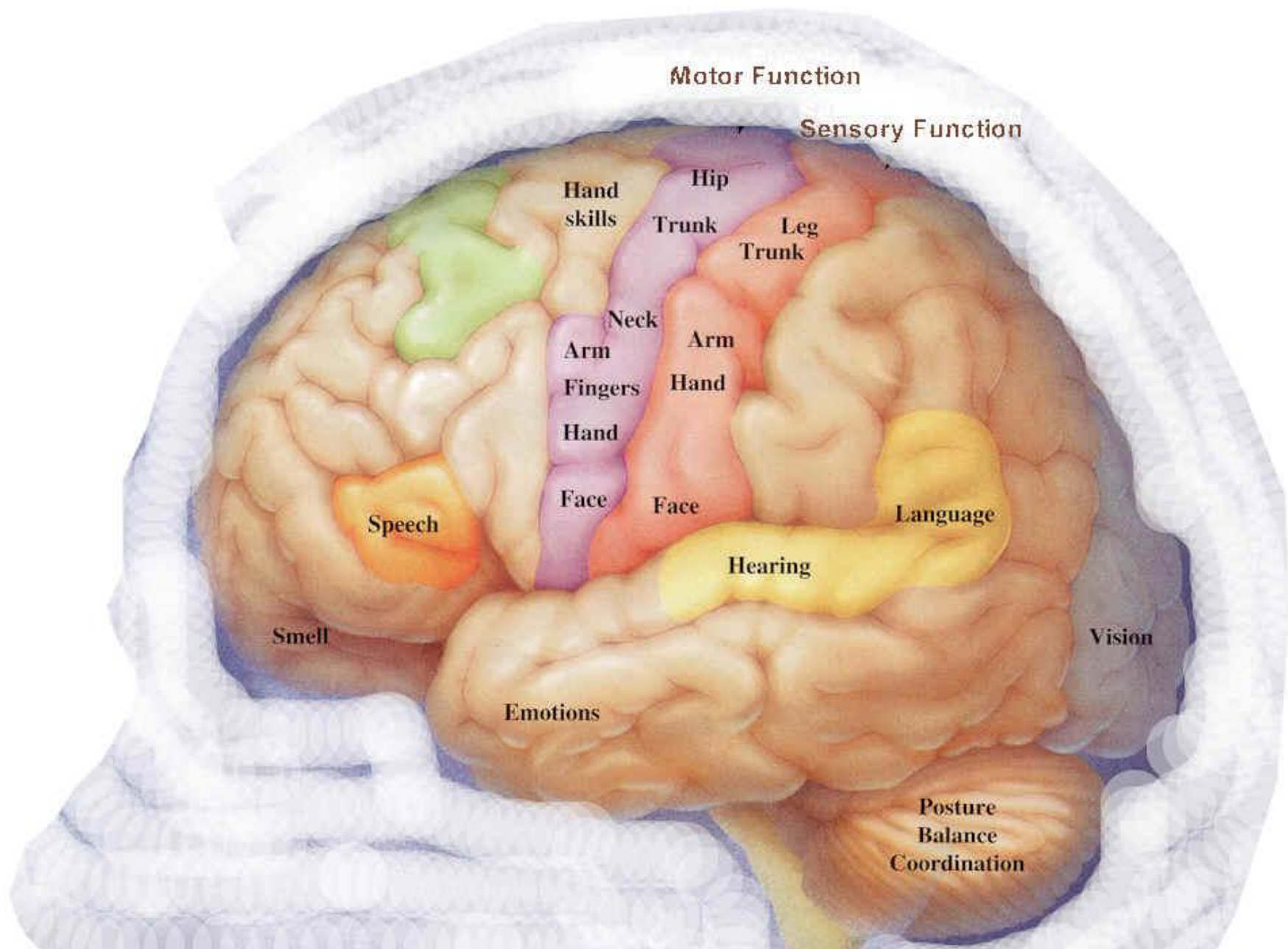
Se eu roubei, se eu roubei teu coração  
É porque tu roubaste o meu também  
Se eu roubei, se eu roubei teu coração  
É porque, é porque te quero bem

Se esta, se esta rua fosse minha  
Eu mandava, eu mandava ladrilhar  
Com pedrinhas, com pedrinhas de brilhante  
Para o meu, para o meu amor passar

