



# Psychoacoustic Influences on the Neural Correlates of Music-Syntactic Processing

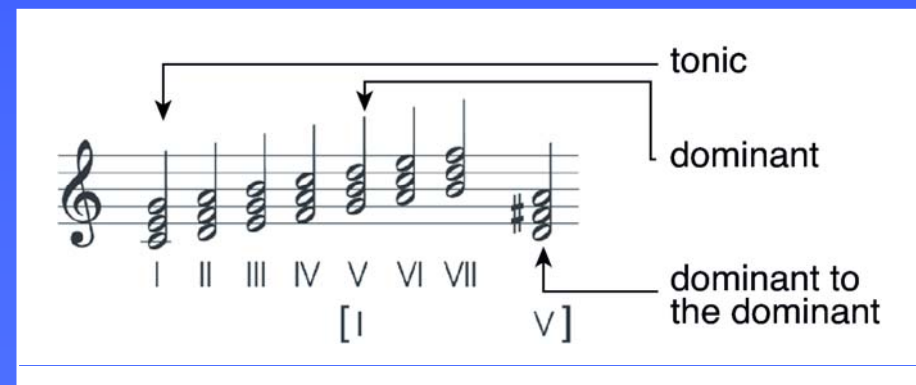
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# Musical Syntax

Music is...

- organized of perceptually discrete elements
- structured according to syntactic regularities  
(Koelsch, 2005; Patel, 2003; Tillmann, Bharucha & Bigand, 2000)
- harmonic structure – arrangement of chord functions



# Music-Syntactic Processing

- violation of music-syntactic regularities usually elicits ERAN and N5

(Koelsch, 2005; Koelsch, Gunter, Friederici, & Schröger, 2000; Leino, Brattico, Tervaniemi, & Vuust, 2007; Loui, Grent-'t-Jong, Torpey, & Woldorff, 2005)

- ERAN can be elicited by expressive music

(Koelsch & Mulder, 2002; Steinbeis, Koelsch, & Sloboda, 2006)

- ERAN larger in musicians

(Jentschke, Koelsch, & Friederici, 2005; Koelsch, Fritz, Schulze, Alsop, & Schlaug, 2005; Koelsch, Schmidt, & Kansok, 2002)

# Cognitive vs. Sensory Processing

- syntactic regularities and acoustic factors are closely intertwined
- several experimental paradigms tried to disentangle “sensory” and “cognitive” mechanisms  
(Bigand, Madurell, Tillmann, & Pineau, 1999; Bigand & Pineau, 1997; Regnault, Bigand, & Besson, 2001; Tekman & Bharucha, 1998)
- regular and irregular chords in the previous experiments had sensory differences

# Overview

- Experiment I: Untangling syntactic and sensory processing
- Experiment II: Influences of short-term experience on music-syntactic processing
- Experiment III: Music-syntactic processing of chord sequences and melodies
- Development of music-syntactic processing

# Stimuli

- minimize acoustic differences between music-syntactically regular and irregular chords
- regular chord sequence  
(ending on a tonic)
- irregular chord sequence  
(ending on a dominant to the dominant)
- irregular chord sequence  
(ending on a supertonic)

The image displays three musical staves, each representing a different chord sequence in 2/4 time. The first staff shows a regular sequence ending on a tonic chord (F#m), indicated by a single speaker icon. The second staff shows an irregular sequence ending on a dominant chord (A), indicated by a single speaker icon. The third staff shows an irregular sequence ending on a supertonic chord (G), indicated by two speaker icons. Arrows point to the final chord in each sequence.

# Experiment I: Untangling syntactic and sensory processing

# Experiment I – Stimuli

- minimize acoustic differences between music-syntactically regular and irregular chords
- regular chord sequence  
(ending on a tonic)
- irregular chord sequence  
(ending on a dominant to the dominant)
- irregular chord sequence  
(ending on a supertonic)

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# Experiment I – Acoustic Differences?

