The Kraus Lab

biology of auditory learning

harnessing neuroplasticity to improve human communication

music
bilingualism

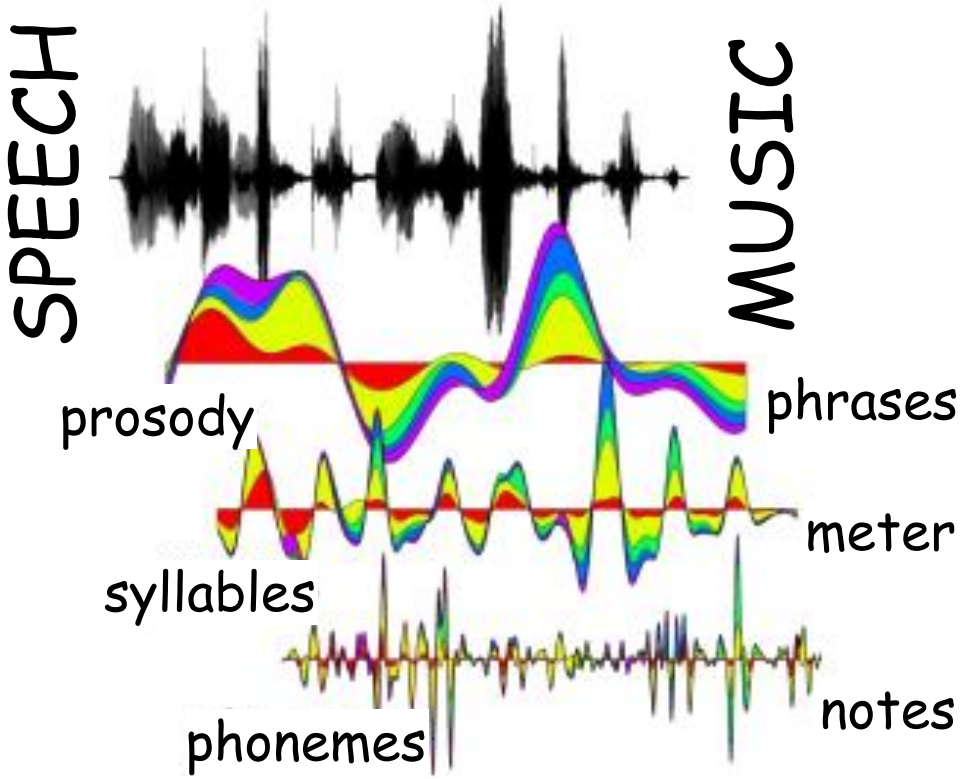
enrichment

aging
poverty
dyslexia
autism

deprivation / disorder / decline

Sound Processing

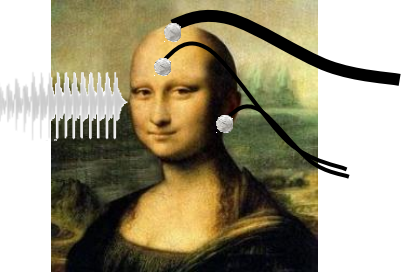
working at different time scales… …simultaneously