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# The Brain



# Laterization of Brain Functions

## Left Hemisphere Functions

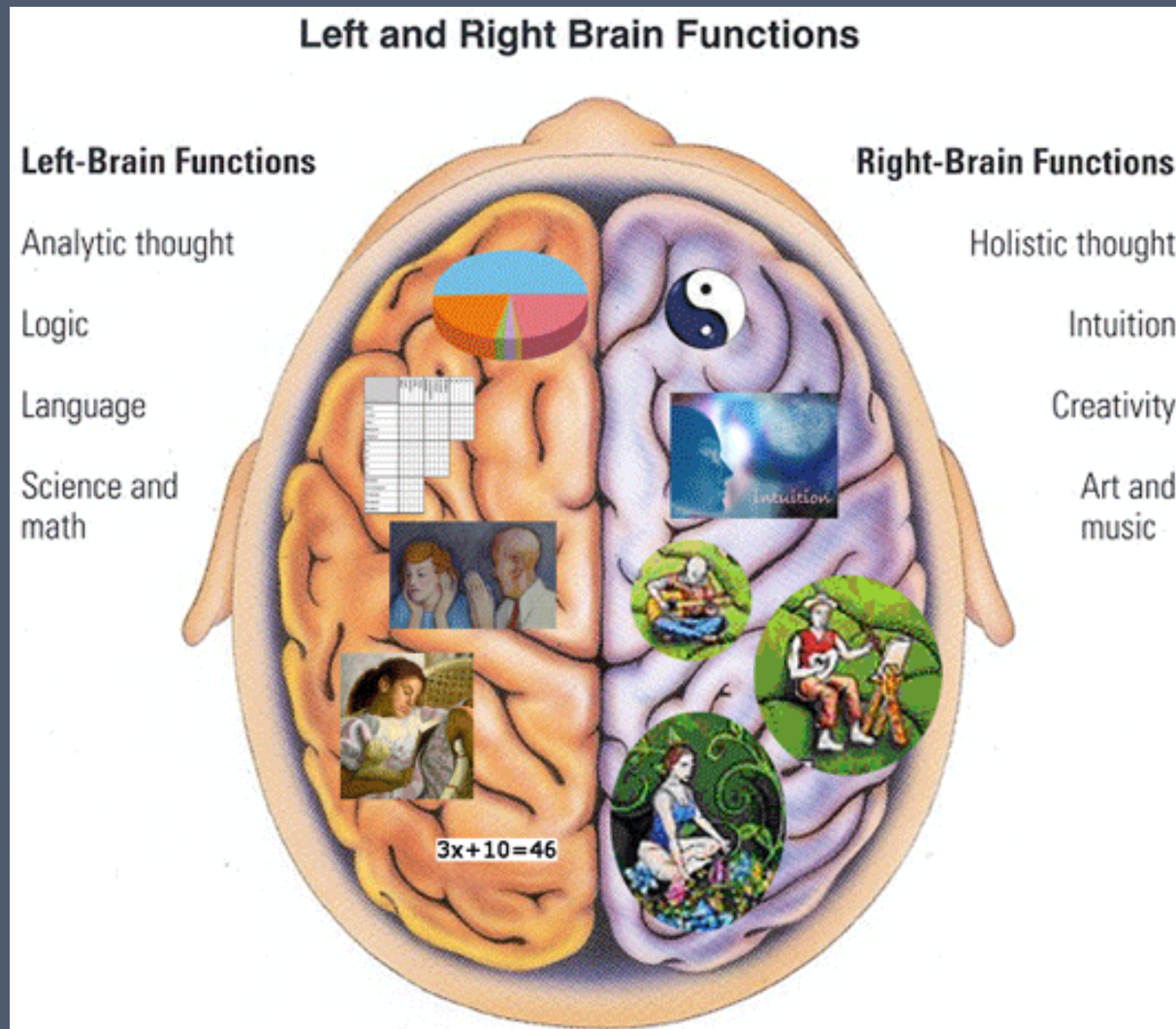
- Uses logic
- Detail oriented
- Facts rule
- Rational
- Reality based
- Safe
- Practical
- Analytical
- Forms strategies
- Order/pattern perception
- Objective
- Language: grammar, vocabulary; literal

## Right Hemisphere Functions

- Uses feeling
- “Big picture” oriented
- Imagination rules
- Intuitive
- Fantasy based
- Impetuous
- Risk taking
- Holistic synthesizing
- Presents possibilities
- Spatial perception
- Subjective
- Language: prosodic features (intonation, accentuation)



<http://www.glittra.com/yvonne/neuropics/leftright.gif>



# Language in brain

What happens in brain when you  
- read?  
- listen to speech?  
- speak?

Which brain regions are activated?  
In which order and how quickly?  
Which areas are connected?

