Opposite Lateralization of Prosodic Processing in Musicians and Nonmusicians

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Background

- Prosody processing
  - Reports about language prosody processing are ambivalent in regard to hemispheric prevalence [1, 2]
  - Hemisphere involved dependent on kind of tonal elements of language prosody [3]
- Processing tonal elements in music and in language
  - Advantage for musicians vs. non-musicians [4]
  - Musicians: more bilateral activity pattern [5]
  - Nonmusicians: more right hemispheric dominance [5, 6]
- Long-term musicaltraining causes neural plasticity changes [7-9]
- Previous EEG study by Eckstein and Friederici [10]
  - Broadly distributed negativity between 300-500ms aligned to word onset for prosodic incongruities
- Question: Does the lateralization of prosody processing change with musical expertise?
  →Localization of prosody processing with high temporal resolution

Hypotheses

1. Musicians show a behavioral 'tonal advantage' in the processing of prosody and melody
2. Advantage reflected in different patterns of activation/ lateralization and activation strength

Participants

- 18 nonmusicians and 18 musicians with at least 5 years of musical training (age range 18-35 years)
- Right handed according to Edinburgh handedness test (LQ > 80)

Methods

- Stimuli taken from Eckstein and Friederici [10]
  - Sentences of six types (four conditions plus two filler)
  - Phrase-structure and intonation contour manipulated in a 2x2 design
- Participants' task: judge the correctness of each sentence in regard to either syntax or prosody
- Data recording with 306 channel MEG , 2 EOG, 1 ECG 1000 Hz sampling rate, DC-330 Hz online filtering Maxfilter® Elekta Neuromag for noise suppression, movement correction and head position alignment
- MEG data analysis based at an average of more than 90% of useable trials
- Individual volume conductor models + source space (cortical layer and T1-weighted MRI) as segmented by Freesurfer [11], MNE solutions by MNE [12]

Stimuli

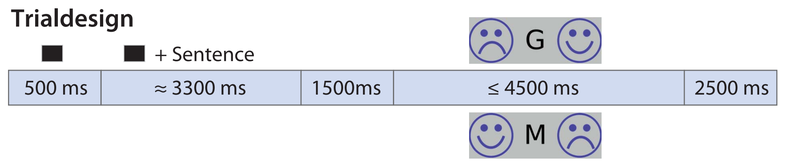
- 48 items/condition
- 4 blocks with 12 test items/condition
  + 24 filler items

Tobias sieht, dass der Dackel zum **Futter** hinsaust.
(Tobias sees, that the dachshund towards the chow dashes.)

Tobias sieht, dass der Dackel zum **Futtert** hinsaust.
(Tobias sees, that the dachshund towards the chows dashes.)

Prosody \ Syntax	correct	incorrect
correct	CC	CS
incorrect	PC	PS

Trialdesign



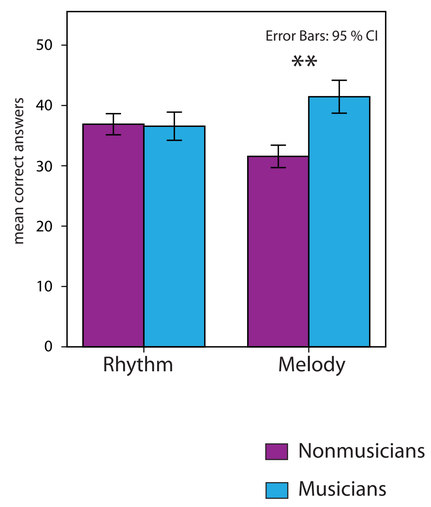
- Anatomical definition of regions of interest (ROIs) within the cortical layer, mean activity time courses for further statistical analysis
- Three-way mixed ANOVA for each ROI and time window with factors:
  - Syntax (correct/violated)
  - Prosody (correct/incorrect)
  - Hemisphere (left/right)
- Control for multiple comparison through FDR correction for dependent factors [13]

Results

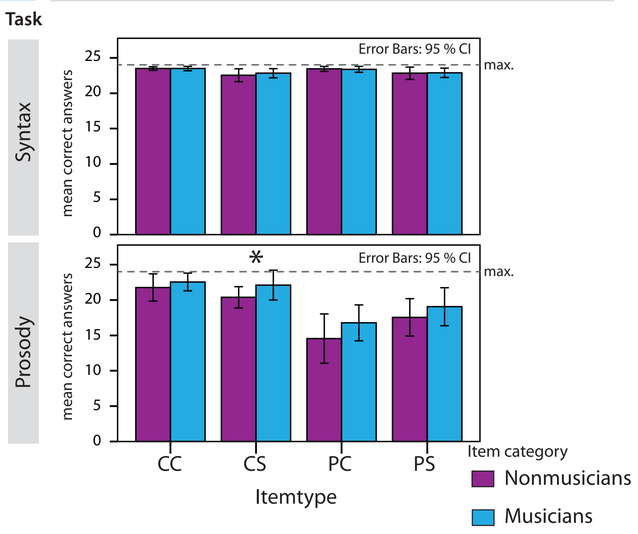
Behavioral Data

- Musical Ear Test [14]:
  - No difference between groups in comparing rhythm patterns
  - Musicians showed clear advantage in comparing melodies
- MEG experiment:
  - Syntax task: no difference between groups
  - Prosody task: trend of better performance for musicians vs. nonmusicians