seconds

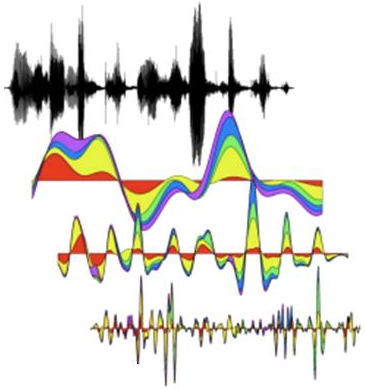
↓

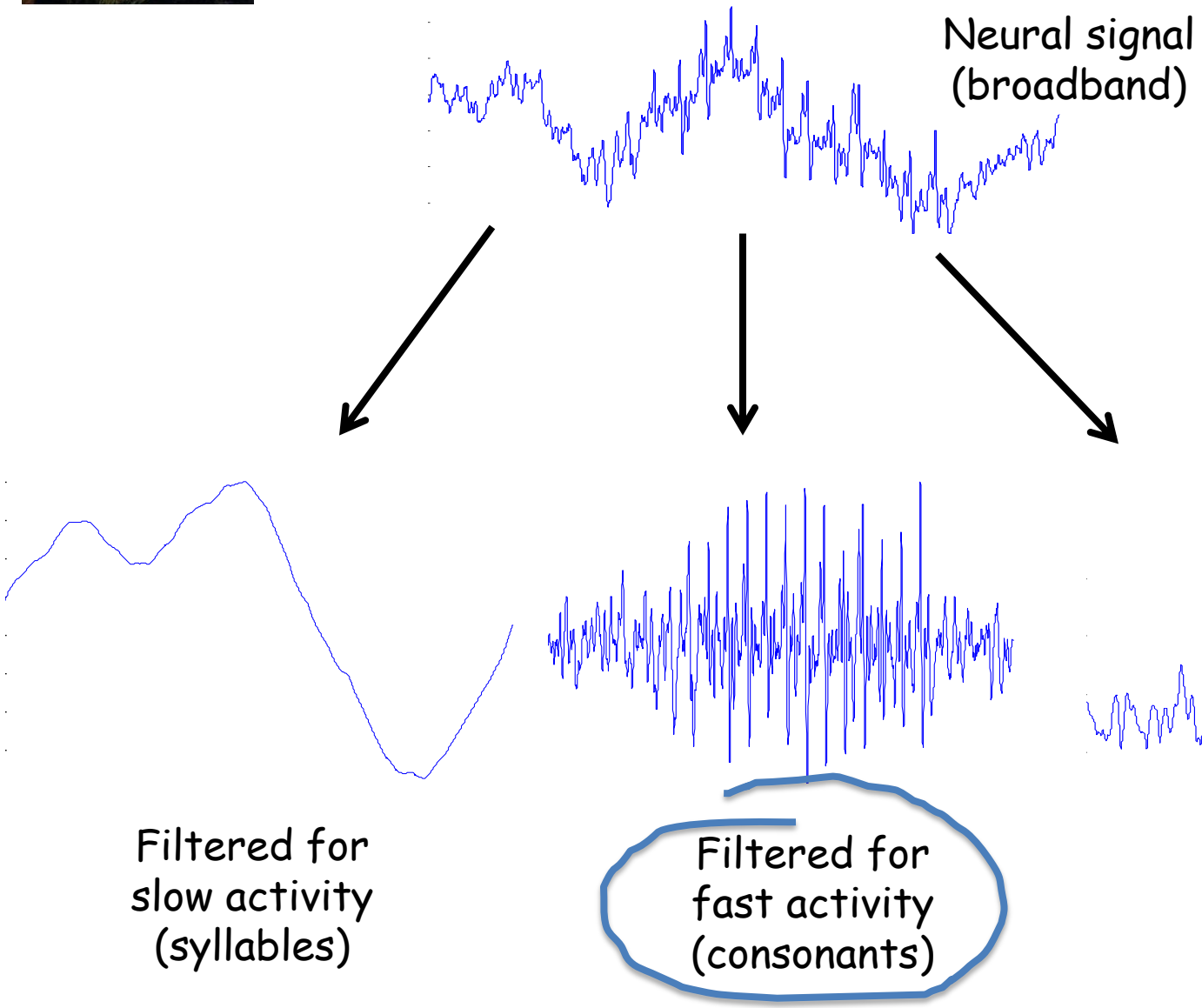
microseconds



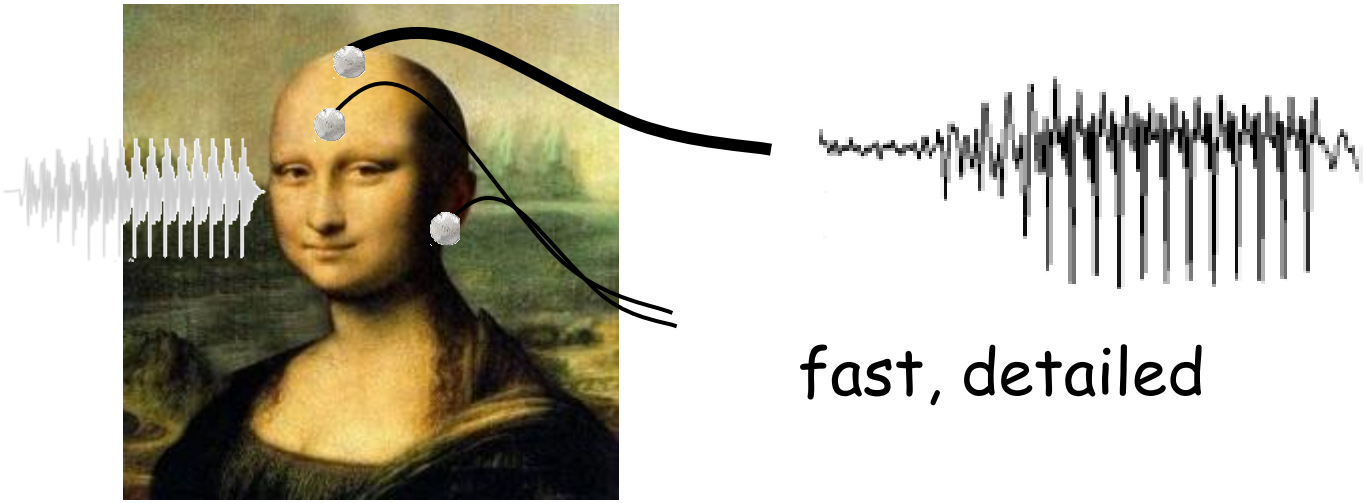
The auditory circuit

working at different time scales…

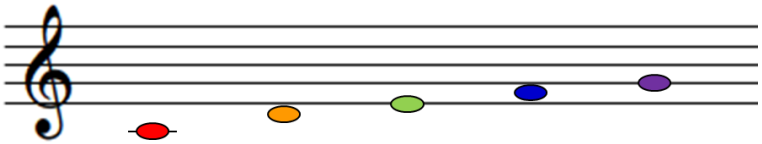




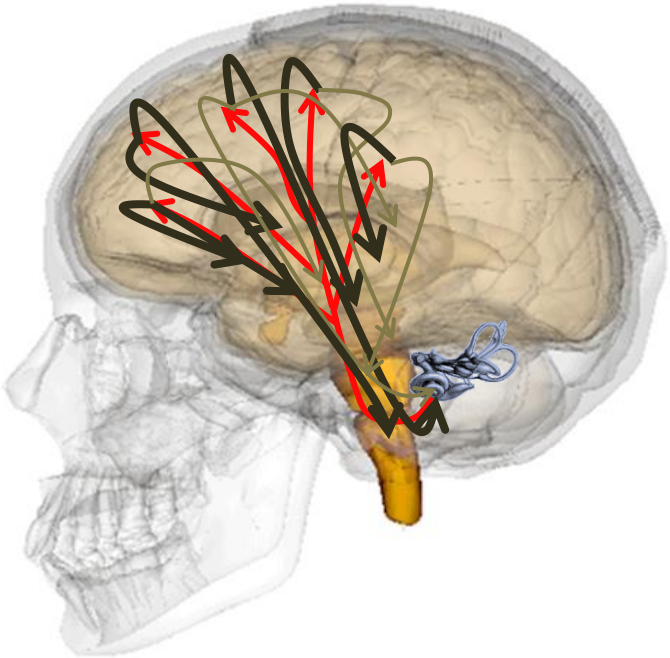
biological snapshot of auditory processing



fast, detailed



biological snapshot of auditory processing

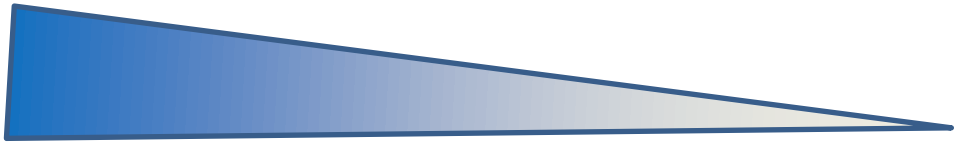


distributed but integrated network

sound details

Fundamental frequency
Pitch tracking
Harmonics
Onset timing
Formant timing (consonants)
Response consistency

experience-dependent



Neural signatures

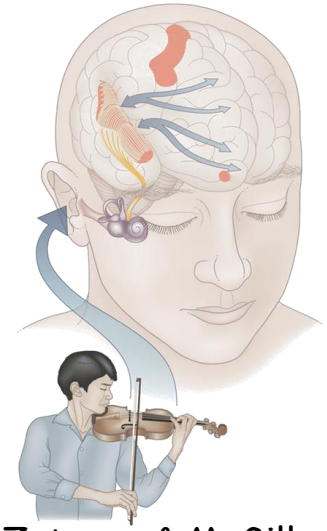
Kraus & Nicol
Springer Handbook of Auditory Research, 2014