## Simplified model of language processing in brain

When you read, listen to speech, or speak, a network of thousands of neurons is activated in your brain. This figure gives an overview of brain regions that have been suggested to participate in various stages of language processing.

### Reading text

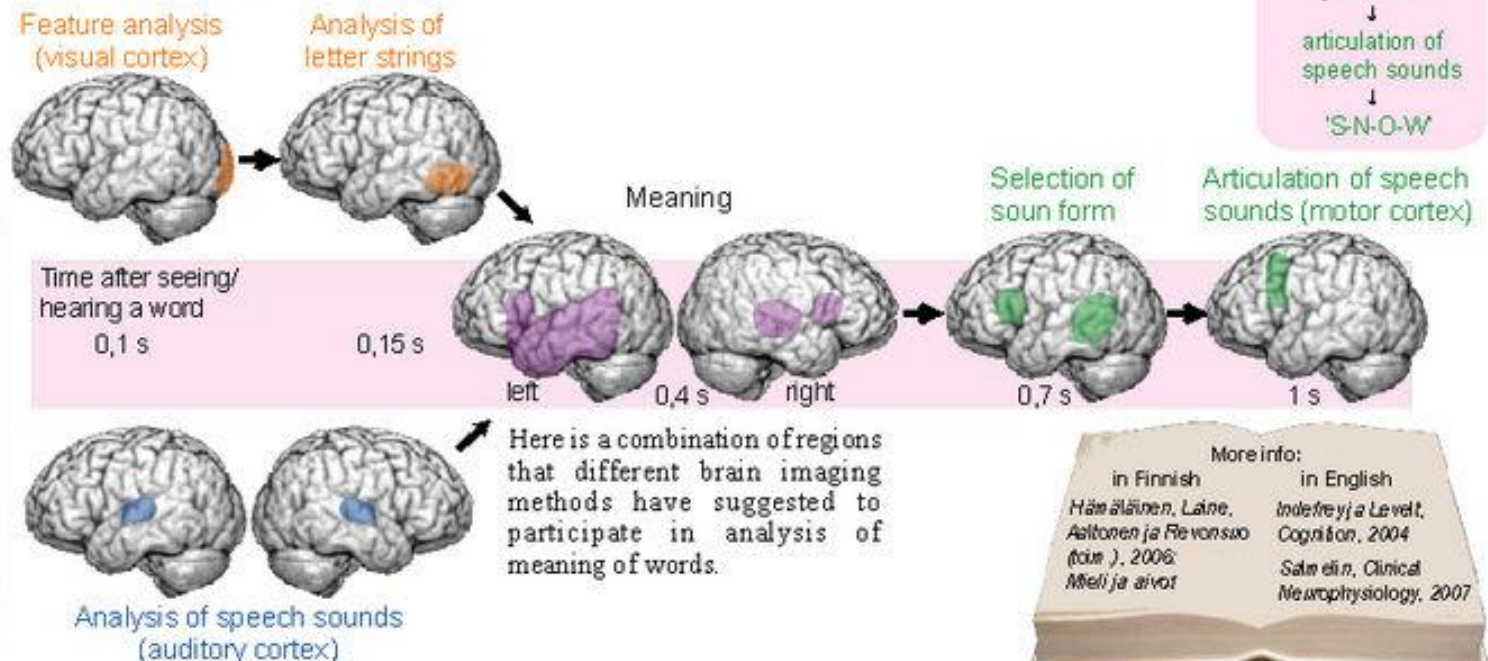
'SNOW'  
↓  
feature analysis  
↓  
individual letters  
↓  
whole word  
↓  
meaning  
↓  
sound form

### Understanding speech

'S-N-O-W'  
↓  
acoustic analysis of sound waves  
↓  
recognition of speech sounds  
↓  
recognition of word form  
↓  
meaning

