From Sounds to Music: Learning the Bohlen-Pierce Scale

Psyche Loui
Beth Israel Deaconess Medical Center
Harvard Medical School

Bohlen-Pierce Scale Symposium
March 7, 2010

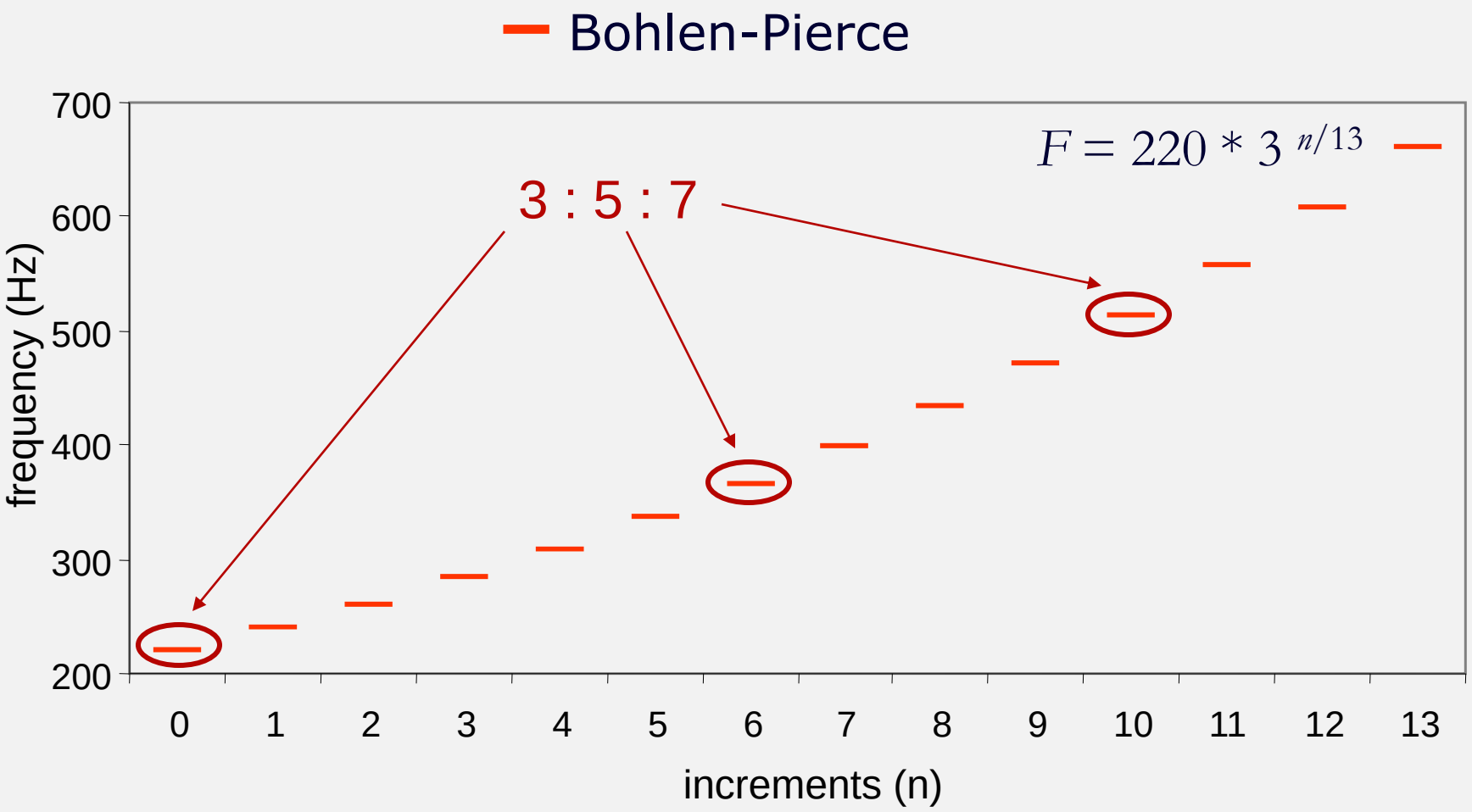
The world knows and loves music

Whence musical knowledge?

Perspectives:

- Developmental studies
- Cross-cultural studies
- Artificial system
  - Bohlen-Pierce scale

The tritave as a musical system

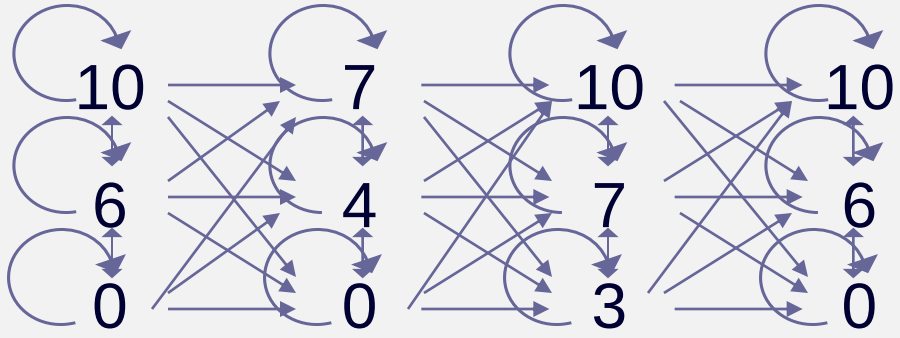


Composing in the Bohlen-Pierce scale

$$F = 220 * 3^{n/13}$$

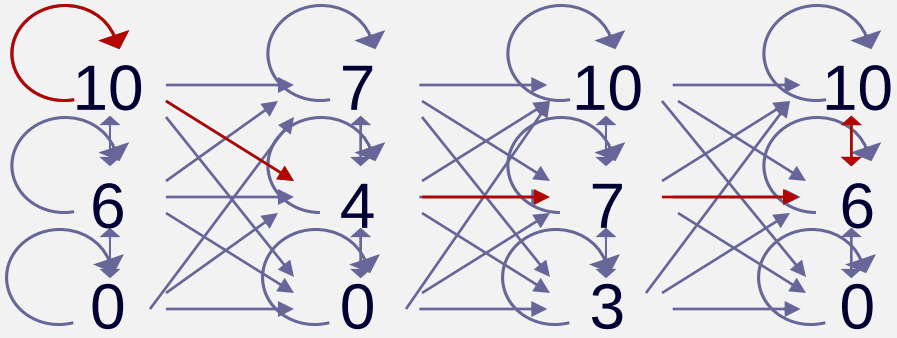
Krumhansl, 1987
Loui & Wessel, 2008

Composing melody from harmony – applying a finite-state grammar



Loui & Wessel, 2008

Composing melody from harmony – applying a finite-state grammar



Melody: 10 → 10 → 4 → 7 → 6 → 10

Loui & Wessel, 2008

Can we learn the B-P scale?