	Fundamental frequency	Pitch tracking	Harmonics	Onset timing	Formant timing (consonants)	Response consistency	Neural noise (spontaneous rate)
Music							
Bilingualism							
Aging							
Hearing Loss							
Language challenges							
Dyslexia							
Autism							
Poverty linguistic deprivation							

enrichment

deprivation
decline
disorder

Neural signatures



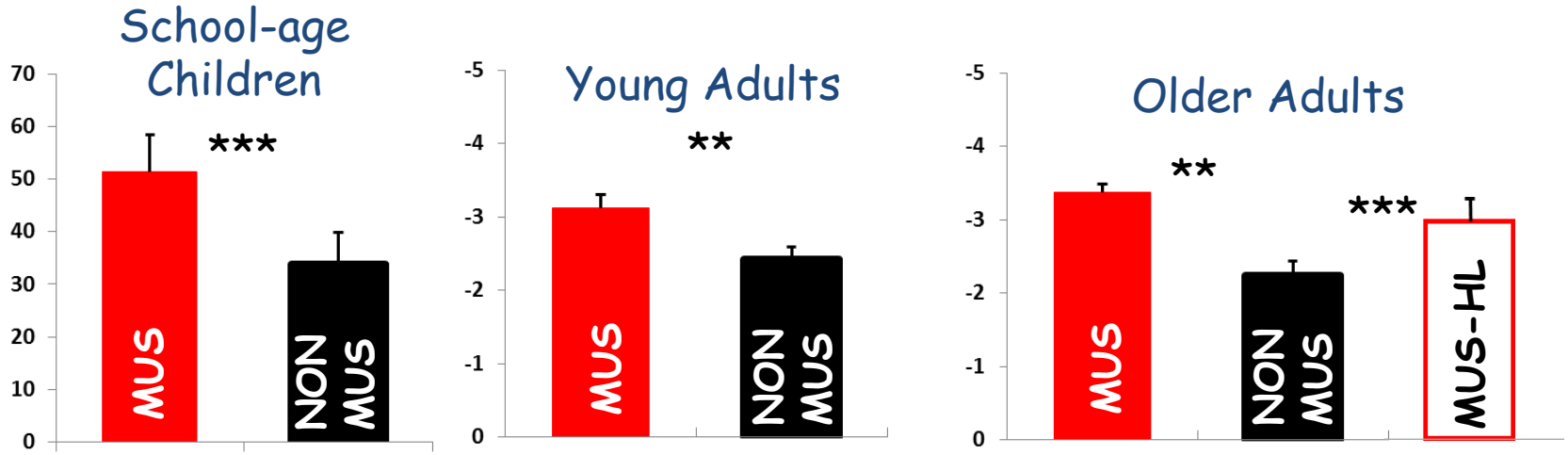
Zatorre & McGill, 2005, *Nature*

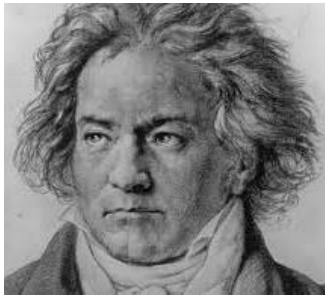
	Fundamental frequency	Pitch tracking	Harmonics	Onset timing	Formant timing (consonants)	Response consistency	Neural noise (spontaneous rate)
Aging			−	−	−	−	+
Music	−	+	+		+	+	

Healthy aging occurs throughout life

What about lifelong music?

Hearing speech in noise



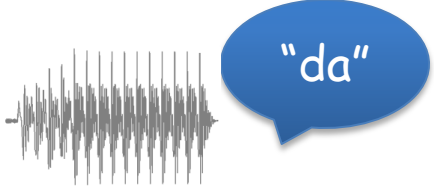


easy

medium

hard

Parbery-Clark et al., *Ear Hear*, 2009
Parbery-Clark et al., *PLoS ONE*, 2011
Zendel & Alain, *Psychol Aging*, 2011
Strait et al., *Cerebral Cx*, 2013
Strait et al., *Dev Cog Neurosci*, 2013
Strait & Kraus, *Hear Res*, 2013 (review)