### Speaking

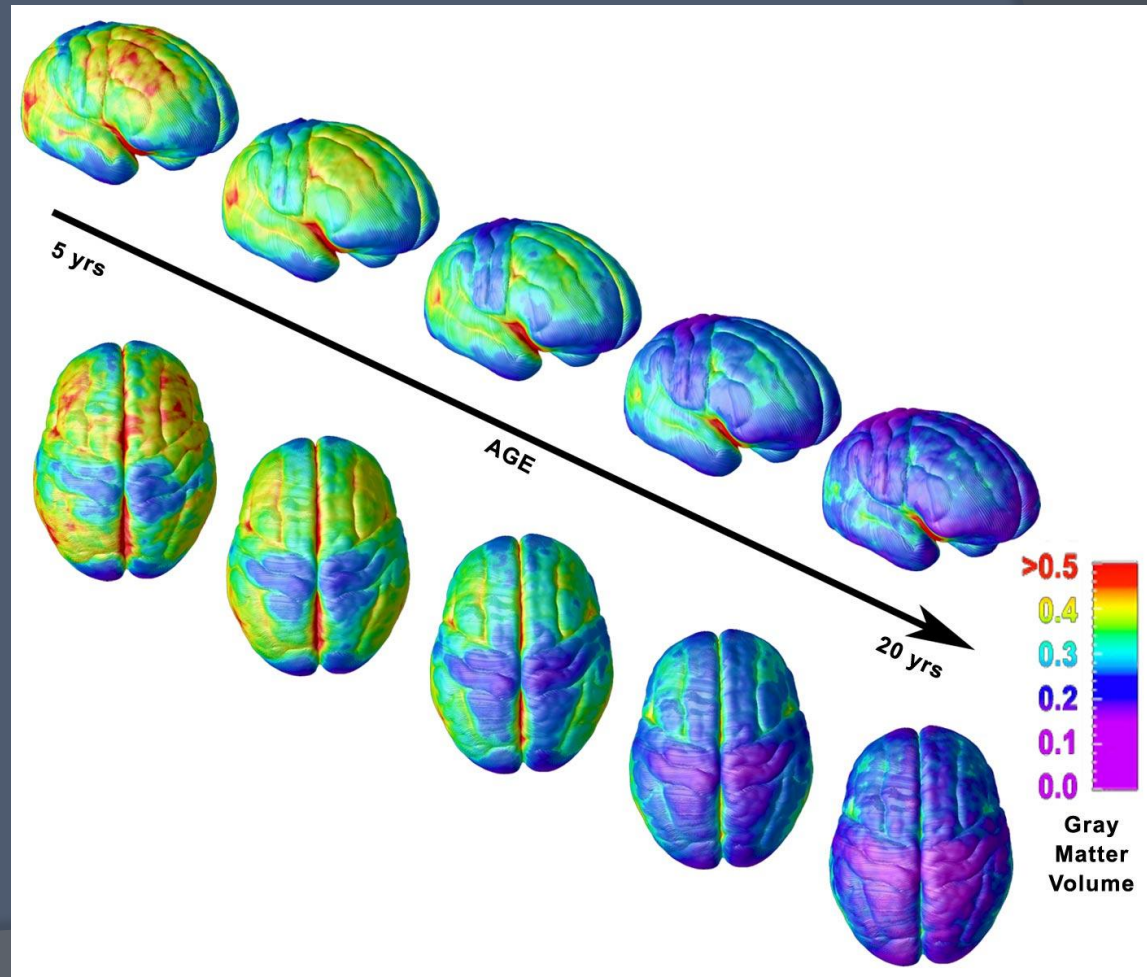
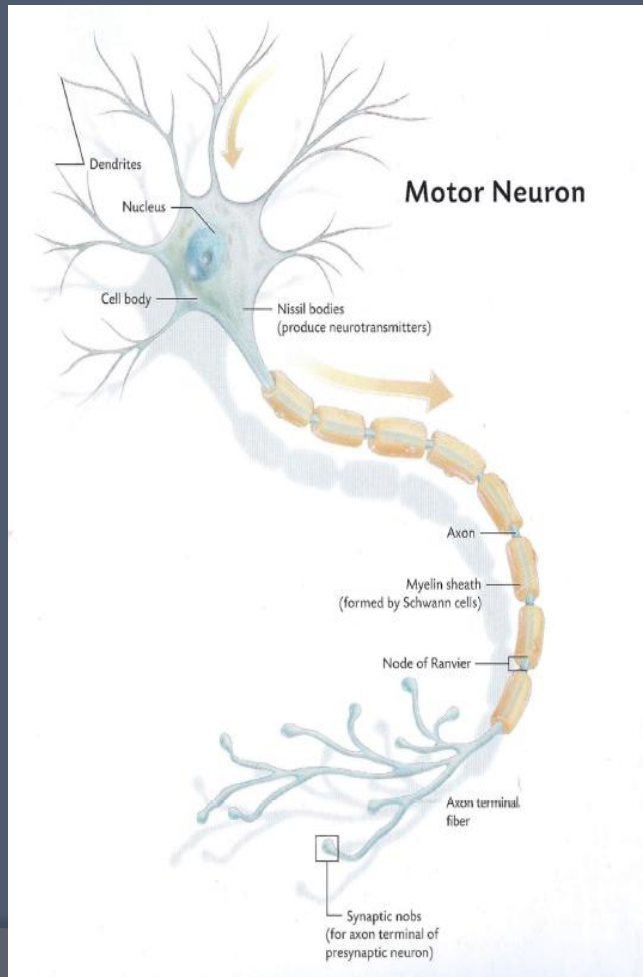
meaning  
↓  
selection of sound form  
↓  
syllabification  
↓  
articulation of speech sounds  
↓  
'S-N-O-W'