- pitch commonality between penultimate and ultimate chord

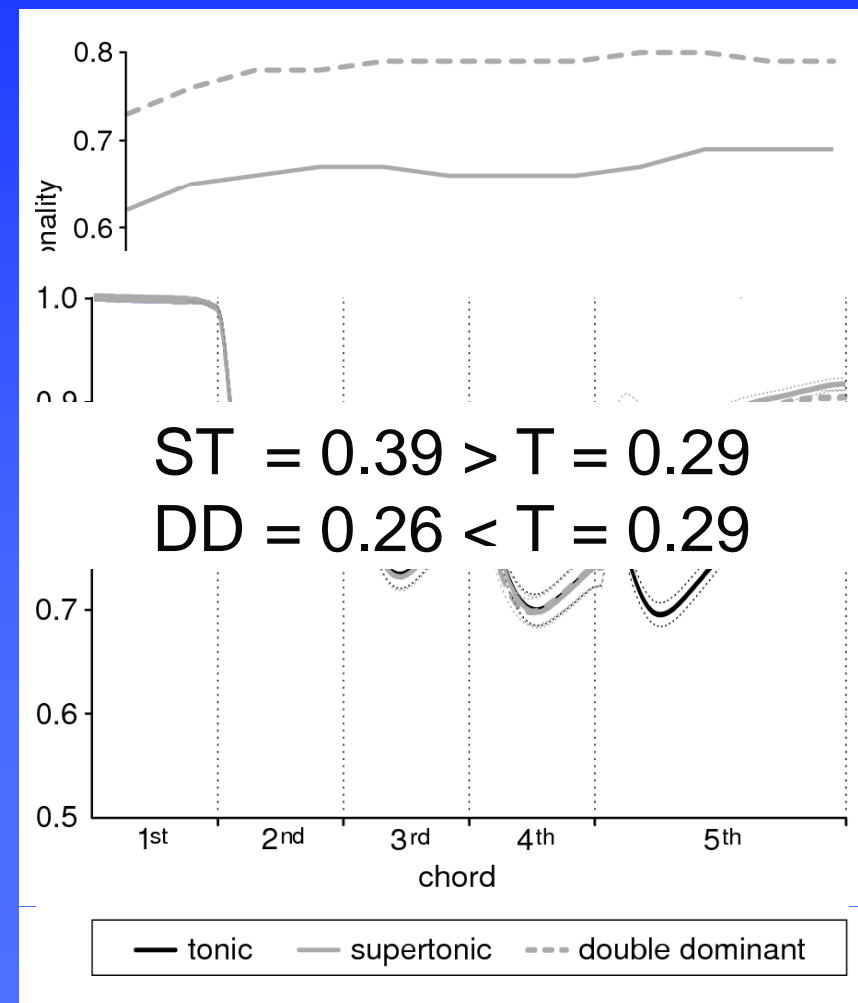
(Parncutt, 1989; Thompson & Parncutt, 1997)

- roughness

(Bigand, Parncutt, Lehrdahl, 1996)

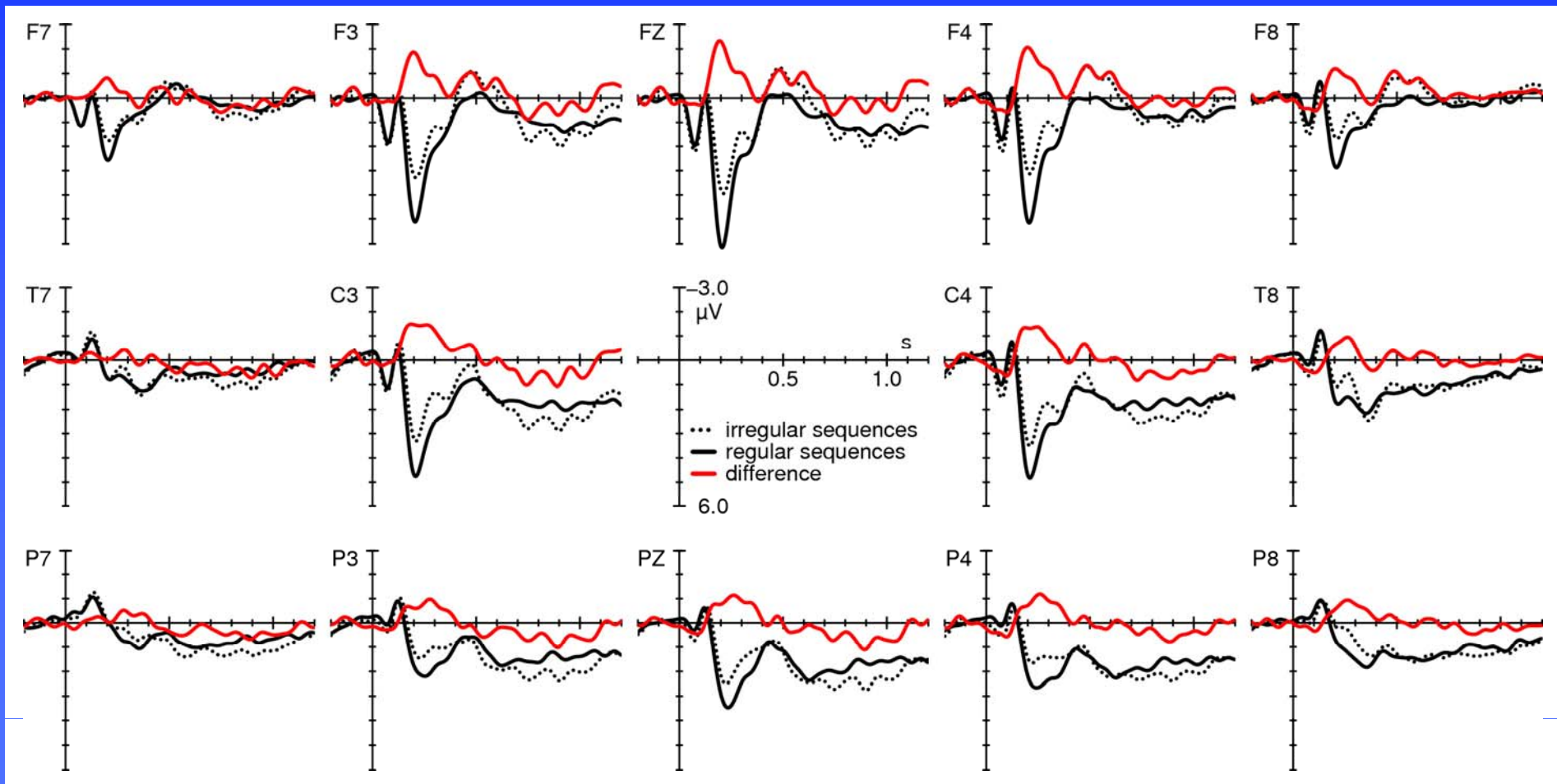
- acoustic congruency with auditory sensory memory traces