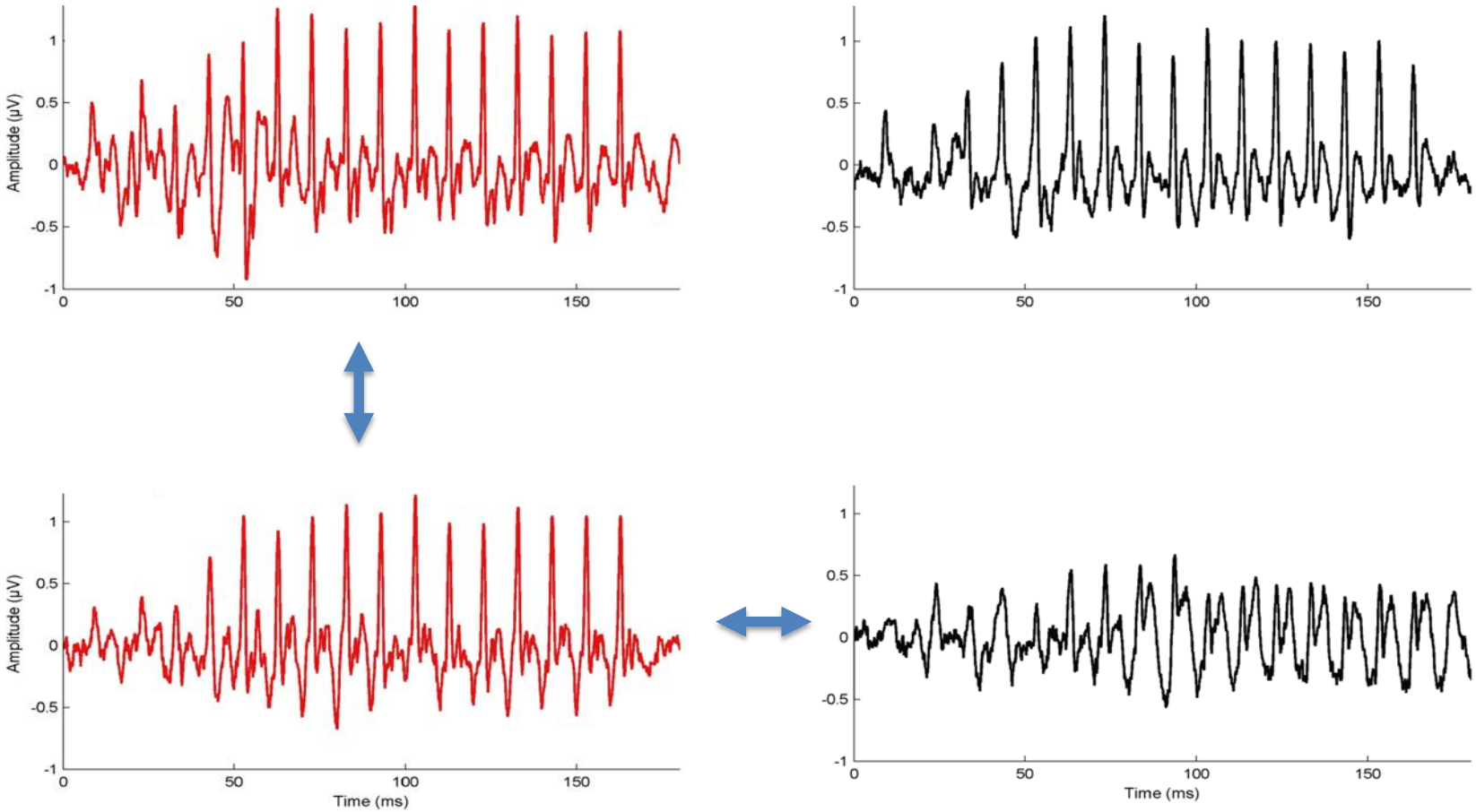
Hearing speech in noise

Musicians

Nonmusicians

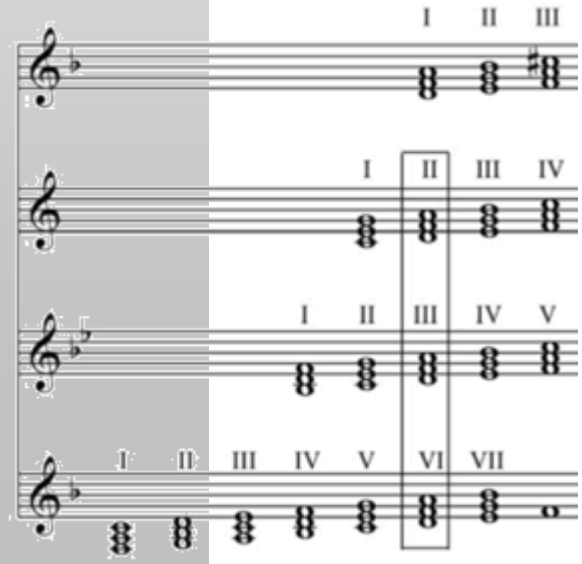
QUIET

NOISE



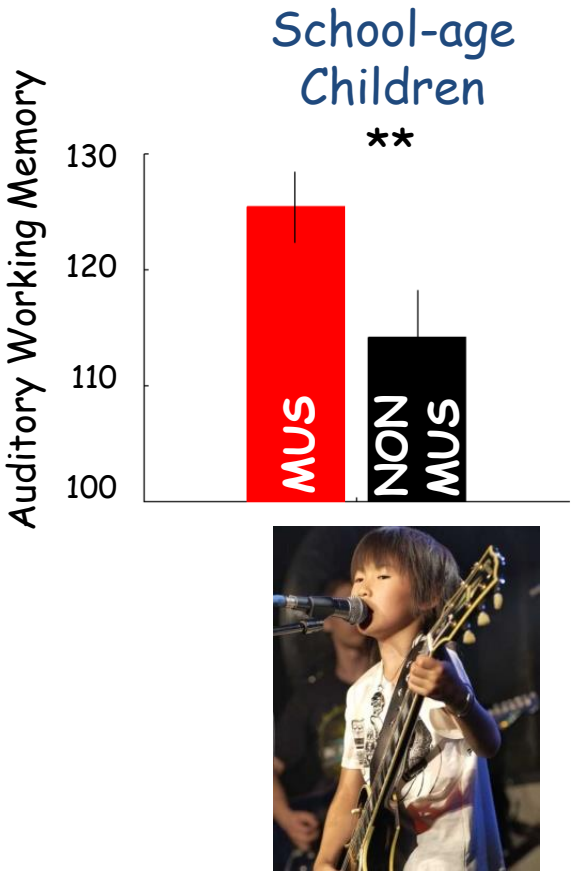
Musical training involves…

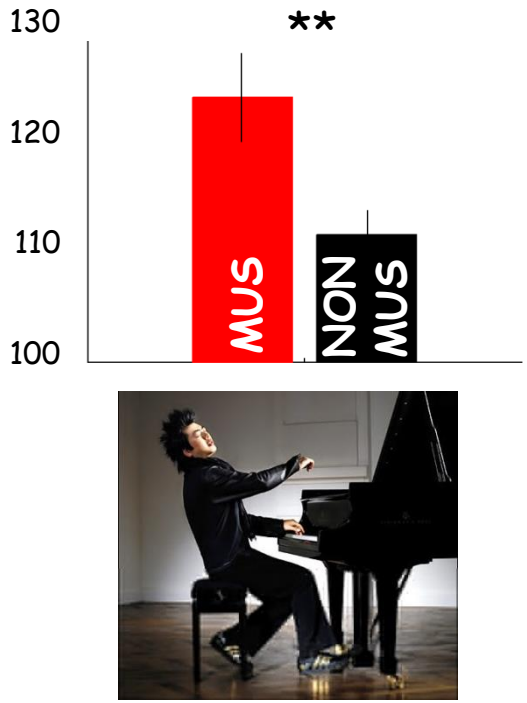
- Memorization of sound and visual patterns
- Memorization of auditory-motor sequences
- Tuning an instrument
- Improvisation