# How Music Affects Intelligence 101

## ● Connections in the brain

- [http://www.loni.ucla.edu/~thompson/DEVEL/5to20\\_NormalDevelopment.jpg](http://www.loni.ucla.edu/~thompson/DEVEL/5to20_NormalDevelopment.jpg)



# How Music Affects Intelligence 102

- ◎ General Coordination Skills – mental and physical coordination
  - Playing drums: Left and Right hand keep different beats
  - “Rhythmic auditory cueing has also been shown to be effective in facilitating movements, such as walking, in those with neurological disorders.” (Thaut, 2007 as referenced in Chen et al, 2009)

## Music on the mind

When we listen to music, it's processed in many different areas of our brain. The extent of the brain's involvement was scarcely imagined until the early nineties, when functional brain imaging became possible. The major computational centres include:

### CORPUS CALLOSUM

Connects left and right hemispheres.

### MOTOR CORTEX

Movement, foot tapping, dancing, and playing an instrument.

### PREFRONTAL CORTEX

Creation of expectations, violation and satisfaction of expectations.

### NUCLEUS ACCUMBENS

Emotional reactions to music.

### AMYGDALA

Emotional reactions to music.

### SENSORY CORTEX

Tactile feedback from playing an instrument and dancing.

### AUDITORY CORTEX

The first stages of listening to sounds. The perception and analysis of tones.

### HIPPOCAMPUS

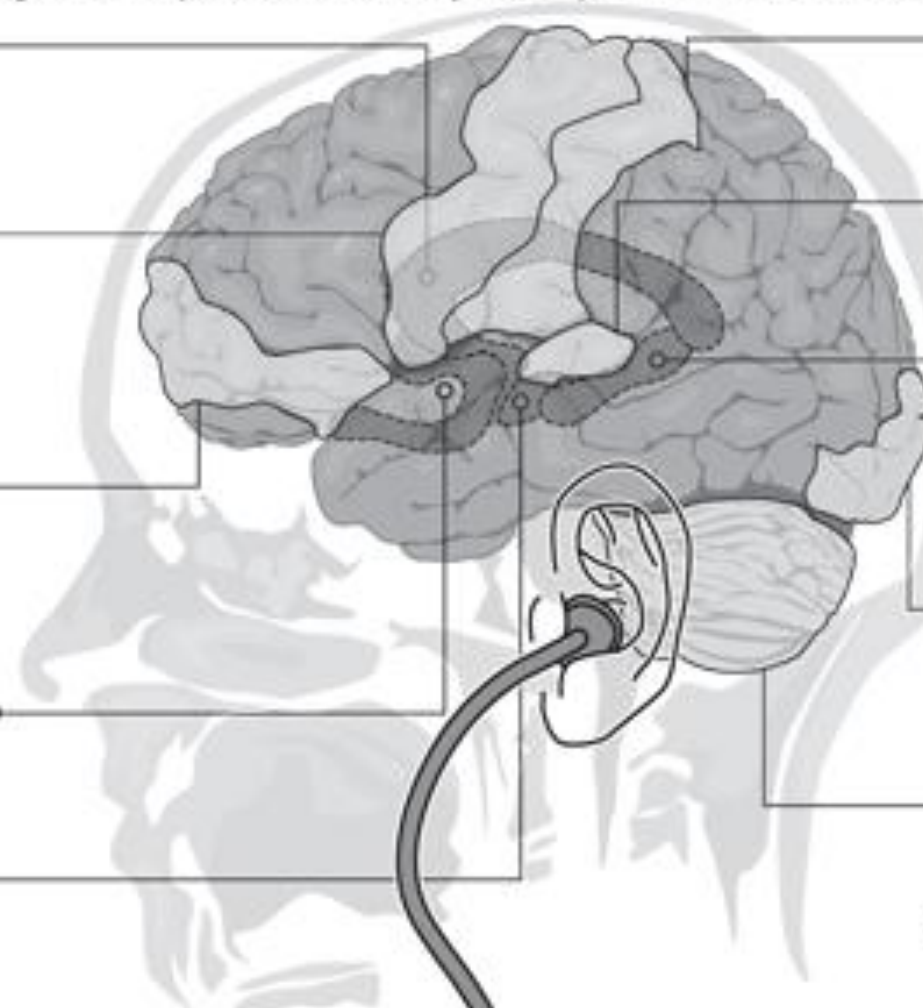
Memory for music, musical experiences and contexts.