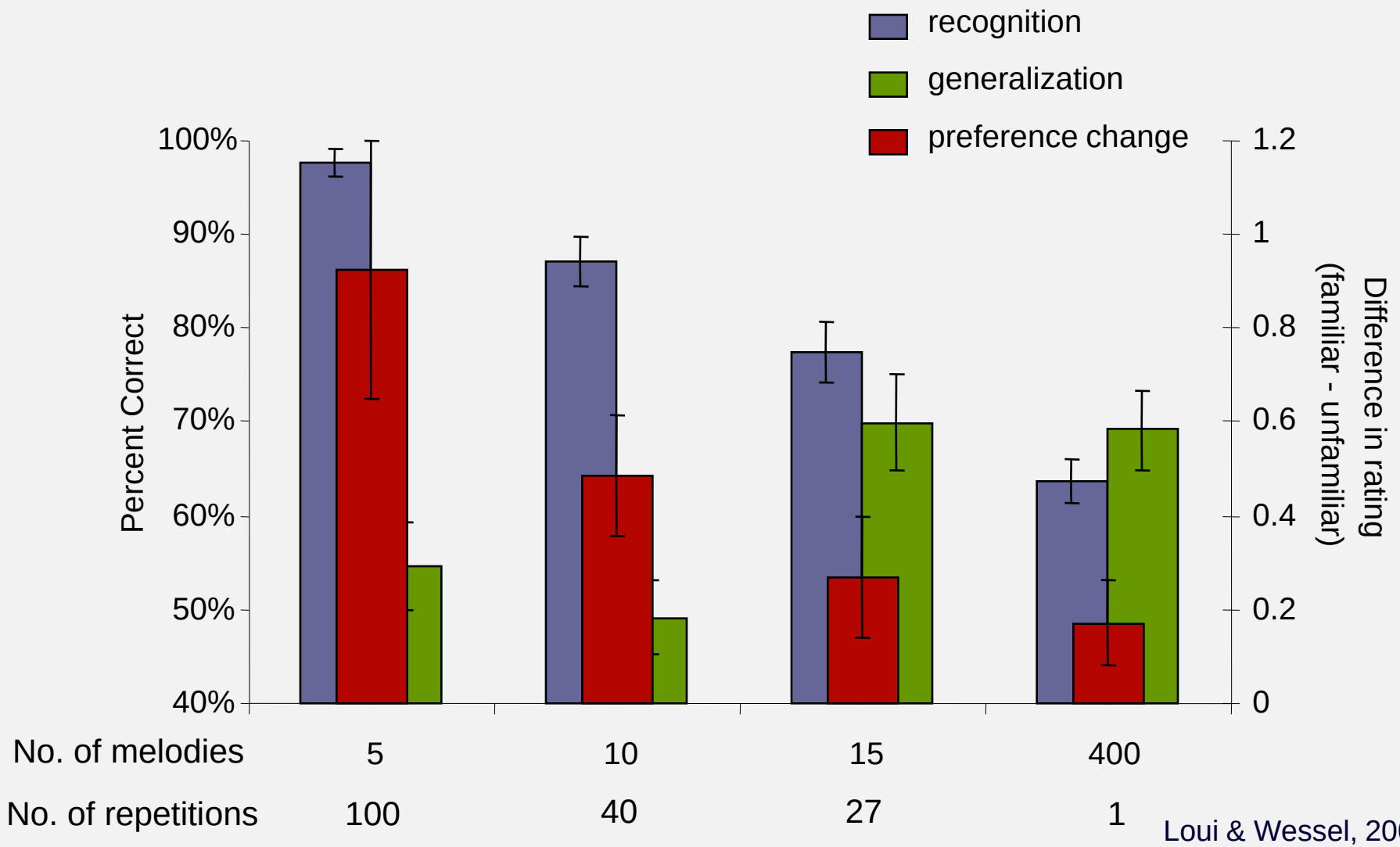
General design of behavioral studies:

1. PRE-TEST
   - assess baseline
2. EXPOSURE to melodies in one grammar
   - ~30 minutes
3. POST-TESTS
   - assess learning

Learning a musical system: basic questions

- Can we recognize old melodies?
  - 2-AFC test of recognition
- Can we generalize to new melodies?
  - 2-AFC test of generalization
- Can we learn to like new melodies?
  - Preference ratings