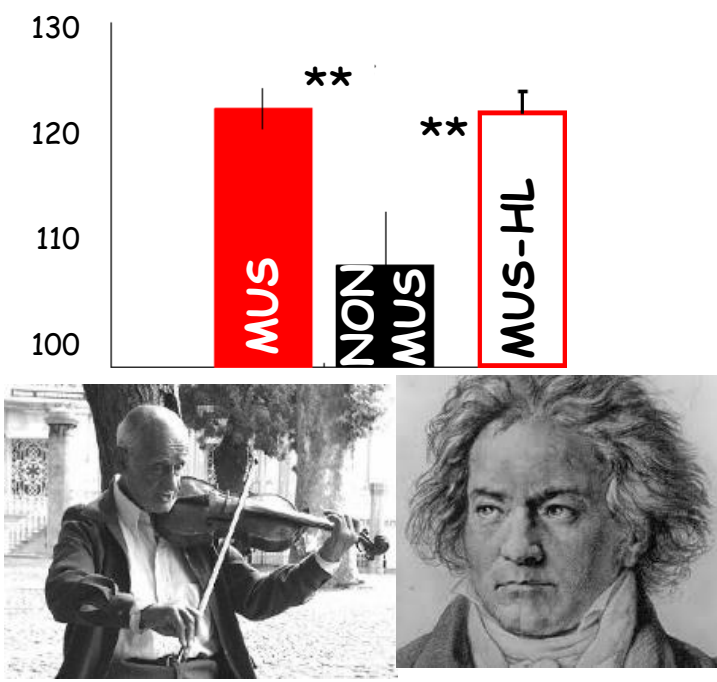


all exercise
auditory
working
memory

Auditory working memory



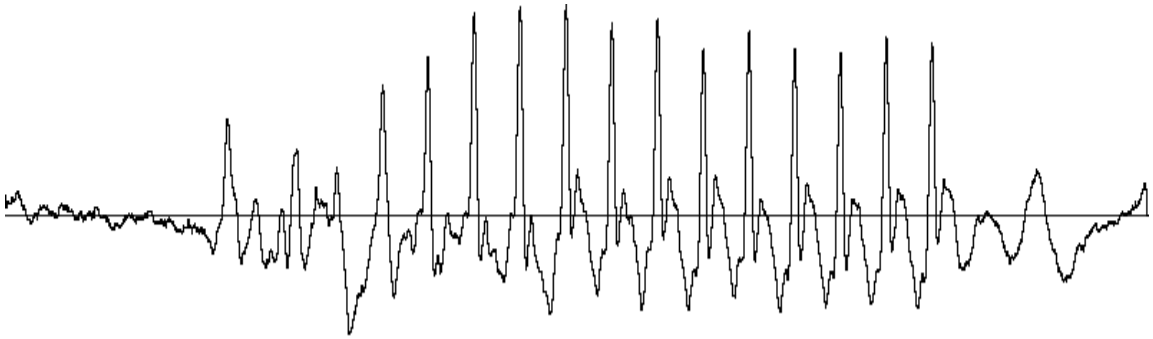




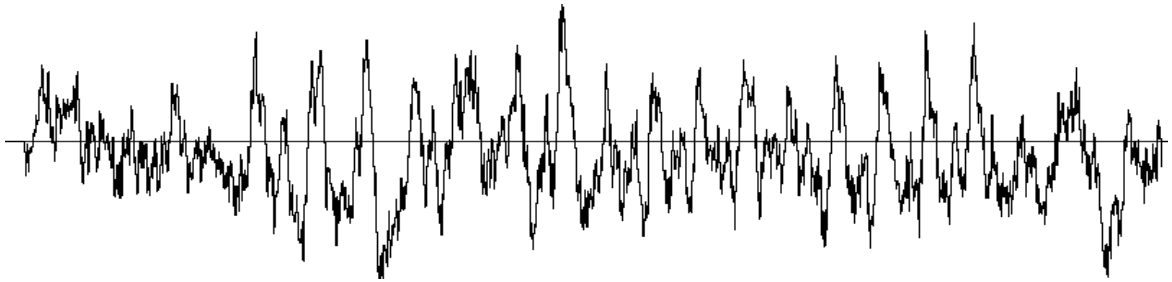
Chan et al., *Nature*, 1998
Trainor & Corrigall, *Mus Percept*, 2010
Jakobson et al., *Mus Percept*, 2008
Parbery-Clark et al., *Ear Hear*, 2009
Parbery-Clark et al., *PLoS ONE*, 2011
Strait et al., *Cereb Ctx*, 2013
Kraus et al., *NY Acad Sci*, 2012
Strait & Kraus, *Hear Res*, 2013 (review)