### VISUAL CORTEX

Reading music, looking at a performer's or one's own movements.

### CEREBELLUM

Movement such as foot tapping, dancing, and playing an instrument. Also involved in emotional reactions to music.



# How Music Affects Intelligence 103

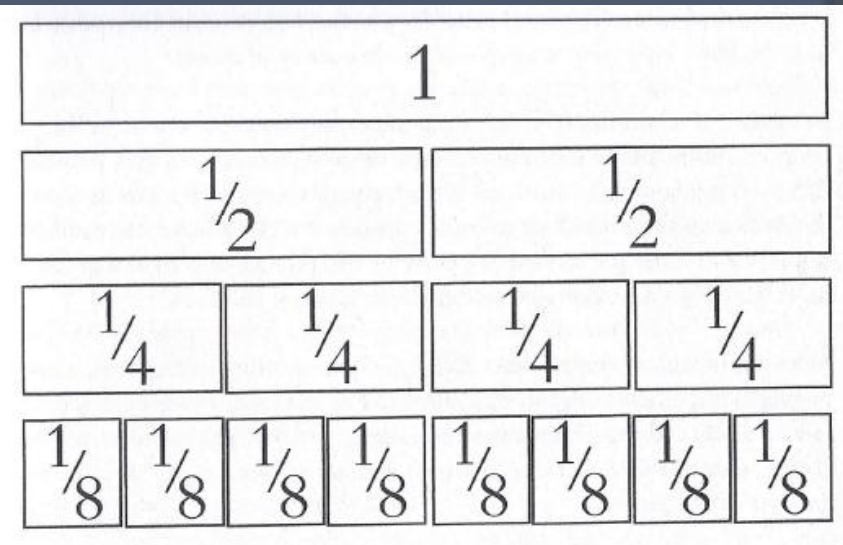
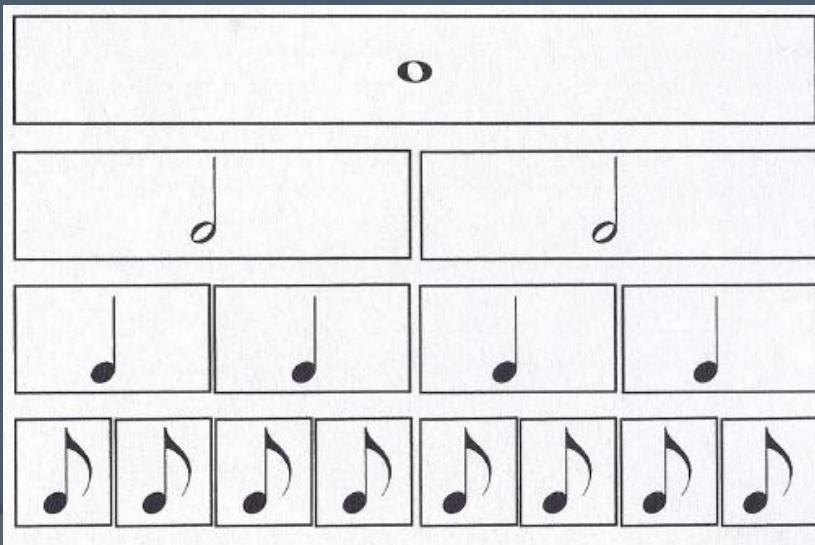
- Memory functions

- Language skills

  - Prosody

    - Pitch: “Really?” (question; sarcasm; bored; disbelief)
    - Stress: “I want to dance with you.” (stress different word each time)

- Math skills



# Why Should I Sing With My Child?

- ⦿ Social Intelligence: promotes bonding
- ⦿ Prosody: Songs & Speech
- ⦿ Auditory Feedback Loop: hears parent's voice, modulates own voice
- ⦿ Lyrics (words in the music): promotes child's vocabulary, understanding of syntax
- ⦿ Fingerplays: motor coordination & singing
- ⦿ Songs can teach specific skills:  
counting/number concept; days of the week;  
parts of the body; animal names/sounds;  
colors; sounds of the alphabet; motor  
coordination;

# 1 Little, 2 Little, 3 Little Fingers

---

One little, two little, three little *fingers*

Four little, five little, six little *fingers*

Seven little, eight little, nine little *fingers*

Ten little *fingers on my hand*

## Suggestions:

- Substitute “fingers” and “fingers on my hand” with other words
- Count backwards: 10 little, 9 little, 8 little...