Double dissociation between grammar learning and preference change

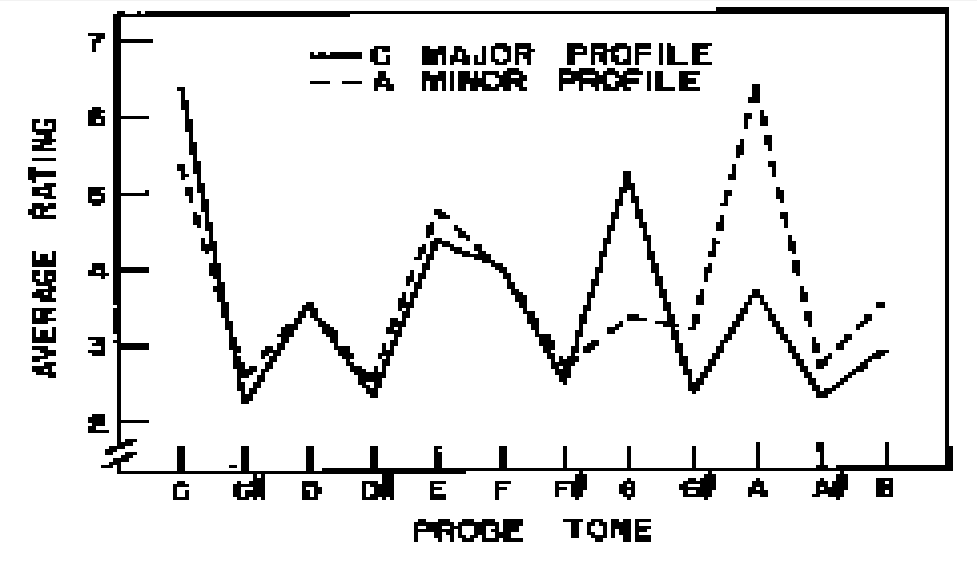


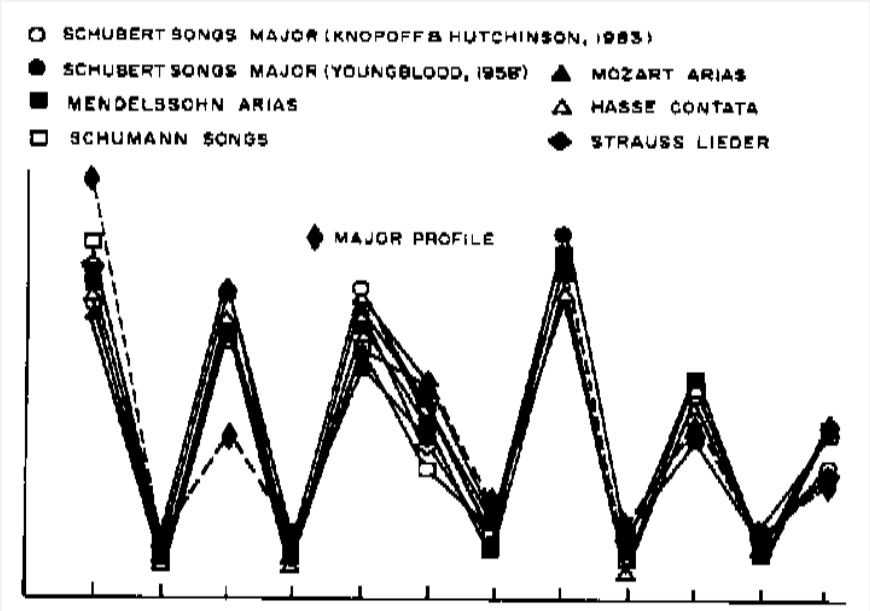
Loui & Wessel, 2008

Loui, Wessel & Hudson Kam, in press.

Learning a new musical system: more questions

- Can we learn to expect frequent tones?
- Probe tone ratings test
  - Probe tone profiles reflect frequencies of compositions





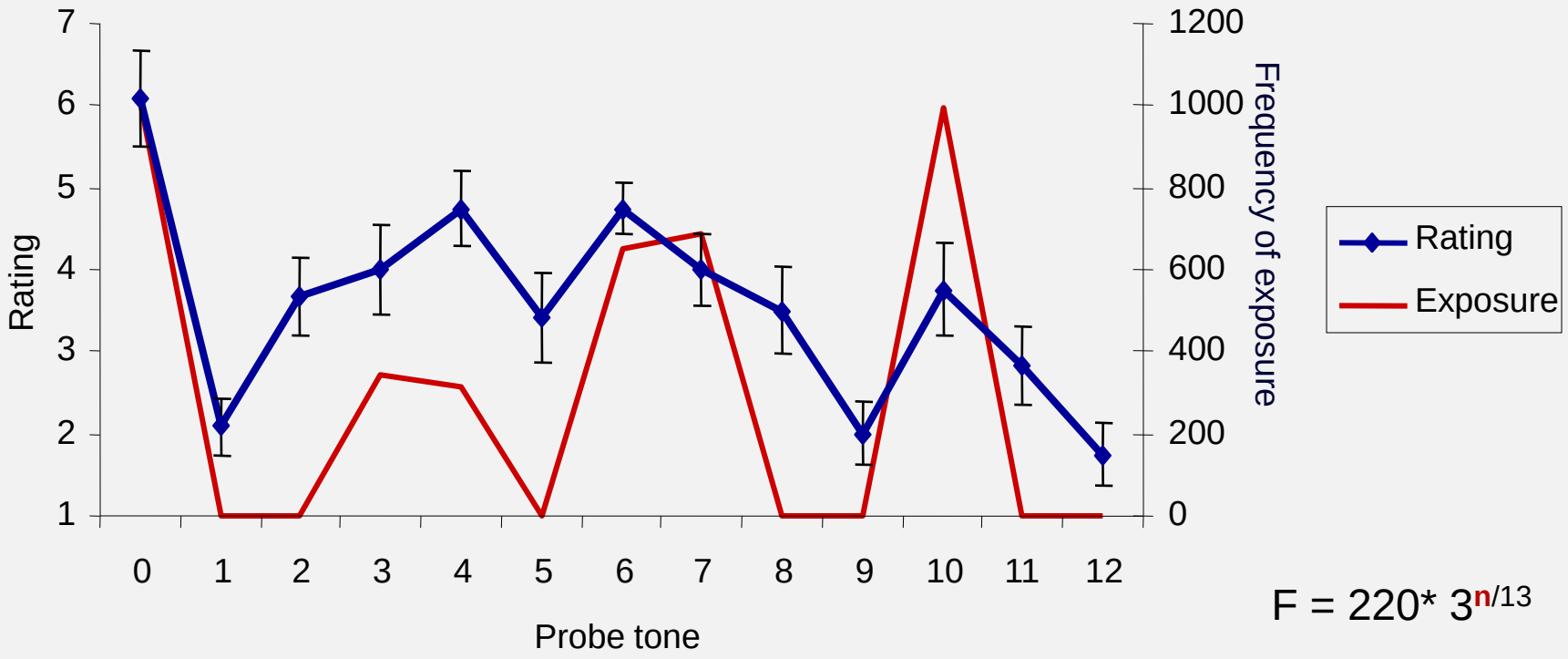
Krumhansl, 1990

Testing for expectation for frequencies

Probe tone ratings test (Krumhansl, 1990)