Aging

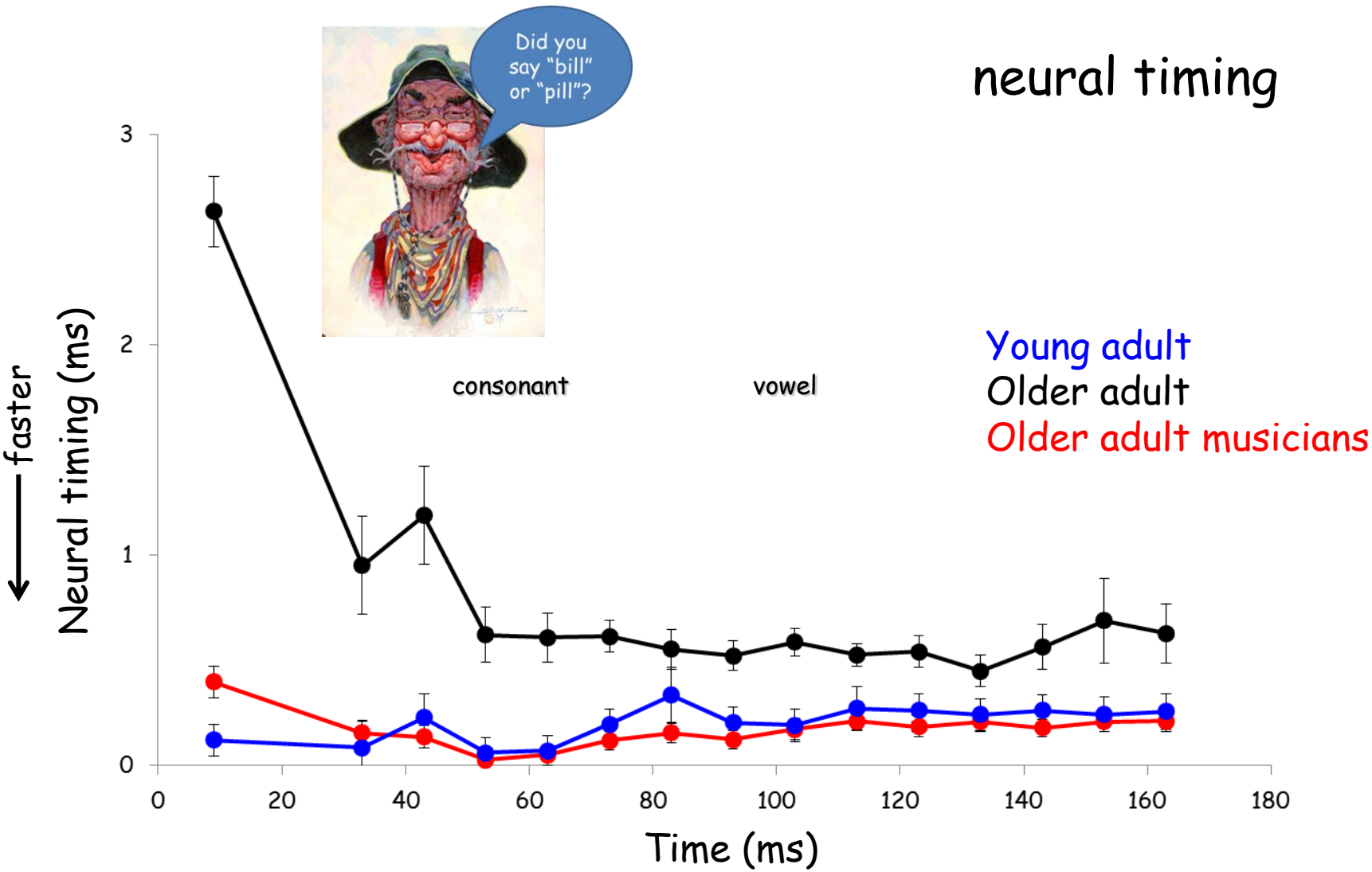
Young adult



Older adult

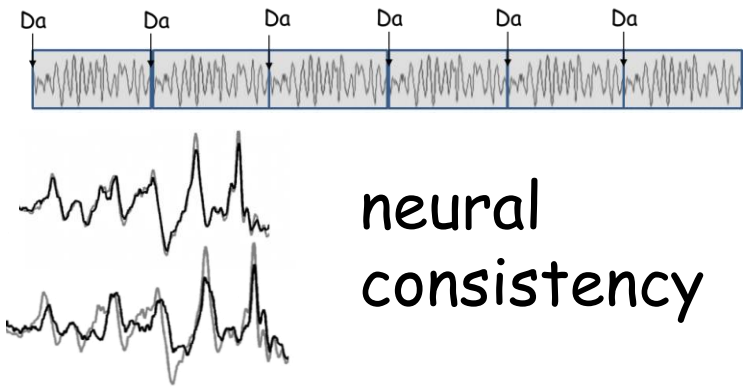


Biological effects of aging—**Lifelong Music Experience**

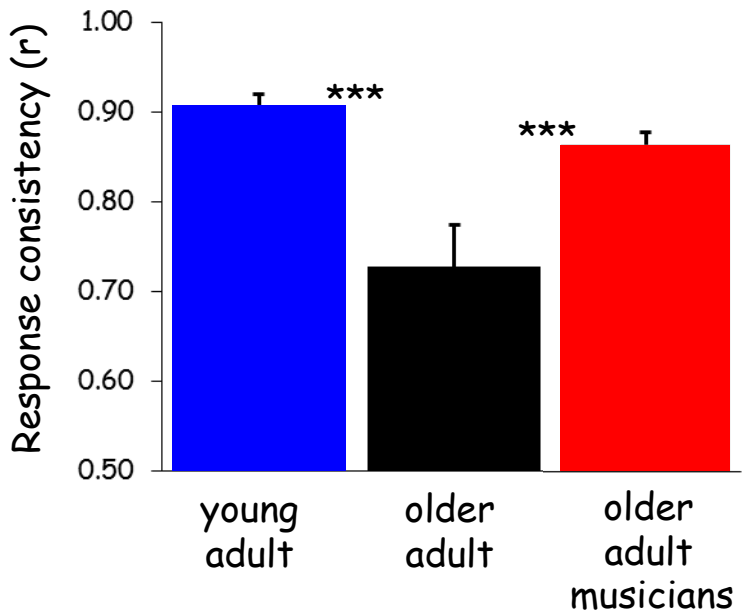


Anderson et al., *J. Neurosci*, 2012
Parbery-Clark et al. *Frontiers*, 2012

Biological effects of aging—**Lifelong Music Experience**



neural consistency



Anderson et al., *J. Neurosci*, 2012
Parbery-Clark et al. *Frontiers*, 2012

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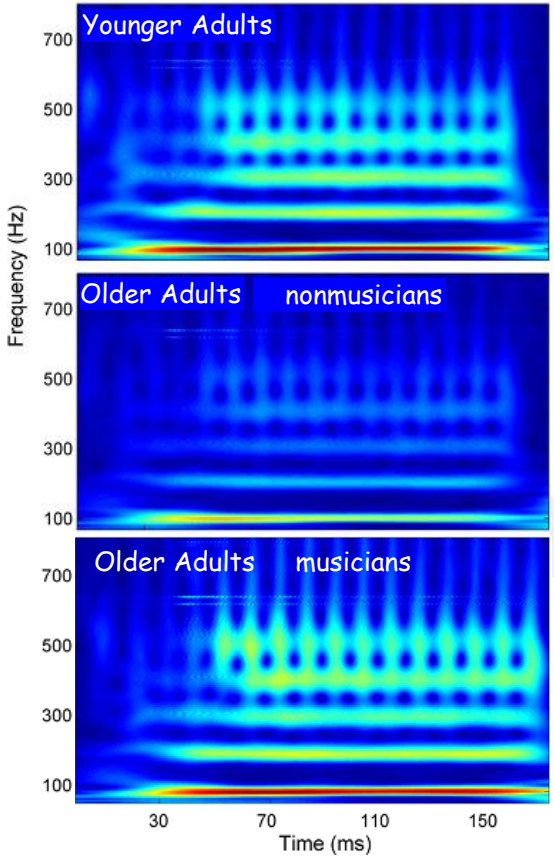
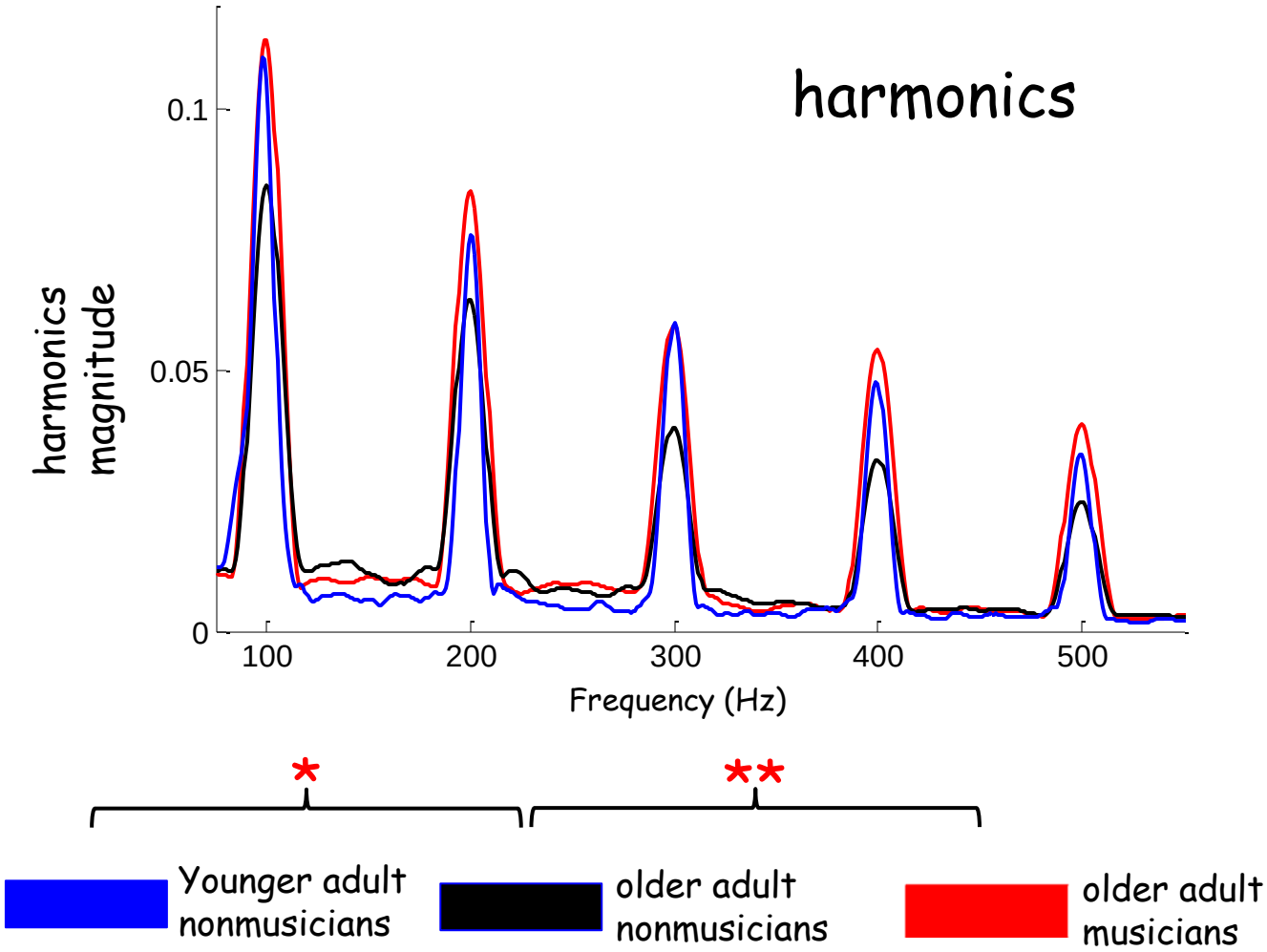