# There Are 7 Days in a Week

---

(tune of: Oh my darling Clementine)

There are seven days,

There are seven days,

There are seven days in a week. (2x)

Sunday, Monday,

Tuesday, Wednesday,

Thursday, Friday, Saturday. (2x)

---



# Head, Shoulders, Knees and Toes

---

Head and shoulders, knees and toes

Knees and toes

Head and shoulders, knees and toes

Knees and toes ... and ...

Eyes and ears and

Mouth and nose ...

Head and shoulders, knees and toes

Knees and toes.

---



# Old MacDonald Had a Farm

---

Old MacDonald had a farm

E – I – E – I – O

And on his farm he had a cow

E – I – E – I – O

With a moo-moo here, and a moo-moo there

Here a moo, there a moo

Everywhere a moo-moo

Old MacDonald had a farm

E – I – E – I – O

---



# I Wanna Eat, Eat, Eat Apples and Bananas

---

I wanna eat, eat, eat apples and bananas

I wanna eat, eat, eat apples and bananas

I wanna eat, eat, eat apples and bananas

I wanna ate, ate, ate (sounds like long **a**)

I wanna eet, eet, eet (sounds like long **e**)

I wanna ait, ait, ait (sounds like long **i**)

I wanna ot, ot, ot (sounds like long **o**)

I wanna oot, oot, oot (sounds like long **oo** in **moot**)

---



# O Mar Estava Sereno

---

O mar estava sereno, sereno estava o mar

O mar estava sereno, sereno estava o mar

Vamos ver la luna, la luna, la luna (4x)

A mar estava serena ...

Vamos ver la luna, la luna, la luna (4x)

E mar esteve serena ...

I mar istivi sereni ...

O mar estava sereno ...

U mar ustuvu serenu ...

---



# O Carro Do Chefe

---

O carro do chefe tem um furo no pneu

O carro do chefe tem um furo no pneu

O carro do chefe tem um furo no pneu

Colemos com chiclete.

## Motions:

- carro : pretend you are driving
  - chefe : scout salute
  - furo : point index finger down, make /f/ sound index, pull hand upward
  - pneu : make 2 “C”s with hand, fingers touch
  - chiclete: chewing, tongue click, stretching chewing gum out
- 