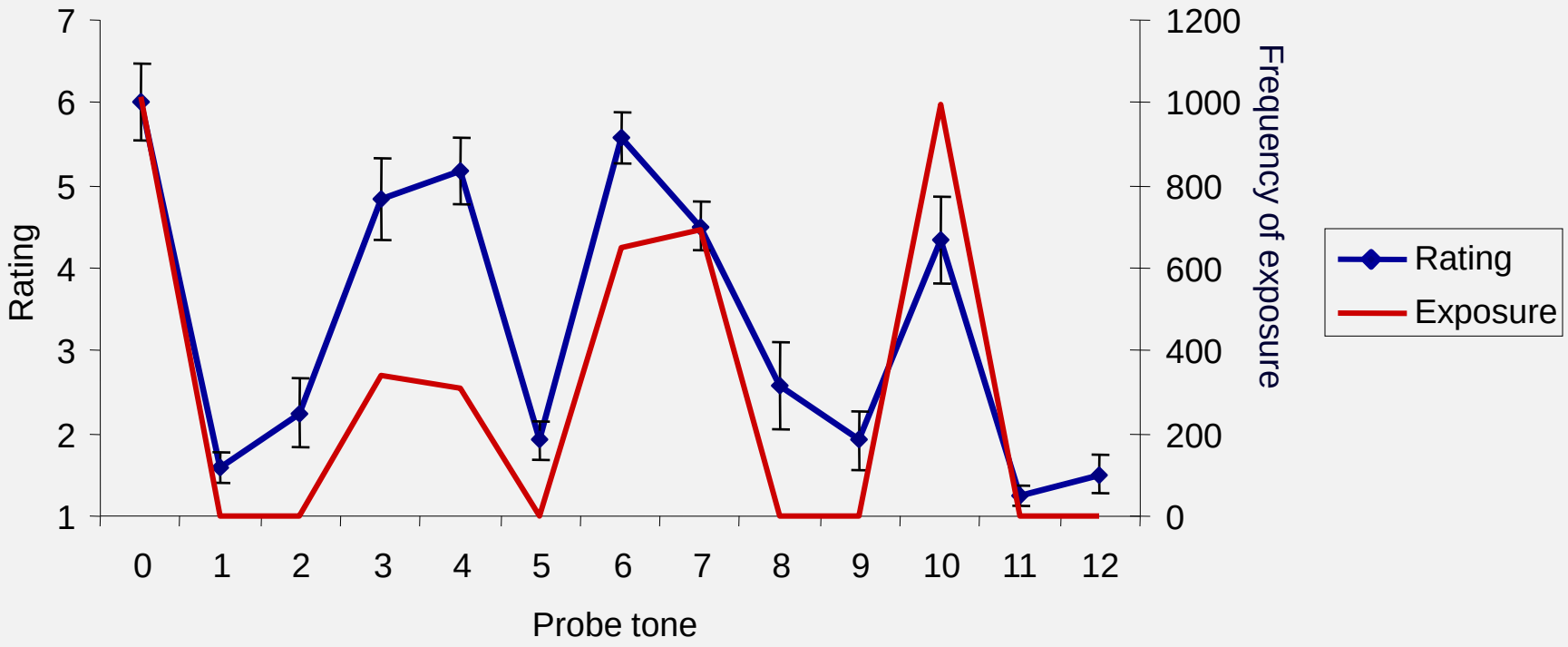
- Melody → tone
- Task: rate how well the tone fits the melody
  - Scale of 1 through 7
- Tests conducted both pre- and post-exposure

Pre-exposure probe tone ratings



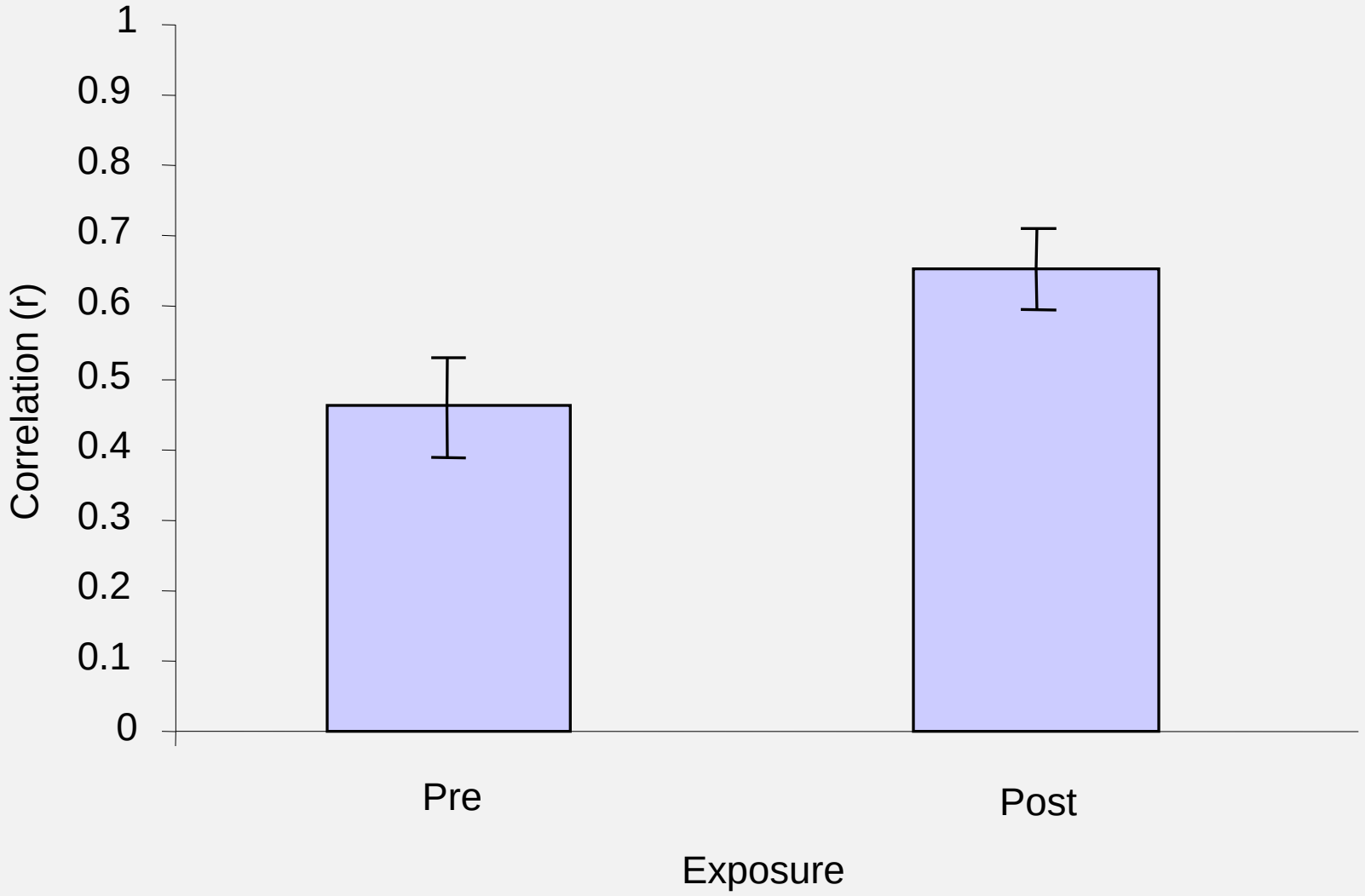
Loui, Wessel & Hudson Kam, in press.