neural synchrony

Anderson et al., *J. Neurosci*, 2012
Parbery-Clark et al. *Frontiers*, 2012

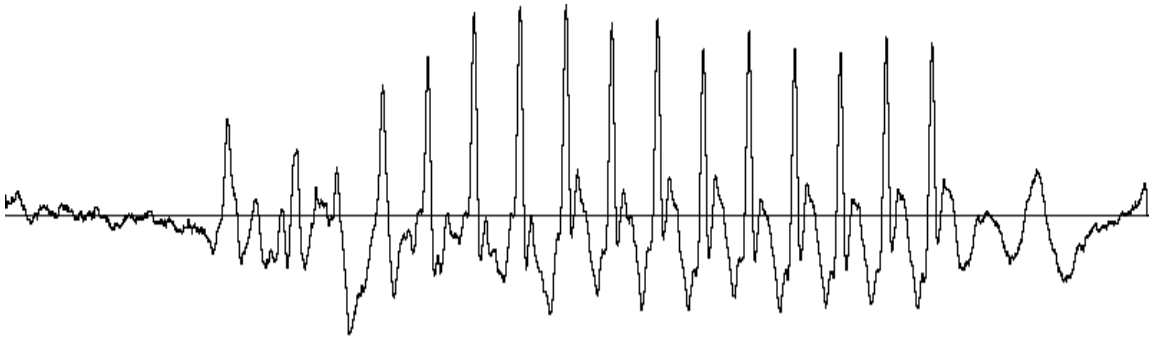
Biological effects of aging—**Lifelong Music Experience**



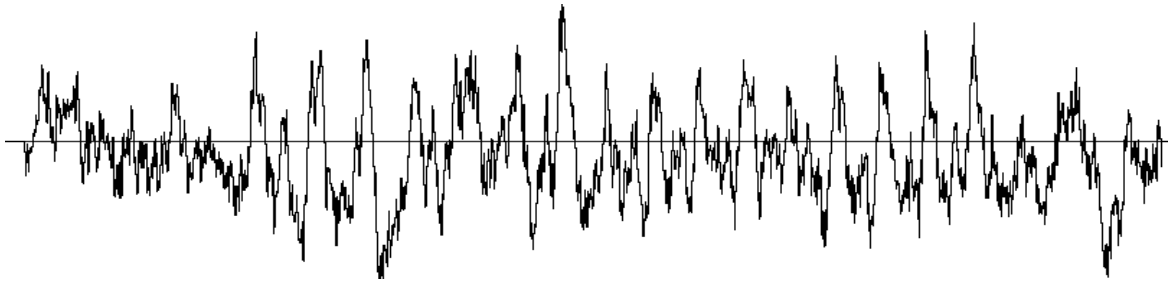
Anderson et al., *J. Neurosci*, 2012
Parbery-Clark et al. *Frontiers*, 2012