(Leman, Lesaffre, Tanghe, 2005)

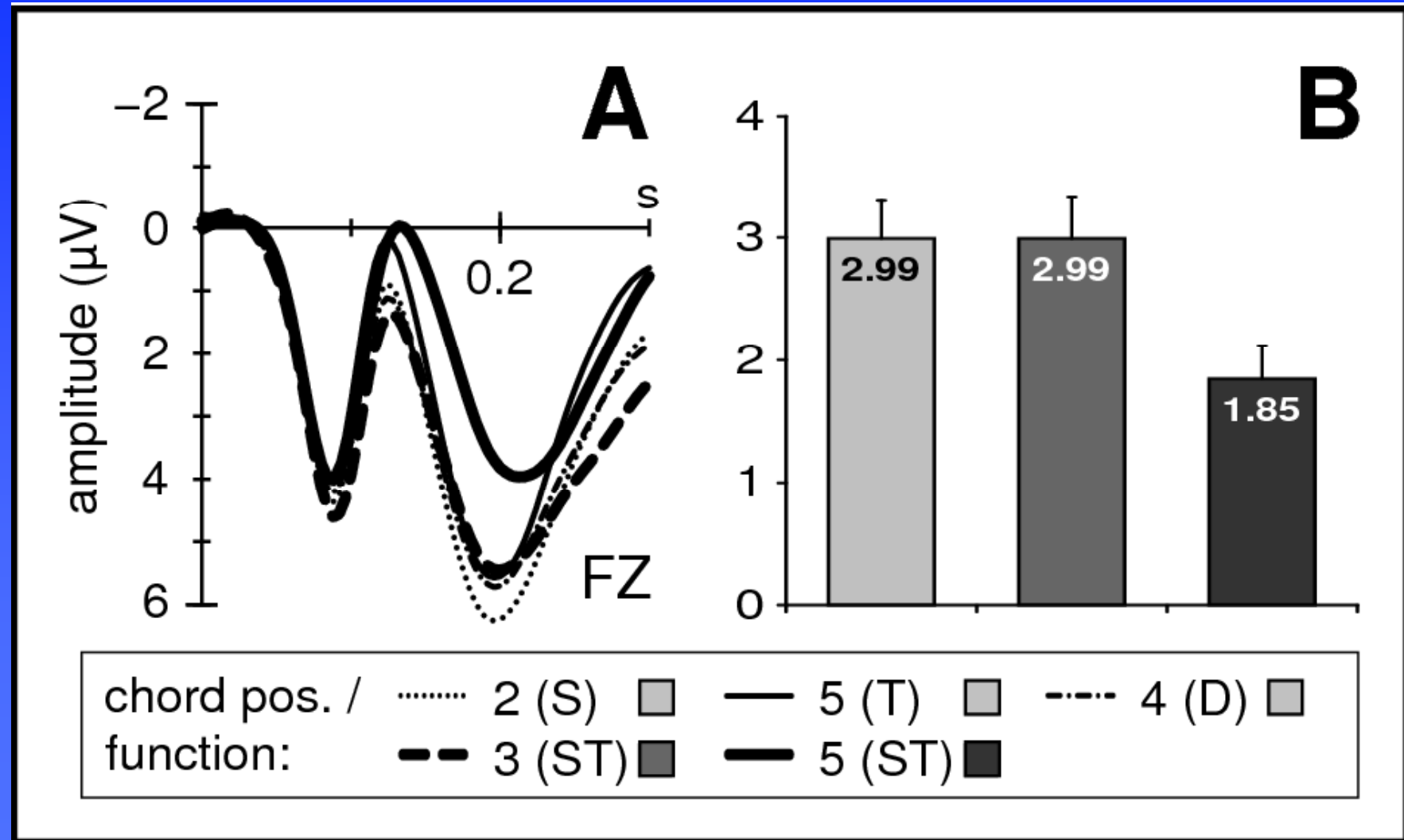


# Experiment I - Results

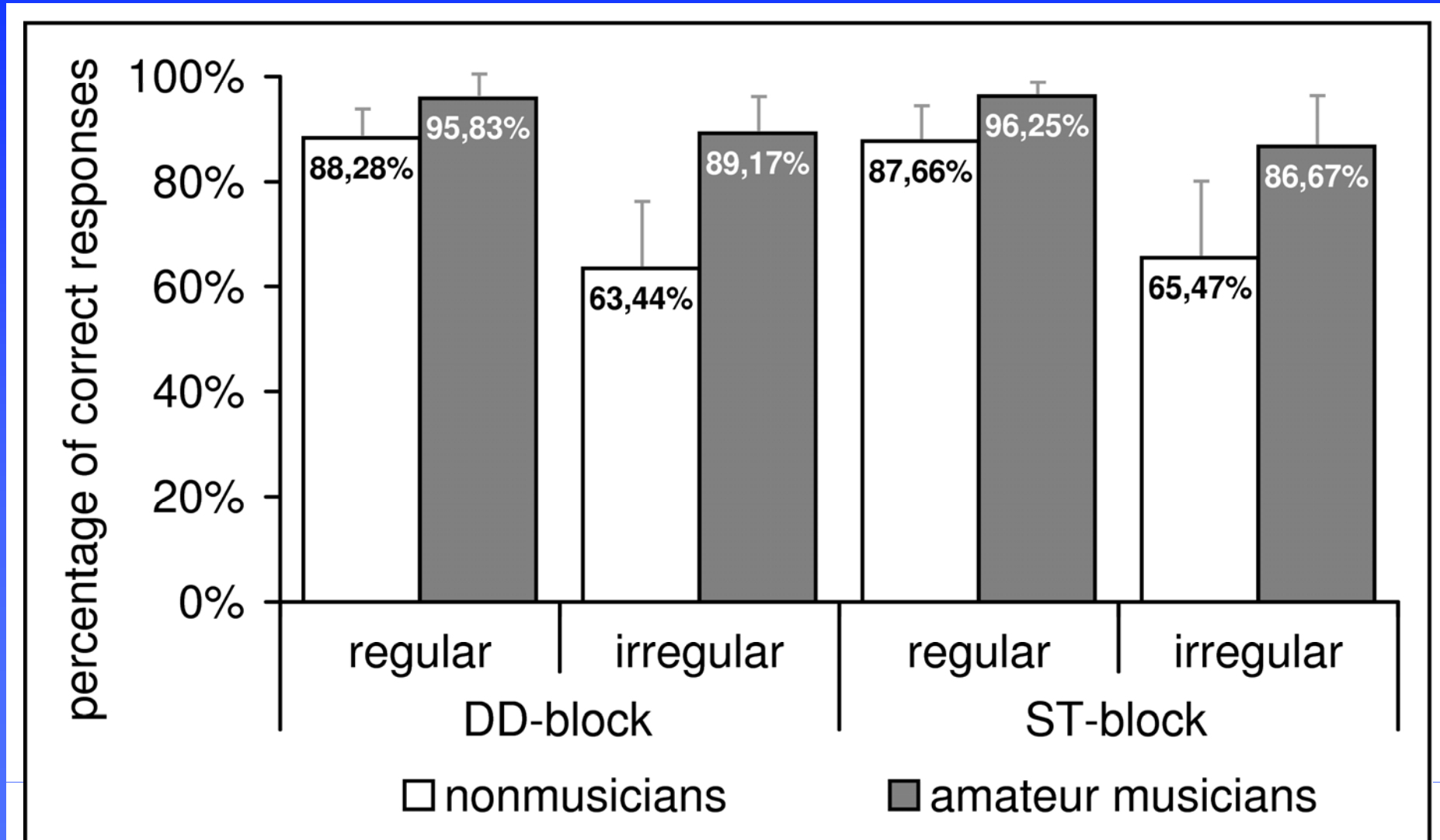
Dependent on their dominant hemisphere regular sequences:



# Experiment I - Results



# Experiment I - Results



# Experiment I - Discussion

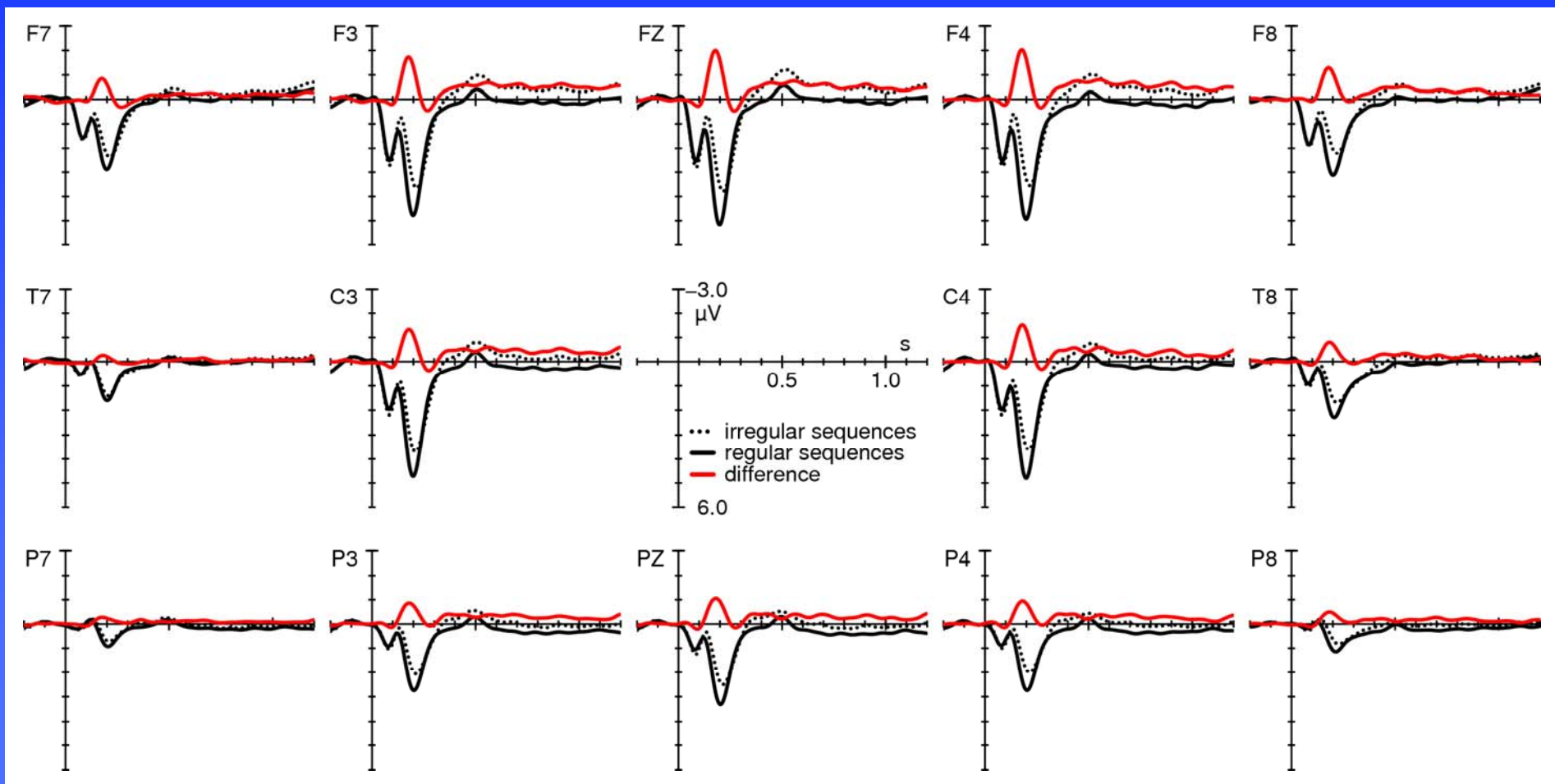
- neurophysiological correlates were present even though irregular sequences were acoustically even more similar
- same chord function elicited different brain responses depending on the context
- amateur musicians: neurophysiological response and behavioural performance enhanced

