Automatic representation of pitch in human auditory cortex is linear and not helical

Tamar Regev[1] Israel Nelken[1,3] Leon Y. Deouell[1,2]

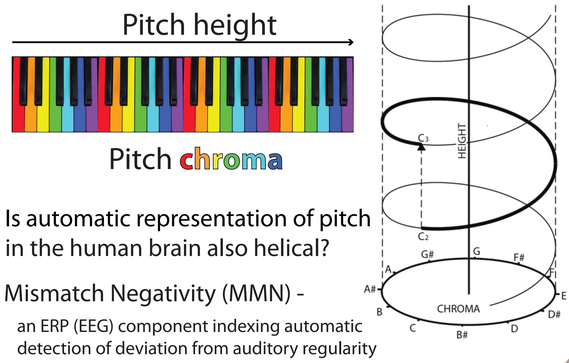
1- Edmond and Lily Safra Center for Brain Sciences, 2- Department of Psychology, 3- Department of Neurobiology, The Hebrew University of Jerusalem, Israel. Contact - tamaregev@gmail.com

THE HEBREW UNIVERSITY OF JERUSALEM

ELSC The Edmond & Lily Safra Center for Brain Sciences

Introduction

- Pitch is frequently described as two-dimensional[1,2,3]:

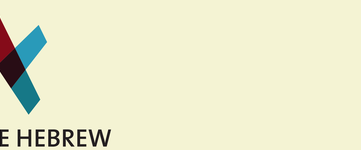


- Is automatic representation of pitch in the human brain also helical?
- Mismatch Negativity (MMN) -
  an ERP (EEG) component indexing automatic detection of deviation from auditory regularity

Method

Discriminating pure tones across 4 octaves based on pitch chroma:

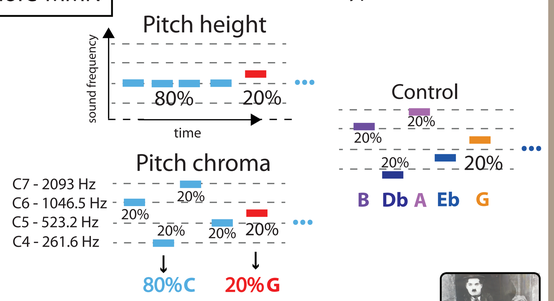
Ear training



27 musicians OR 30 musicians

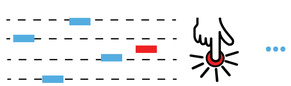
'Ignore' MMN

MMN Block types:



... while viewing a silent film

'Attend chroma'