Post-exposure probe tone ratings



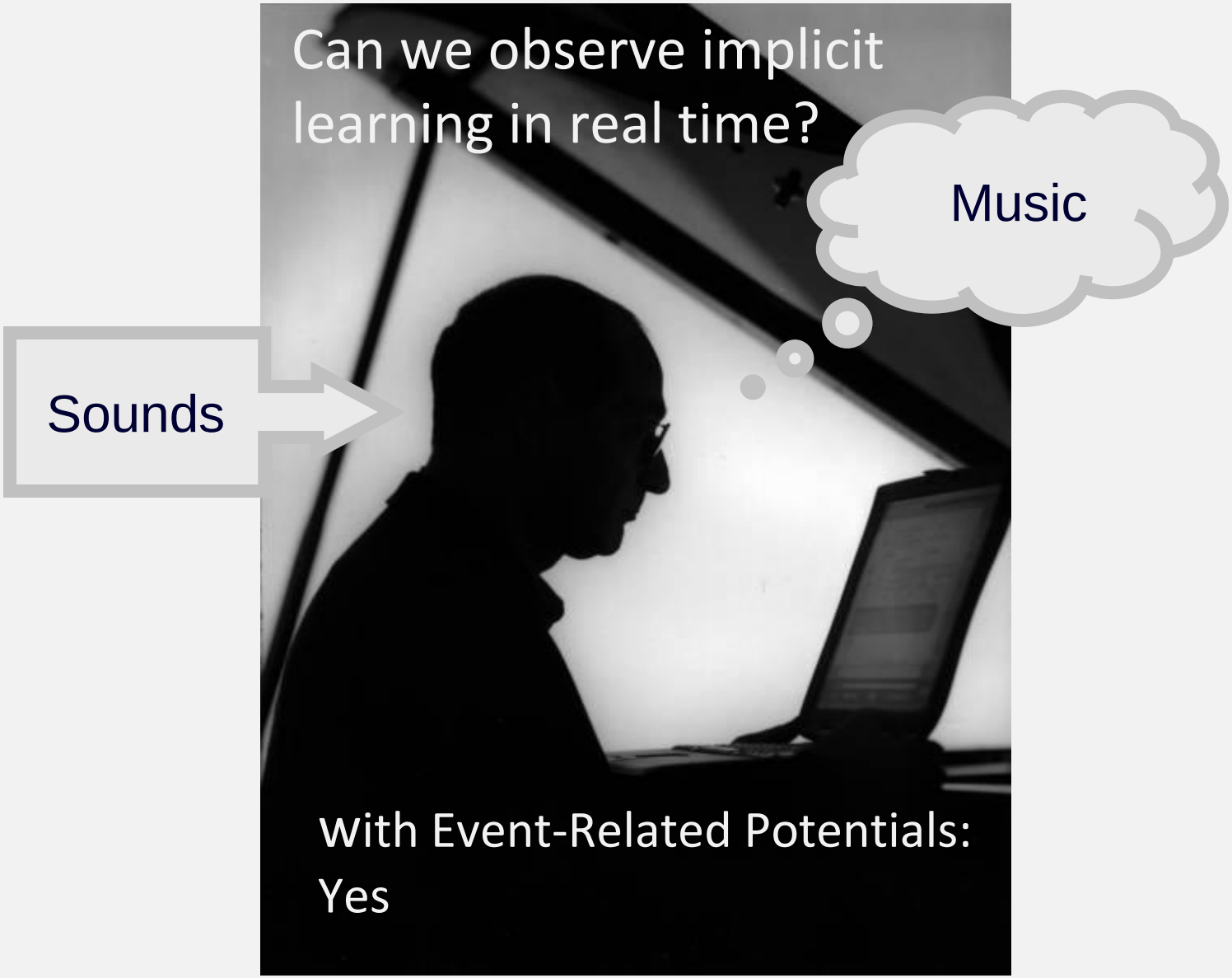
Loui, Wessel & Hudson Kam, in press.

Correlating ratings with exposure

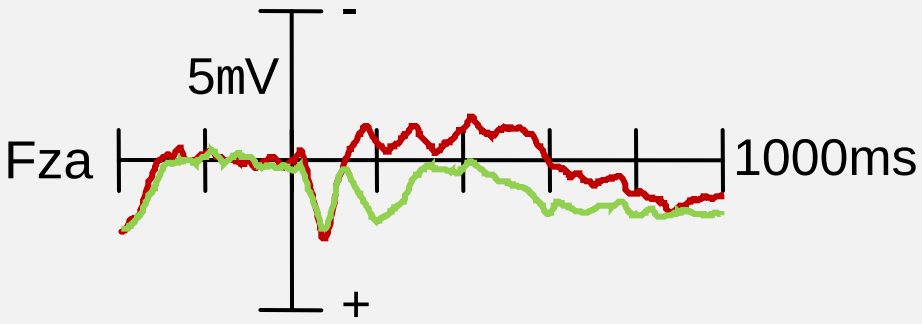


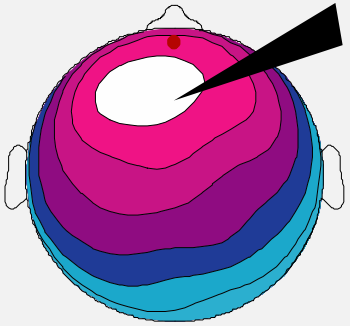
Loui, Wessel & Hudson Kam, in press.

Sounds give rise to implicit learning of music



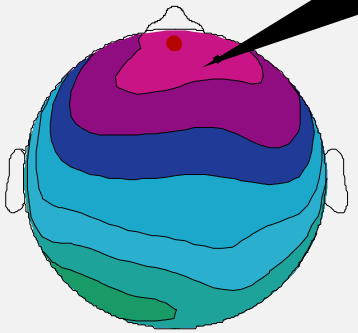
Event-Related Potentials can measure brain activity – Western music





Early Anterior Negativity

150-200ms



Late Negativity

500-550ms

Deviant

Standard

Loui et al, 2005

Event-Related Potentials can measure brain activity in the Bohlen Pierce scale

- Experiment design:

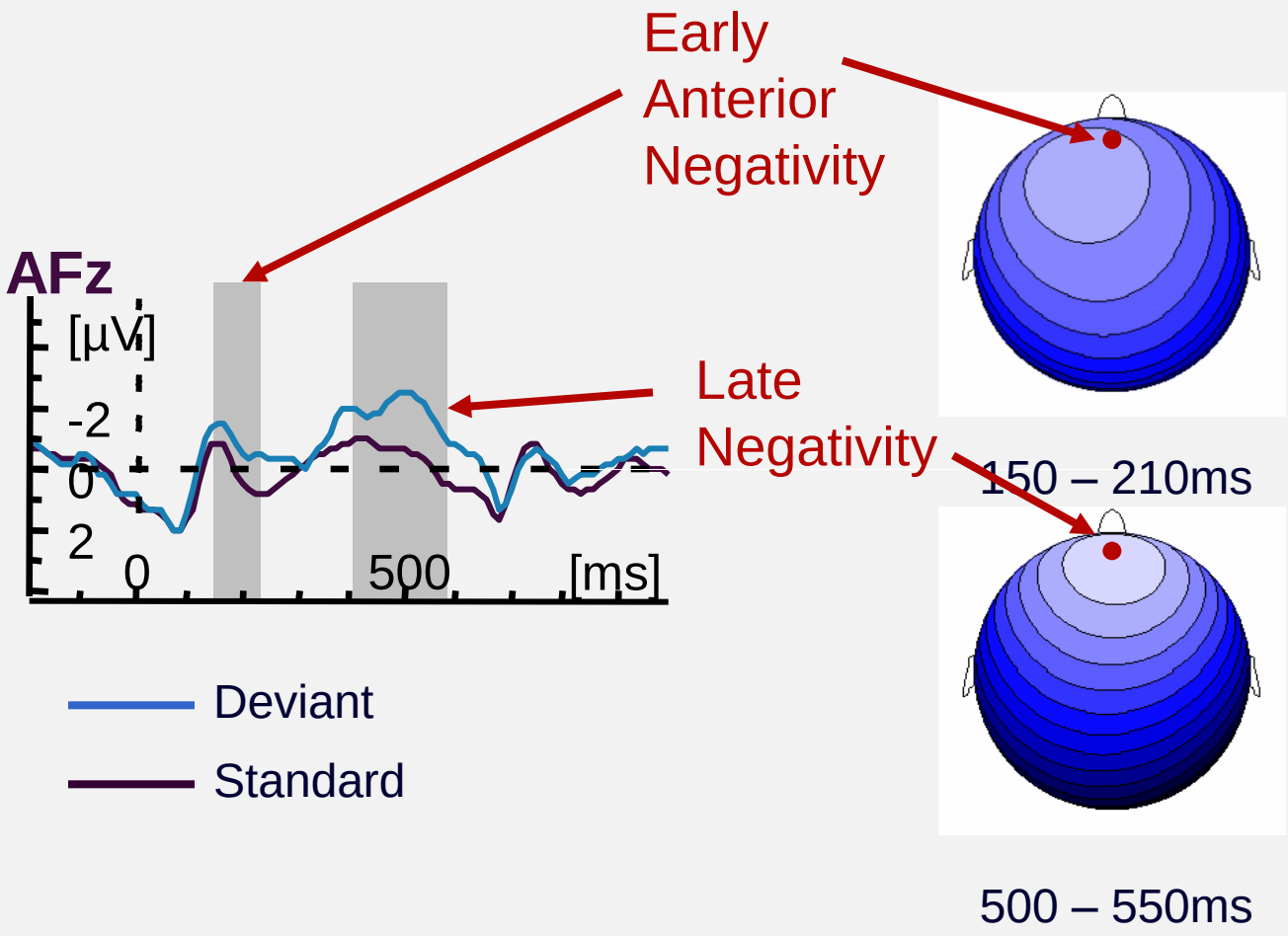
  Chord progressions:

  - Standard 70% 
  - Deviant 20% 
  - Fadeout 10% 

- Amplitude change detection task
  - Attending to auditory stimuli but not to harmony
  - Dissociating perception from decision-making

Loui, Wu, Wessel, & Knight, 2009.

ERP responses to Bohlen-Pierce scale



ERPs for improbable chords in B-P scale elicit EAN and LN.

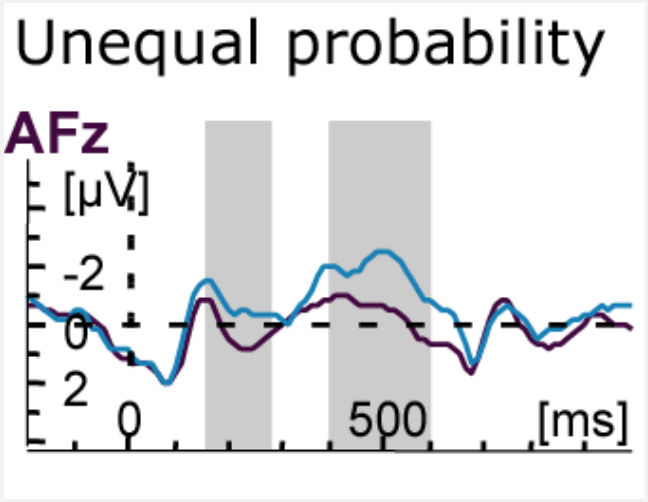
Loui, Wu, Wessel, & Knight, 2009.

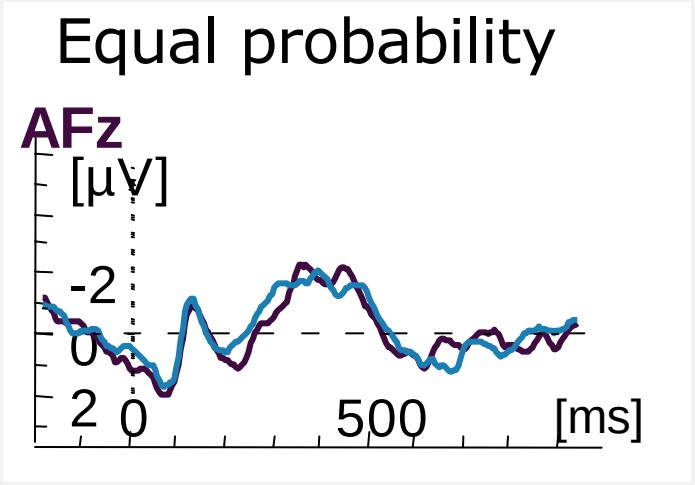
Effects driven by probability?

Probability of exposure

vs.

surface features of stimulus





Loui, Wu, Wessel, & Knight, 2009.