# Experiment II: Influences of short-term experience on music-syntactic processing

# Experiment II – Short-term influence?

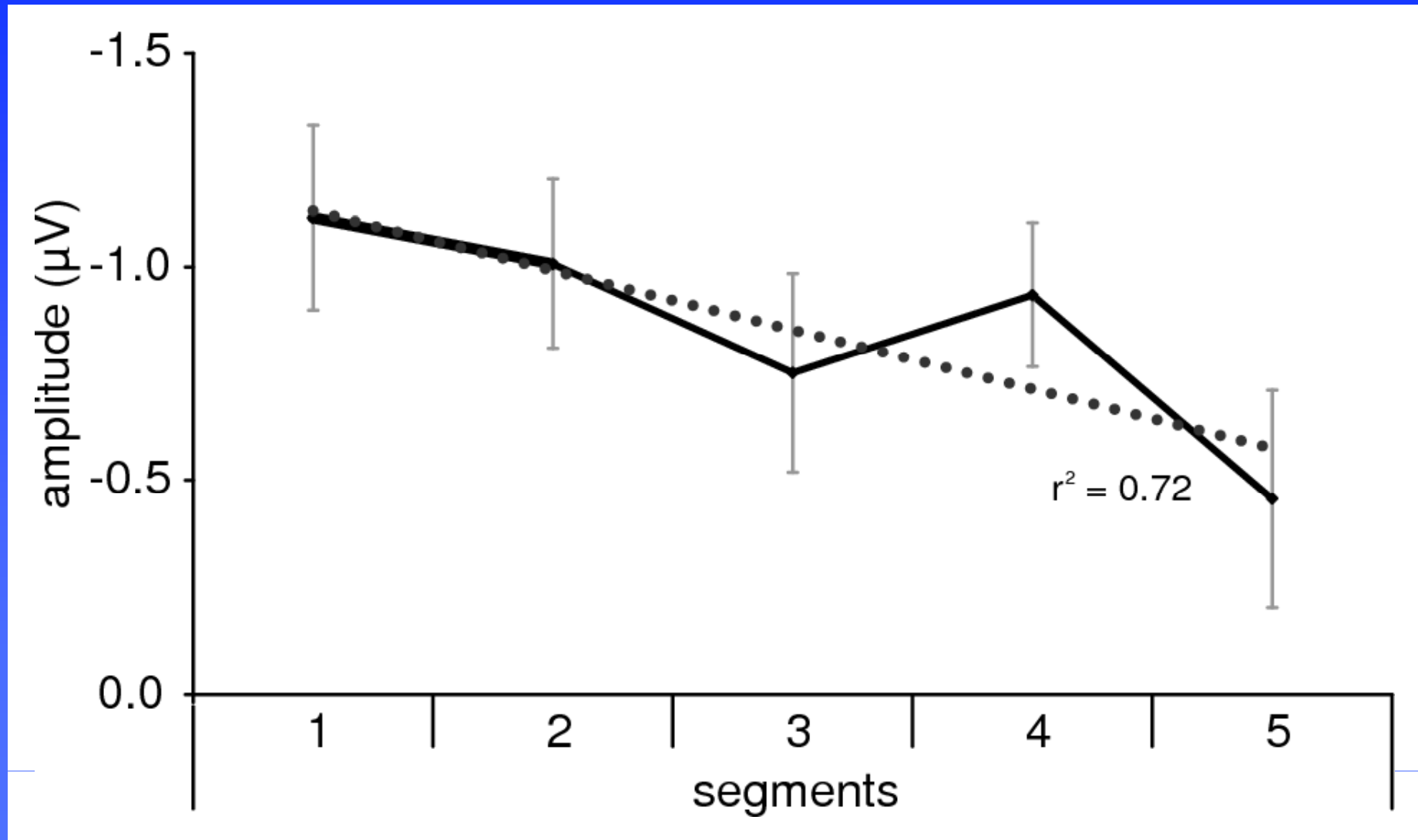
- syntactic regularities: grounded on acoustical principles and culture-specifics acquired through implicit learning  
(Leman, 2000; Bharucha & Krumhansl, 1983; Tillmann, Bharucha & Bigand, 2000)
- long-term experience: influences of musical training on music-syntactic processing  
(Koelsch, Schmidt, Kansok, 2002; Bigand et al., 1999; Koelsch, Fritz, Schulze, Alsop, & Schlaug, 2005)
- short-term effects?

