Preattentive auditory processing in professional musicians versus non-musicians – an fMRI study

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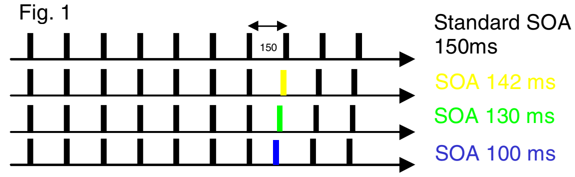
Introduction

The brain of musicians represents an interesting experimental model to investigate neuroplasticity. We investigated professional musicians using a mismatch paradigm measuring automatic encoding of deviant rhythms. The aims of this pilot study are: Which are the most usable stimuli to examine the temporal precision of acoustic perception using fMRI? Which brain areas are involved in the automatic detection of acoustic deviants? Do music experts show differences in preattentive auditory processing compared to musical laypersons?

Methods

We recruited 7 professional musicians (all experts in the field of ear-training) and 7 non-musicians, matched by age, gender, and handedness. In an fMRI-scanner, the participants were exposed to an acoustic temporal mismatch paradigm. Sine tones were presented with a standard stimulus onset asynchrony (SOA) of 150 ms. Deviant shorter SOAs with three different levels of deviance (142, 130 and 100 ms) occurred every 16 - 20 seconds (Fig. 1).

Fig. 1



Each deviant condition was repeated 12 times in a pseudorandomized order. The subjects were instructed to watch a silent movie and to ignore the presented sounds. The fMRI data were acquired on a 1.5 T standard clinical MRI scanner (Siemens, Espree). The variances of all image time series were estimated voxel-wise according to a random effects convolution-based general linear model analysis.

Results

The occurrence of sine tones presented with shorter SOAs (142, 130, 100 ms) compared to the standard SOA (150 ms) elicited a mismatch response in the planum temporale of the right hemisphere (rPT) (Fig. 2A).

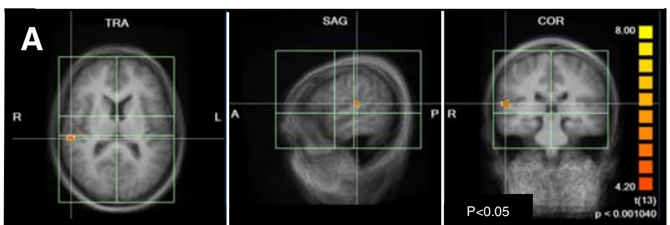


Fig. 2A Computing a linear contrast reveals that deviance (all SOAs) in the regular temporal pattern induces BOLD activity in planum temporale of the right hemisphere (rPT) in musicians and non-musicians (p < 0.05 cluster level correction).

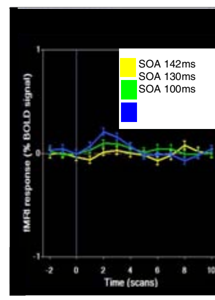


Fig. 2B Event-related averaging of BOLD signal changes in rPT elicited by deviant events shows a parametric variation of the mismatch response according to the different degrees of deviance, i.e. the greater the deviance to the regular pattern the more neural activity in rPT is induced.

This region is considered as a computational interface, which is mandatory for segregating spectrotemporal sound patterns and matching them with stored representations (Griffiths, 2002).

Additionally, we showed that in both musicians and non-musicians, BOLD activity in the right temporale plane induced by a mismatch embedded in the otherwise regular temporal pattern depends on the level of deviance, i.e. the greater the deviance in the SOA the more neural activation (Fig. 2B). However, the activation in rPT induced by deviant SOAs did not differ between groups.

Contrasting neural activity evoked by the deviant SOA of 100 ms in musicians versus non-musicians revealed a significant difference in the neural response to temporal mismatch: in musicians the deviant event induces BOLD activity in left anterior hippocampus whereas non-musicians do not show a mismatch response in this region (Fig. 3).

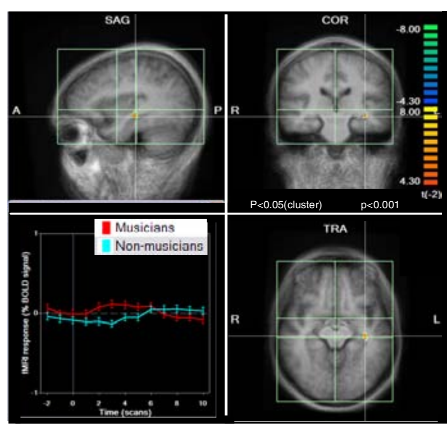


Fig. 3 The mismatch response to a deviant SOA of 100 ms reveals a differential activation of left anterior hippocampus between groups with professional musicians showing pronounced deviant induced activity in this region compared to musical laypersons (p < 0.05 cluster level correction).

Conclusion

Our data suggest that superiority in preattentive auditory processing of musicians is based on differences in second-order mismatch detection represented by differential activation of left anterior hippocampus and not due to discriminative temporal mismatch representation in auditory cortices. The anterior hippocampus has been previously suggested to act as a mismatch detector by comparing stored pattern representations and actual sensory input (Strange, 2001). This function might be enhanced in musicians due to neuroplastic changes after extensive training.

Ref: Strange BA, Dolan RJ. Adaptive anterior hippocampal responses to oddball stimuli. Hippocampus. 2001;11(6):690-8; Griffiths TD, Warren JD. The planum temporale as a computational hub. Trends Neurosci. 2002 Jul;25(7):348-53.