Learning probability during exposure

Standard Early

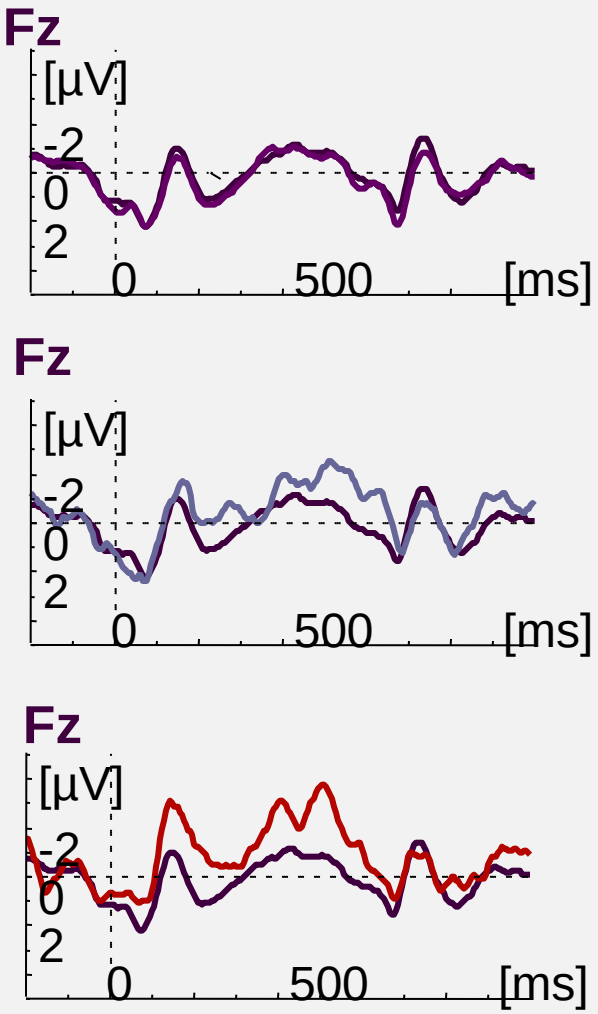
Standard Late

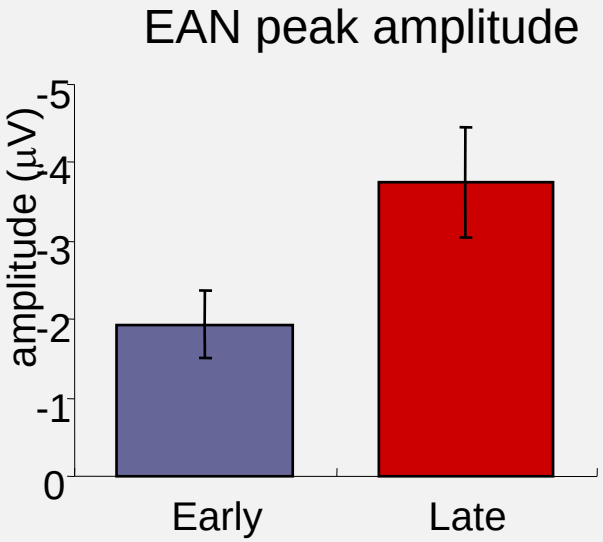
Early

Deviant Early

Late

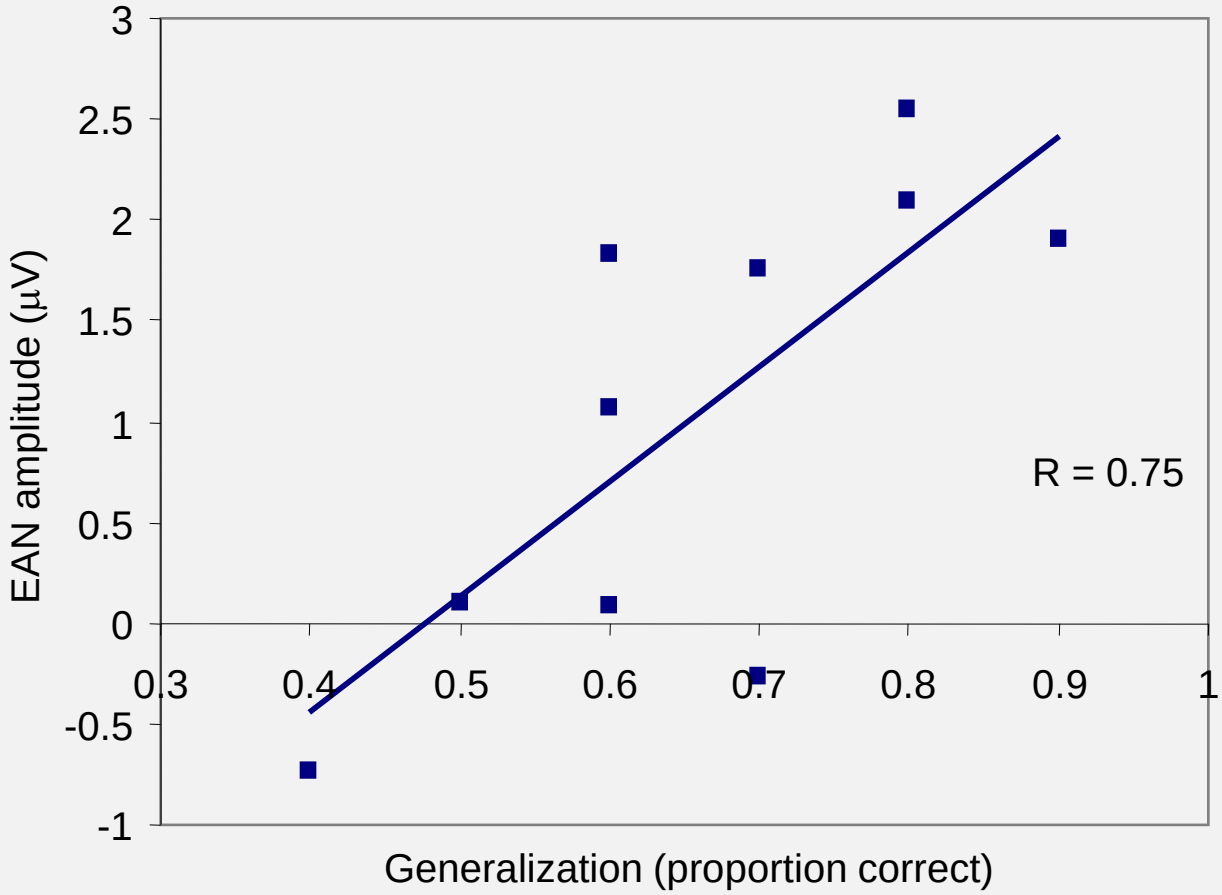
Deviant Late





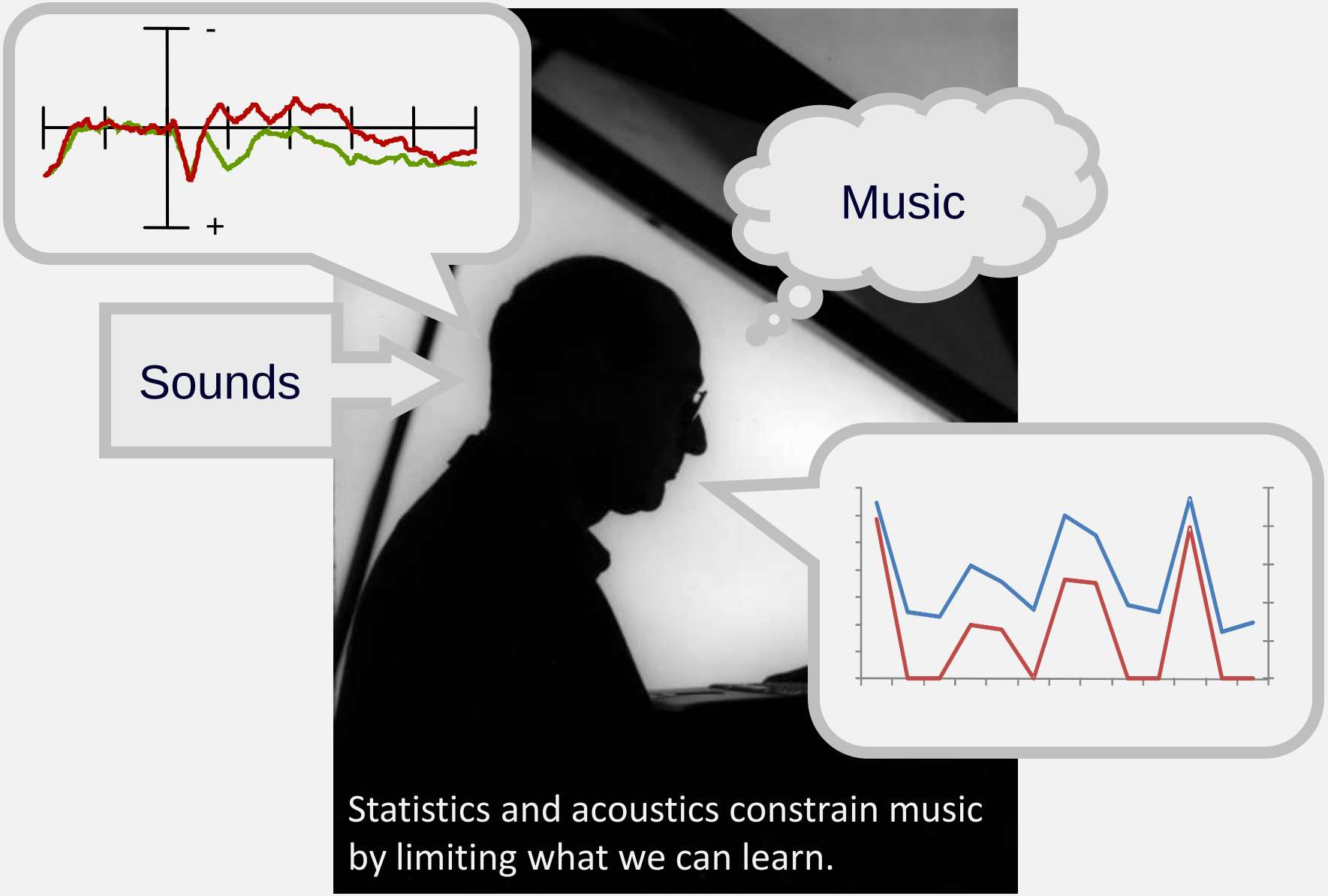
Loui, Wu, Wessel, & Knight, 2009.

ERP amplitude reflects individual differences

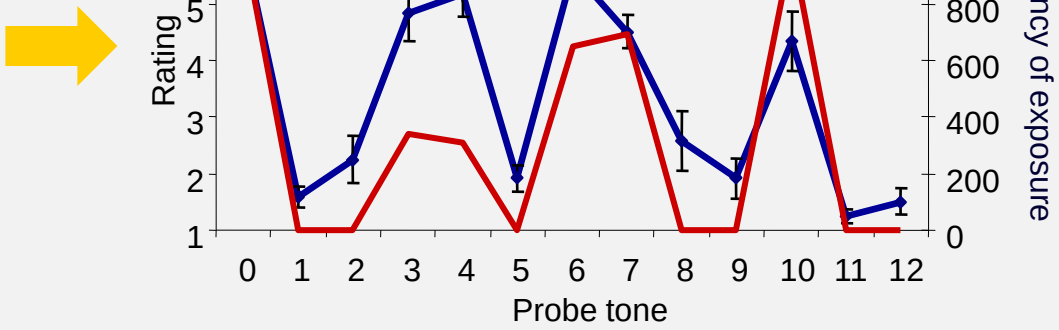


Loui, Wu, Wessel, & Knight, 2009.

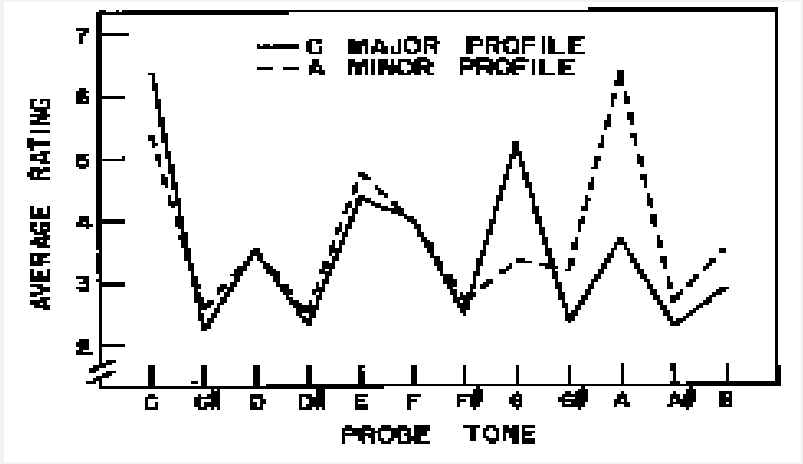
Statistics of sounds give rise to musical knowledge



Sound spectrum constrains knowledge in music



Sound spectrum constrains knowledge in music



Sound spectrum constrains knowledge in speech and language?

Acknowledgements

- David Wessel
- Erv Hafter
- Carla Hudson Kam
- Bob Knight

- Marty Woldorff (Duke)
- Carol Krumhansl (Cornell)

- Center for New Music & Audio Technologies
- Auditory Perception Lab
- Language & Learning Lab
- Knight Lab
- UC Berkeley Psychology

- Research Assistants

Elaine Wu
Pearl Chen
Judy Wang
Young Lee
Charles Li
Shaochen Wu

CNMAT