# Experiment II - Results





# Experiment II - Results



# Experiment II - Discussion

- ERAN amplitude decreased over time
- ERAN still present after about 2 hours
- short-term experience can profoundly influence music-syntactic processing

# Experiment III: Music-syntactic processing of chord sequences and melodies

# Experiment III – Tones vs. Chords?

- processing of music-syntactic regularities was tested with chord sequences and melodies  
(Koelsch et al., 2000; Leino et al., 2005; Loui, Grent-'t-Jong, Torpey, & Woldorff, 2005 vs. Besson & Faita, 1995; Miranda & Ullmann, 2007)
- elicited the most salient (upper) voice the neurophysiological response?

# Experiment III - Stimuli

## Chord sequences

## Tone sequences

regular  
(tonic)



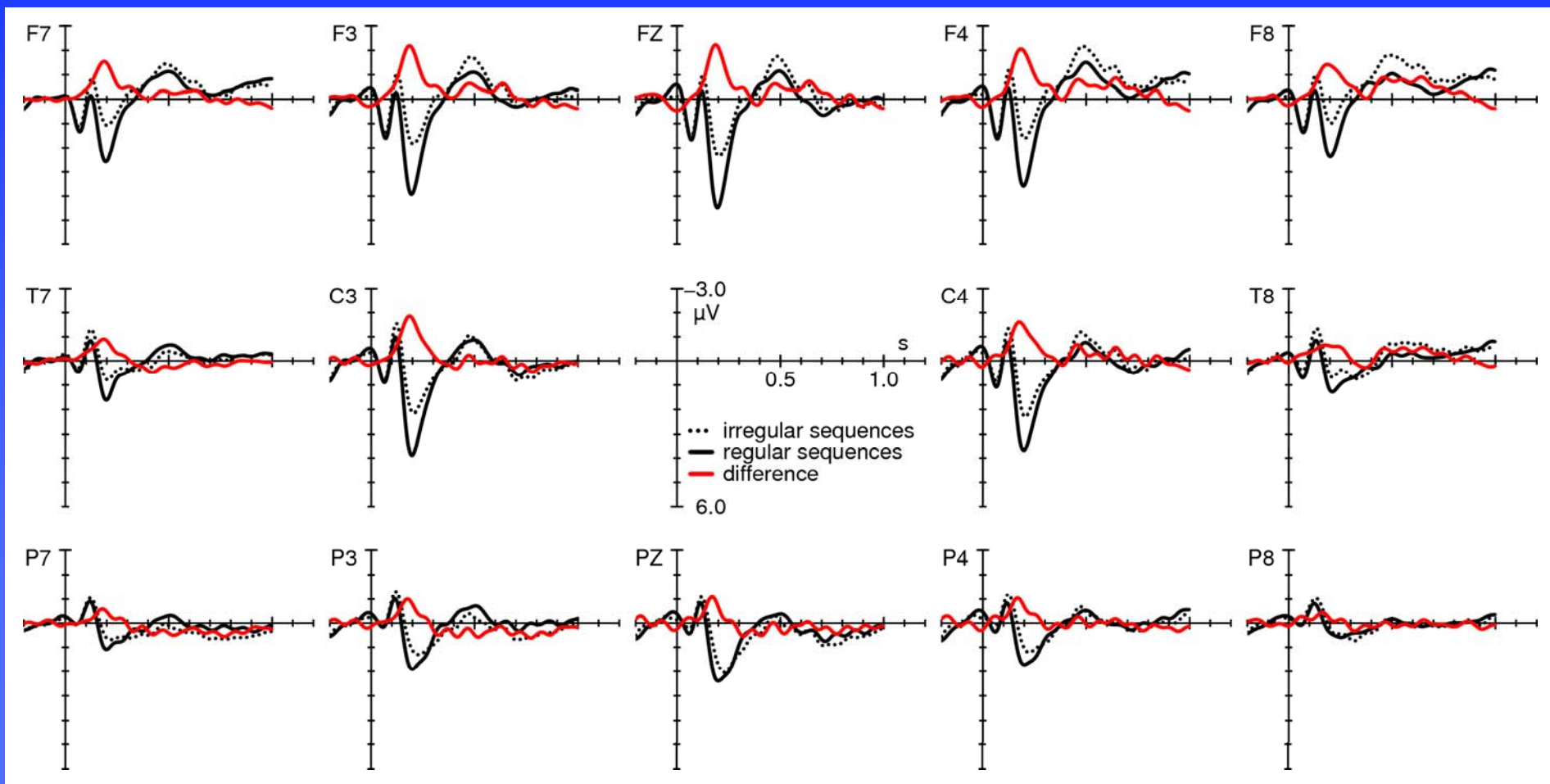
irregular  
(domin. to  
the domin.)