1 Musical ear test



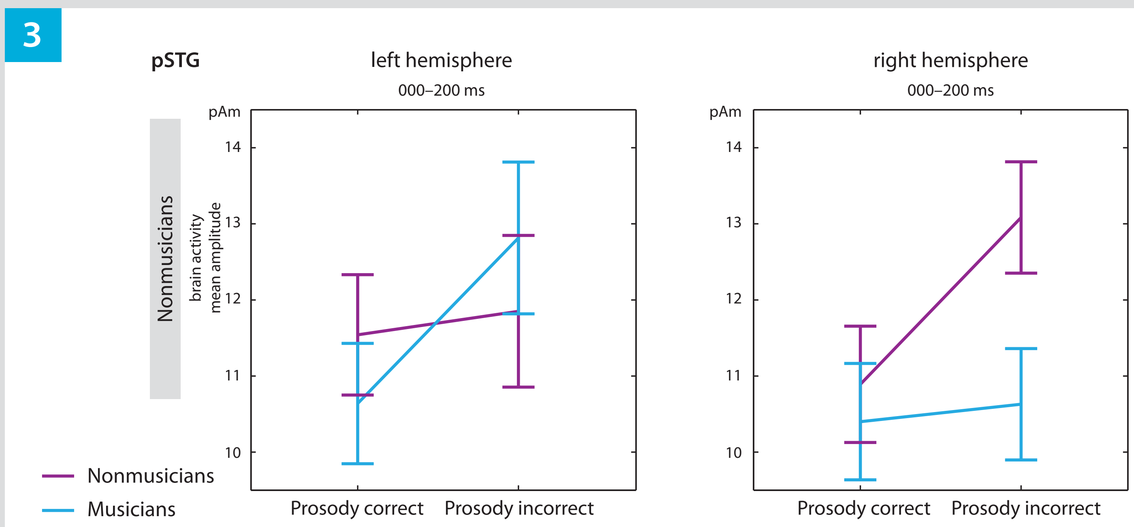
2 MEG Behavioral Data



MEG-Data

- Three-way-interaction of Prosody*Hemisphere*Group in pSTG within first 200ms after critical word onset
  - prosodic violations lead to stronger activations within left pSTG for musicians in comparison to homologue area
  - prosodic violations lead to stronger activations within right pSTG for nonmusicians in comparison to homologue area
  - no significant differences in activation strength between groups

3



4

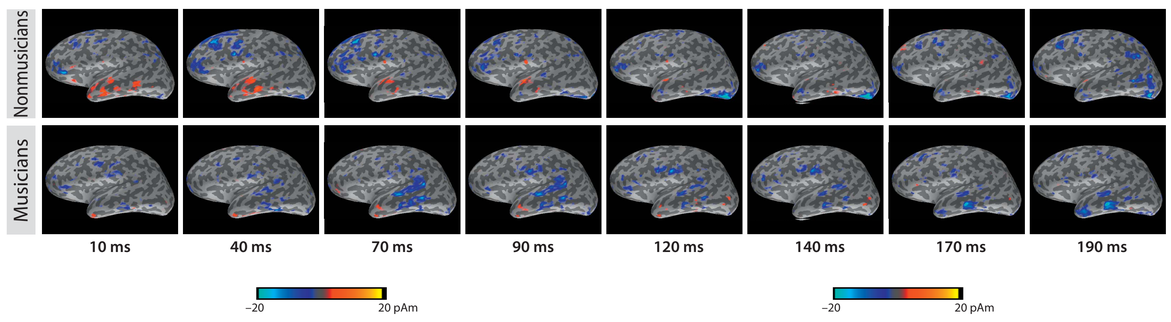
Correct Prosody > Incorrect Prosody

pSTG

Minimum Norm Estimates on inflated cortex

Correct Prosody > Incorrect Prosody

pSTG



Discussion

Hypothesis 1: Musicians show the trend of a 'tonal advantage' in prosody processing along with a clear advantage of melodic processing

Hypothesis 2: Activity patterns following prosodic violations showed opposite lateralization in pSTG: though there is no significant difference in activation strength between both group, musicians show a left-hemispheric predominance, as opposed to a right-hemispheric weighting in nonmusicians.

This finding may shed some light on the ambivalent findings of previous reports regarding the hemispheric lateralization of tonal material in spoken language. We were able to show that neural plasticity changes due to long-term musical training affects the processing of prosodic material in normal everyday language. This effect can be seen within the first 200ms after prosodic manipulation as opposite lateralized hemispheric differences between nonmusicians and musicians.

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