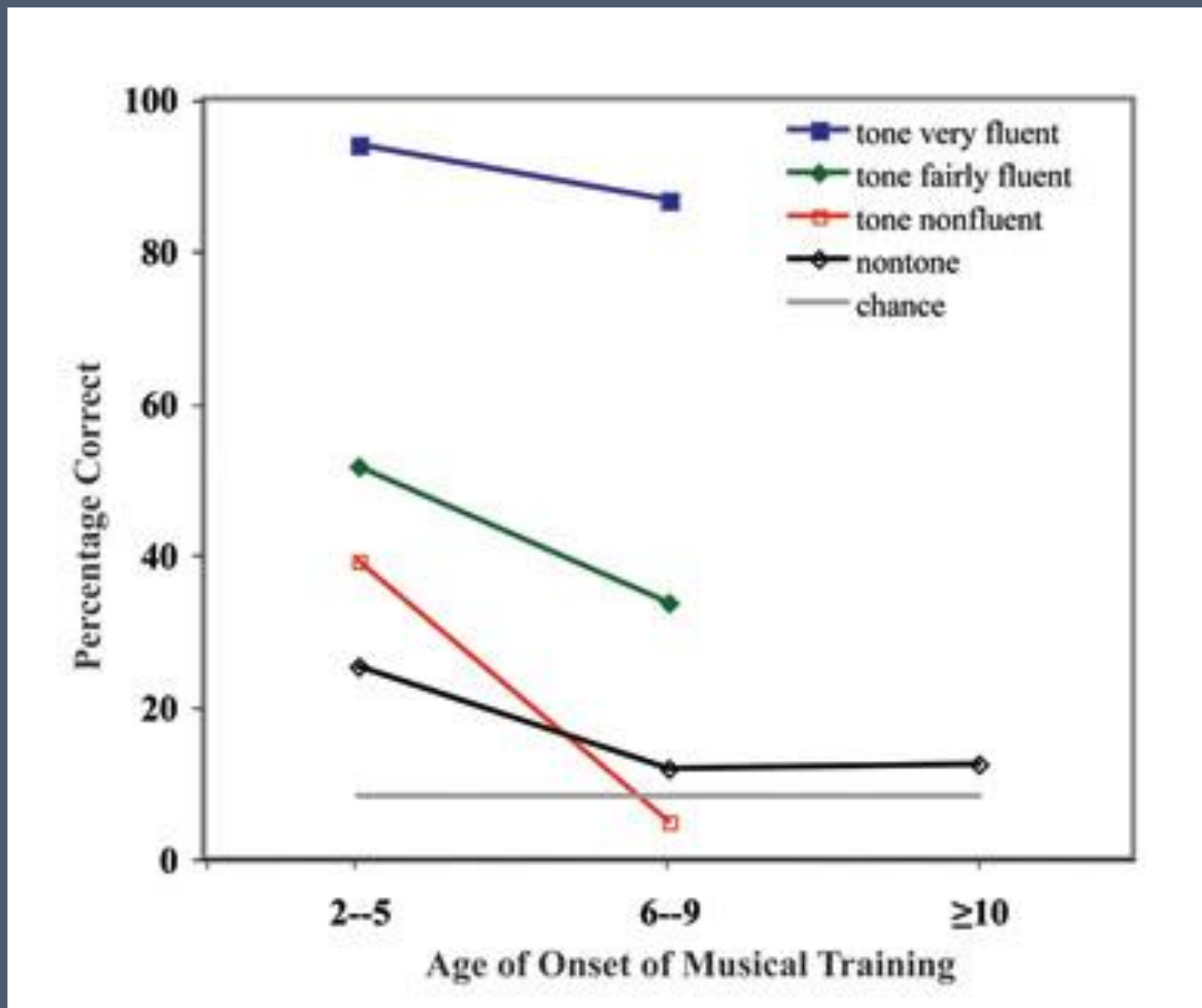
# Research Findings

# Current Research Findings

- Long-term Effects of Auditory Training in Severely or Profoundly Deaf Children
  - Rochette, F. & Bigand, E. (2009). *The Neurosciences and Music III: Disorders and Plasticity*. Ann. N.Y. Acad. Sci. 1169: 195-198
- Music training improves pitch perception in prelingually deafened children with cochlear implants
  - Chen, JK et al. *Pediatrics* 2010 Mar 8
- Musician enhancement for speech-in-noise.
  - Parbery-Clark, A et al. *Ear Hear* 2009 Dec. 30 (6): 653-61
- Musicophilia: through illness or accident we gather information on the functioning of the brain with regards to music perception and production



# Perfect Pitch: Language Wins Out Over Genetics



<http://www.acoustics.org/press/157th/deutsch.html>

<http://deutsch.ucsd.edu/>

Questions?

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- Everest, F.A. & Pohlmann, K.C. (2009). *Master Handbook on Acoustics*. McGraw-Hill, USA.
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- Trimble, M.R. (2007). *The Soul in the Brain: The Cerebral Basis of Language, Art, and Belief*. The John Hopkins University Press, Baltimore

# Web Resources

- <http://www.aschero.com>
- <http://implantecoclear.org/congreso1/>
- <http://www.loni.ucla.edu/~thompson/DEVEL/PR.html>
- <http://mondovista.com/bicamx.html>
- [http://en.citizendium.org/wiki/Musical\\_semantics](http://en.citizendium.org/wiki/Musical_semantics)
- [http://books.google.com/books?id=idx62RIQRUcC&pg=PA20&lpg=PA20&dq=nesta+rua+bruce+trinkley&source=bl&ots=B96QofMir\\_&sig=qypEuiMXtPI6s\\_jep3aizoU8ofY&hl=en&ei=HJLbS82WLYXStAP8x8zxBg&sa=X&oi=book\\_result&ct=result&resnum=1&ved=0CAkQ6AEwAA#v=onepage&q=nesta%20rua%20bruce%20trinkley&f=false](http://books.google.com/books?id=idx62RIQRUcC&pg=PA20&lpg=PA20&dq=nesta+rua+bruce+trinkley&source=bl&ots=B96QofMir_&sig=qypEuiMXtPI6s_jep3aizoU8ofY&hl=en&ei=HJLbS82WLYXStAP8x8zxBg&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAkQ6AEwAA#v=onepage&q=nesta%20rua%20bruce%20trinkley&f=false)
- <http://www.thefreedictionary.com/motif>
- <http://www.ncbi.nlm.nih.gov/pubmed/19734788>
- <http://images.google.com>