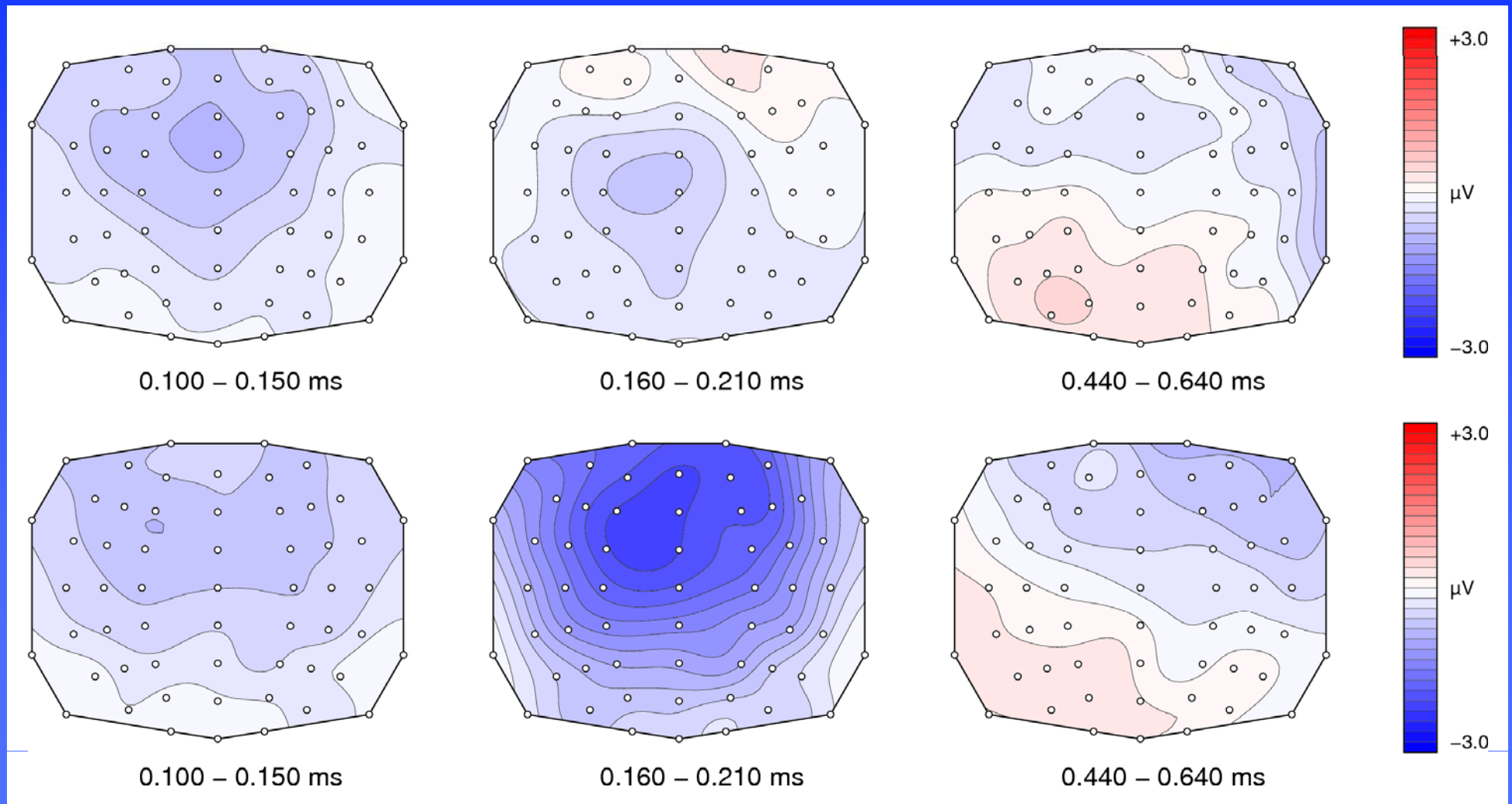
irregular  
(supertonic)



# Experiment III - Results



# Experiment III - Results



# Experiment III - Discussion

- different neurophysiological responses to the two classes of stimuli
- difference for an earlier time window in the melodies
- more sustained to the chord sequences
- later processes of harmonic integration similar

