Pre-attentive processing of contour deviance in musicians

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Introduction: Frontal cortex is involved in both melody processing and deviance detection. The impact of musical expertise on functional capabilities of frontal brain regions, however, remains elusive. We hypothesized that professional musicians show functional differences in response to melodic deviations. Thus, we used fMRI sequences optimized for the examination of the auditory system in combination with an event-related oddball paradigm to investigated differential BOLD responses between professional musicians and non-musicians to melodic contour deviance.

Material and Methods: We investigated two groups of healthy normal hearing subjects. The first group consisted of eight professional musicians, the second of eight control subjects that did not take music lessons or have early childhood musical education and did not learn to play an instrument during their life. The contour deviance paradigm consists of a five-tone melody as standard pattern. For contour deviance the penultimate tone was replaced by the first one. The fMRI data were acquired on a 1.5 T standard clinical MRI scanner (Sonata, Siemens, Erlangen, Germany) equiped with a Sonata gradient system and a circulary polarized radio frequency headcoil. We used a recently developed novel low impact noise acquisition fMRI sequence to increase the dynamic range of BOLD signal. To explore whether there are any differences at the behavioral level in task involving discrimination of melody patterns we used the Advanced Measures of Music Audiation (AMMA).

Results: In the group comparison of the main effects between the musicians and the non-musicians, we found a significant differential response to the deviant stimuli (Figure). In musicians the deviant stimulus elicited an enhanced activation in the right ventromedial prefrontal cortex near to the opercular part of the inferior frontal gyrus and the anterior cingulate, and in left-hemispheric inferior frontal gyrus, middle temporal gyrus and superior temporal gyrus compared to musical laypersons. We found a significant positive correlation of the AMMA subscores for tonality, rhythm and the total AMMA score and the BOLD signal in the regions that showed a differential activation in the group contrast.

Discussion and Conclusion: Musicians showed a different activation pattern than non-musicians to contour deviation with an activation in the right ventromedial prefrontal cortex, bilateral inferior frontal gyrus and left superior temporal gyrus. In these regions the BOLD signal showed a significant correlation to behaviourally tested ability to discriminate changes in complex sound patterns. These results support the hypothesis that musical experience leads to specific changes of the neural mechanisms for processing melodic information and that long term training improves the decoding of pitch relation between successive notes. Our data shows that not only the primary and secondary auditory cortex but also prefrontal cortex is engaged in melody processing. Activation in the ventromedial prefrontal cortex supports the recently emerging hypothesis that this area is a node that is important for binding music with memories within an broader melody-responsive network and that this applies especially for musicians.

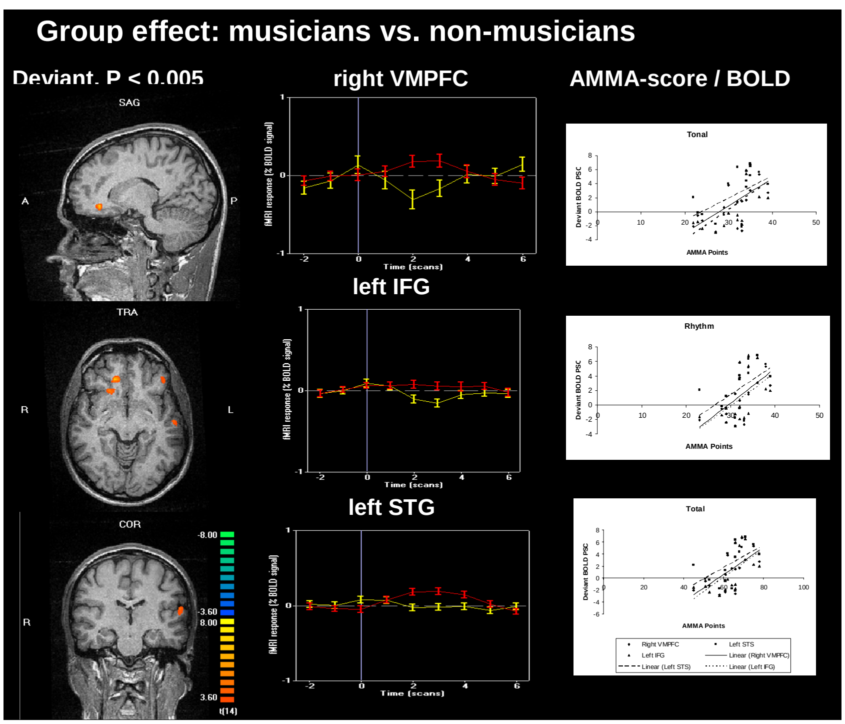

Figure:
In the figure the group effect between musicians and non-musicians is displayed. In the left column the activation due to deviance is shown. The medial column shows the event-related averaging for musicians (red) and non-musicians (yellow). In the right column the correlation between the AMMA-score and BOLD-signal-change in the regions in which a significant ($P < 0.005$) group effect was found is shown.

VMPFC = ventromedial prefrontal cortex; IFG = inferior frontal gyrus; STG = superior temporal gyrus