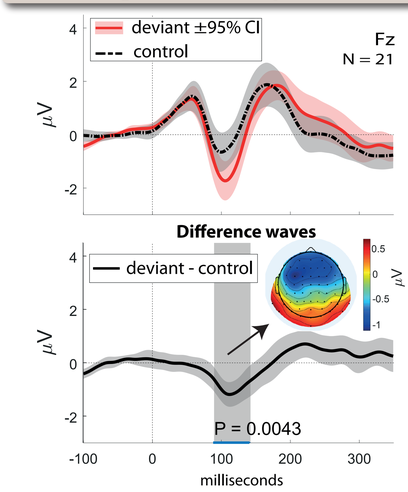


Press a button when the chroma deviant appears

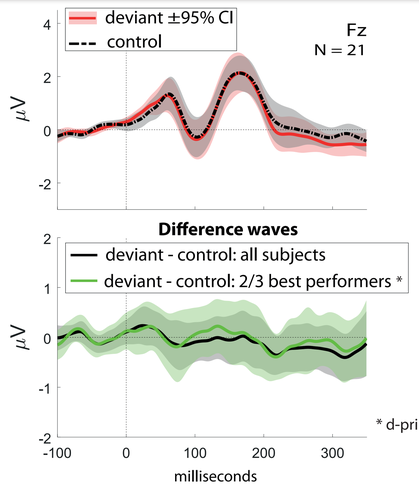
Results

Experiment 1: C vs. G

Pitch height deviation produces an MMN



Pitch chroma deviation does not produce an MMN



* d-prime > 3.48

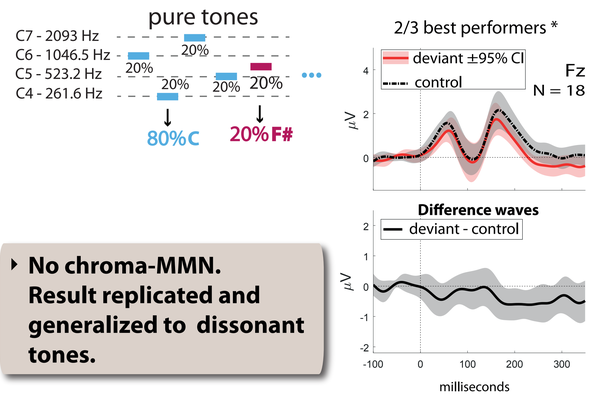
...Even in perfect performers

Results

Is the absence of chroma-MMN in Experiment 1 because C and G are consonant? (No)

Experiment 2: C vs. F#

- C vs. G - 'perfect fifth' - most consonant interval
- C vs. F# - 'tritone' - most dissonant interval



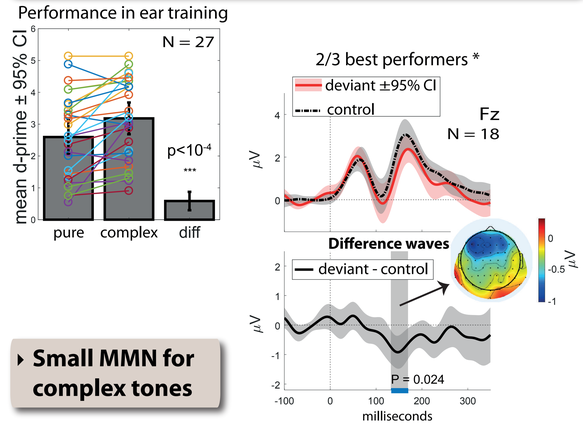
No chroma-MMN. Result replicated and generalized to dissonant tones.

* d-prime > 3.3

Results

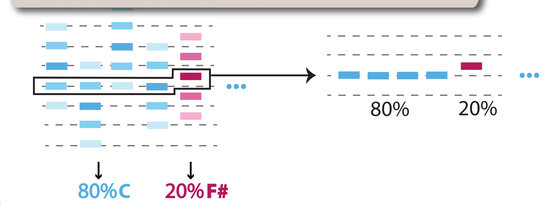
- What about complex tones?

Chroma of complex tones is easier to discriminate



Small MMN for complex tones

Can be due to spectral overlap between complex tones having the same chroma



Conclusion

Pitch height — proceesed automatically and pre-attentively ⟷ **Pitch chroma** — processed later, requires attention

- Discriminating pitch chroma of pure tones can be learned, but we find no evidence that it is processed autmatically and pre-attentively.
- Processing chroma may require higher cognitive processes.
- Pitch chroma of complex tones is easier to perceive and might rely on multiple pitch height representations, due to spectral overlap.

[1] M. Moerel, F. De Martino, R. Santoro, E. Yacoub, and E. Formisano, "Representation of pitch chroma by multi-peak spectral tuning in human auditory cortex," Neuroimage, vol. 106, pp. 161–169, 2015.
[2] J. D. Warren, S. Uppenkamp, R. D. Patterson, and T. D. Griffiths, "Separating pitch chroma and pitch height in the human brain.," Proc. Natl. Acad. Sci. U. S. A., vol. 100, no. 17, pp. 10038–42, Aug. 2003.
[3] P. M. Briley, C. Breakey, and K. Krumbholz, "Evidence for Pitch Chroma Mapping in Human Auditory Cortex," Cereb. Cortex, vol. 23, no. 11, pp. 2601–2610, 2012.