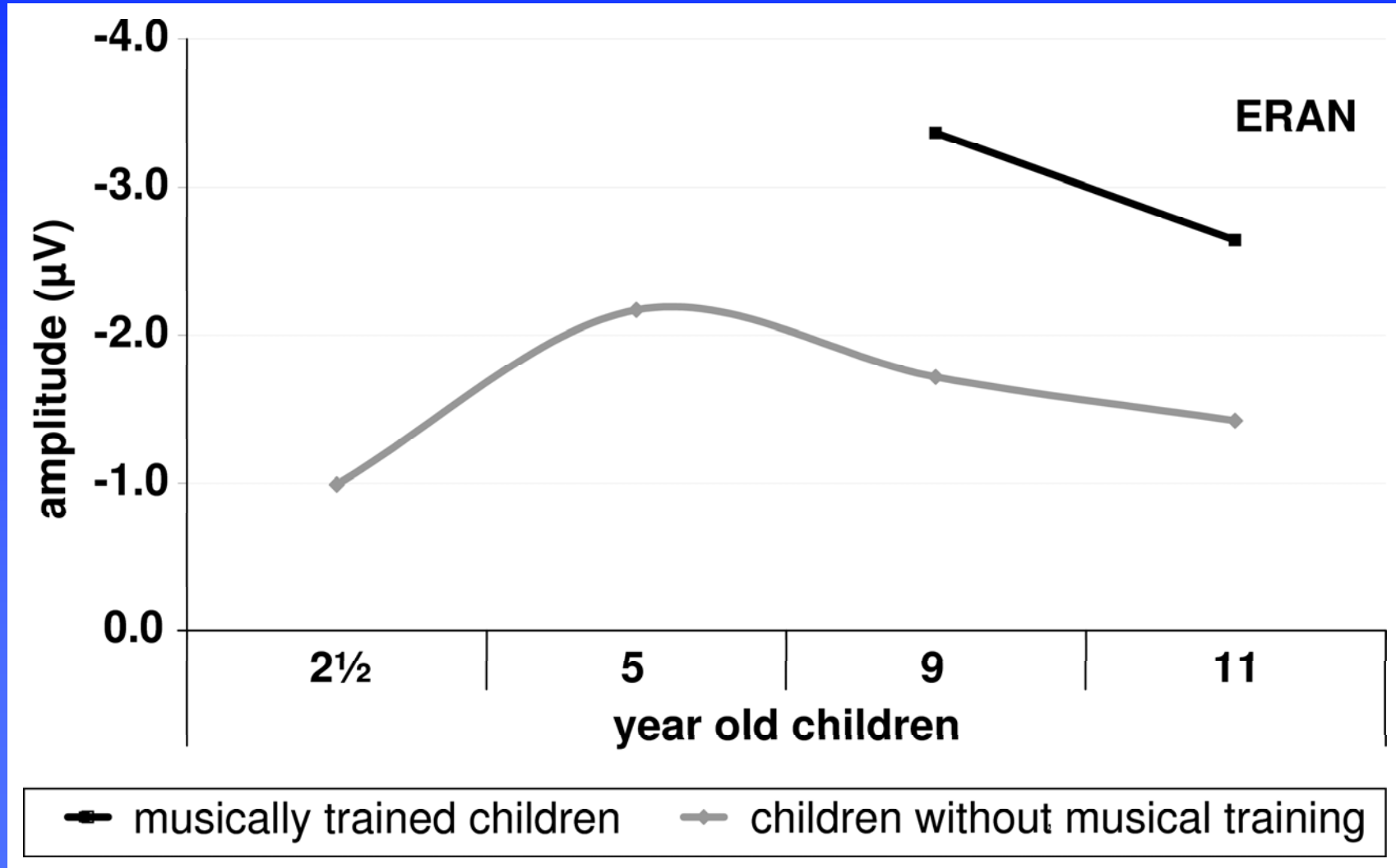


# Development of music- syntactic processing

# Developmental Aspects

- investigate music-syntactic processing in children of different age groups
- when become these processes established
- influences of musical training in children

# Developmental Aspects - Results

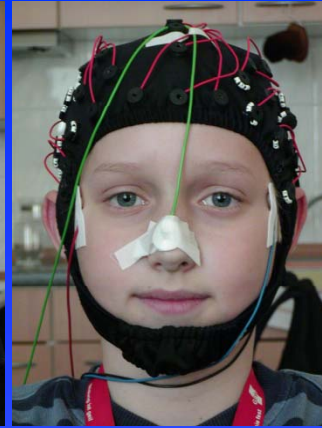
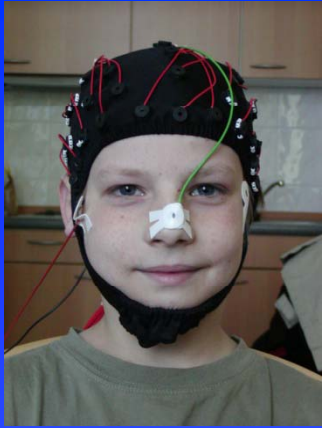


# Developmental Aspects – Discussion

- knowledge of music-syntactic regularities becomes established early in life
- relatively high developmental stability of music-syntactic processing
- influences of musical training on the neural correlates of syntax processing

# Summary

- music-syntactic processing is not necessarily influenced by acoustical features
- short-term experiences influence music-syntactic processing
- music-syntactic processing of chord sequences and melodies differs with regard to the involved processes
- music-syntactic processing is established quite early and is relatively stable during development



Thank you  
for your attention!