Lifelong Music Experience

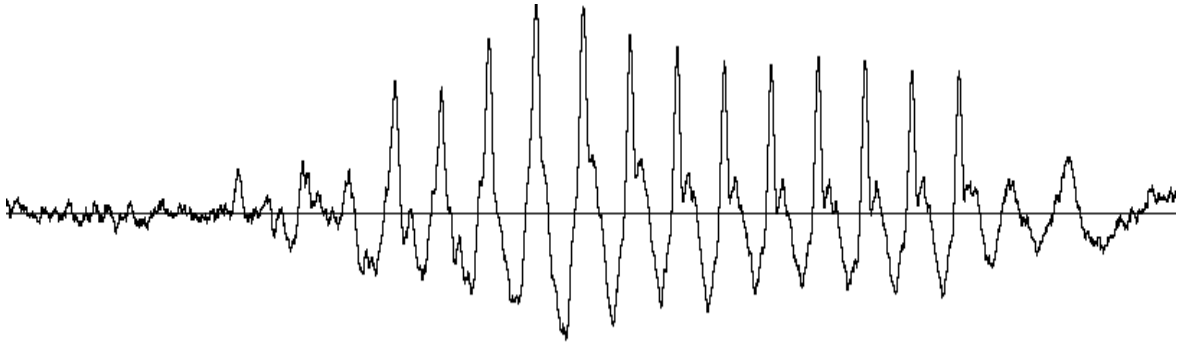
Young adult



Older adult



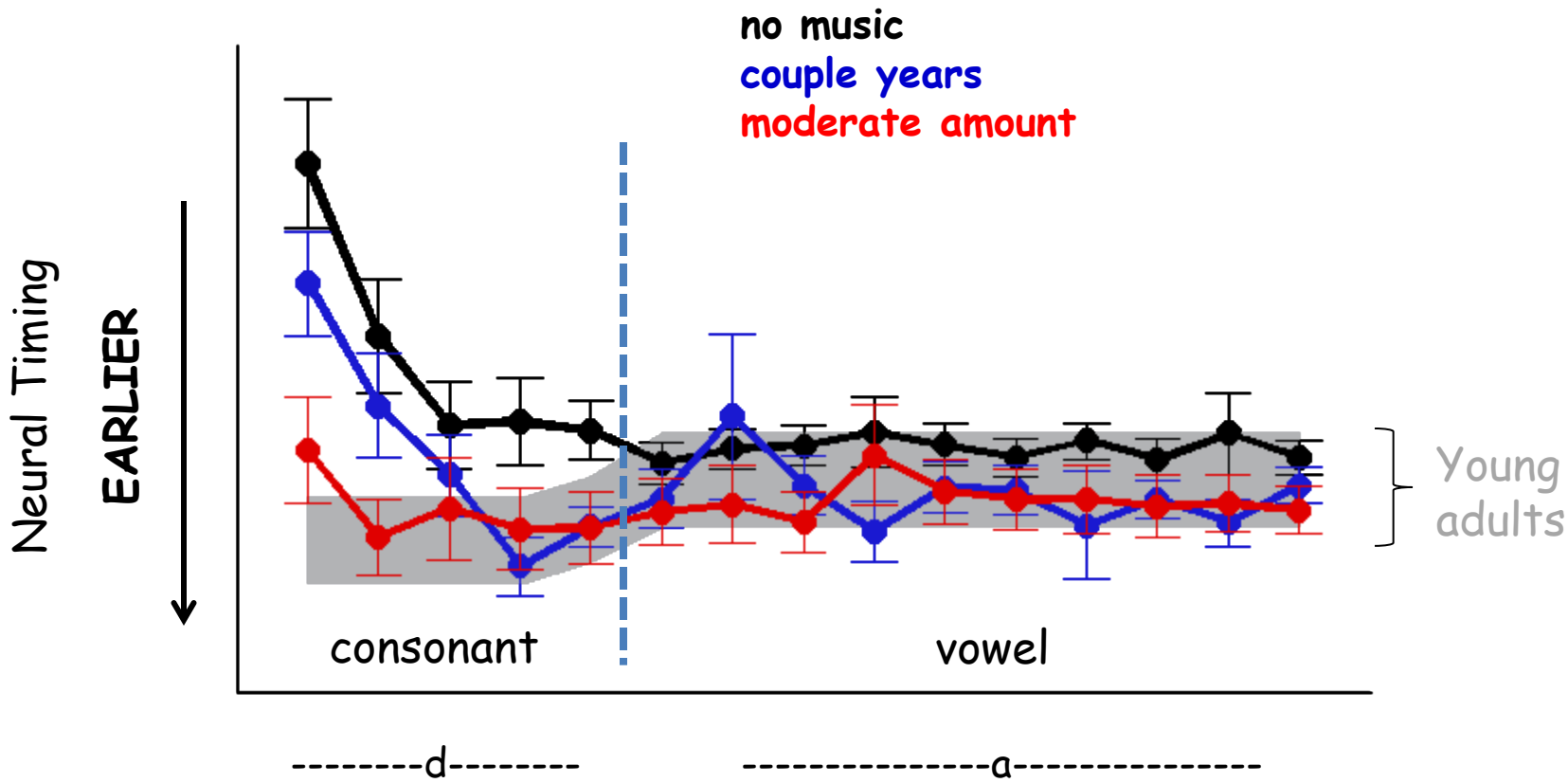
Older adult musician



What happens after you stop playing music????
Does the brain continue to profit?

YES!

Music during Childhood – Older Adults



White-Schwoch…Kraus *J Neurosci* 2013

Grand Summary

- Aging...sound processing
- impact of Music (lifelong and in childhood)

WE ARE WHAT WE DO

OUR PAST SHAPES OUR PRESENT

What Next?

..music initiated/resumed in older adults

What Else?

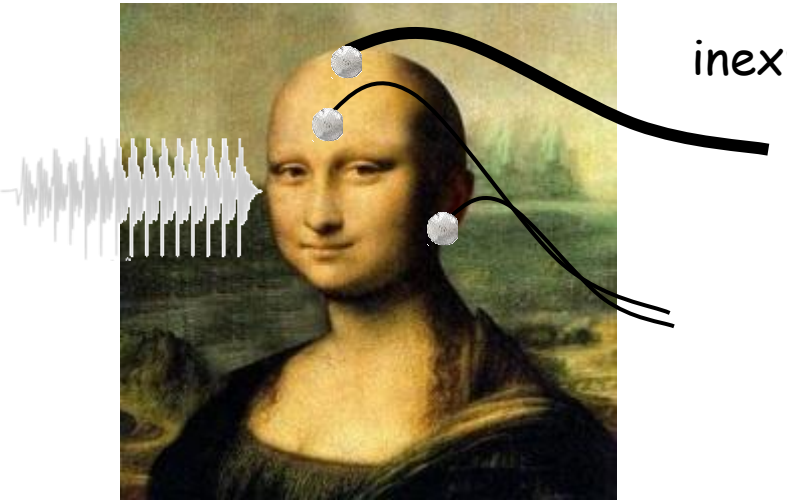
Biological links between rhythm & language

What Else?

We have a powerful, biological snapshot of auditory processing in humans

Empower scientists and clinicians

Language development; auditory processing - lifelong
Hearing aids – fitting; audio device development
Treatment outcomes: brain training; drug therapies
Genetically engineered animal models



inexpensive & user-friendly

www.brainvolts.northwestern.edu

Northwestern University
School of Communication

The Roxelyn and Richard Pepper
Department of Communication Sciences and Disorders

Auditory Neuroscience Laboratory

auditory neuroscience lab
people
lab projects
publications

technologies
freeware

talks (upcoming & previous)
community outreach
in the news

i would like to participate
directions to the lab

Lab Projects

- Music
- Reading
- Speech in Noise
- Aging
- Bilingualism
- Neuroeducation
- Pre-School Language Development
- Autism

- Technologies

NSF: Finding Your Science - Spring 2010
Music and the Brain

Demonstration
Neural response to complex sounds: Our approach

Marion Downs Lecture - 2014
Biological Assessment in Audiology:
Auditory Processing and Hearing in Noise