Functional asymmetry in the brain's response to left and right auditory space: a DCM study

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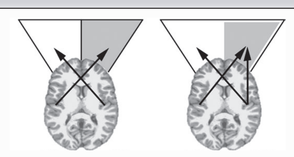
Hypothesis

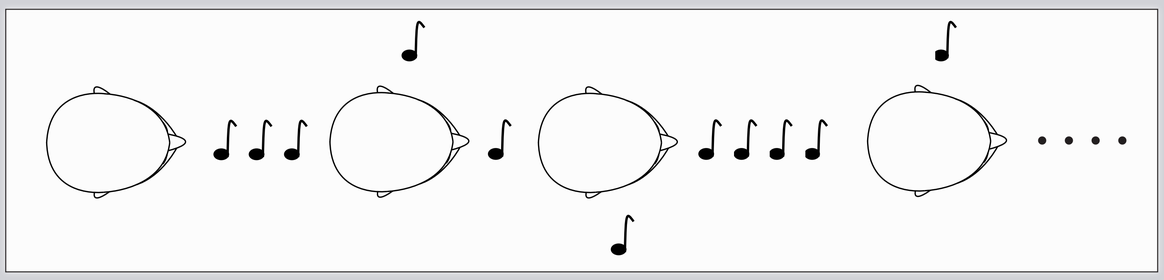
Neuroimaging studies (Krumbholz 2004, Kaiser *et al* 2000) have shown that perception of auditory space is processed asymmetrically beyond A1 with a right-hemisphere dominance for both contralateral and ipsilateral auditory hemifield that parallels the asymmetry in visuo-spatial attention (Corbetta & Shulman 2002). This functional *asymmetry* is known as the 'Neglect Model' as opposed to the 'Contralateral Bias Model' (Mesulam 1999, Teshiba 2012).



Contralateral Bias Model' versus 'Neglect Model'

Paradigm

We recorded 64-channel electroencephalography (EEG) from 12 healthy adults (age 21-35) during an auditory location oddball paradigm. Pure tones of duration 75 ms were presented every 500 ms. Frequent tones presented in stereo had 80% probability of occurrence. Rare tones presented at 20% probability were randomly interleaved among frequent tones. Interaural time delay (ITD) of 800 µs between left and right ear created the perception of an oddball in subjective left (10%) and right auditory space (10%). Spectral, amplitude and duration parameters were kept constant.

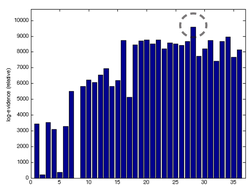


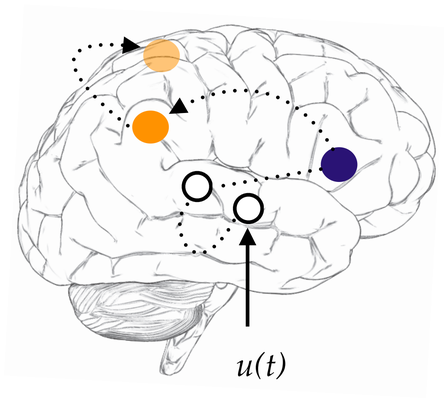
Dynamic Causal Modeling

Using DCM for evoked responses (David *et al* 2006, Kiebel *et al* 2006) we compared a set of plausible hypotheses for the cortical neuronal network that generated observed ERP responses to left and right audiospace. These network models were build upon prior connectivity work on MMN generation (Garrido *et al* 2009). Bayesian Model Comparison and Bayesian Model Selection (BMS) of DCMs was performed in terms of the *log* Group Bayes Factor (GBF) using a Variational Bayesian approximation to the model evidence $p(y|m)$ known as the negative Free Energy (Friston *et al* 2006).

Left audiospace

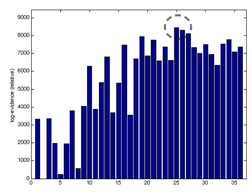
Bayesian Model Selection
***log* Bayes Factor = 623**

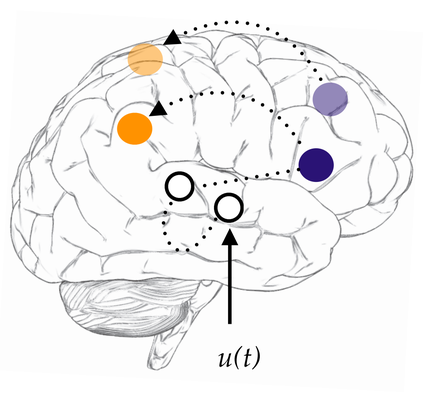




Right audiospace

Bayesian Model Selection
***log* Bayes Factor = 127**

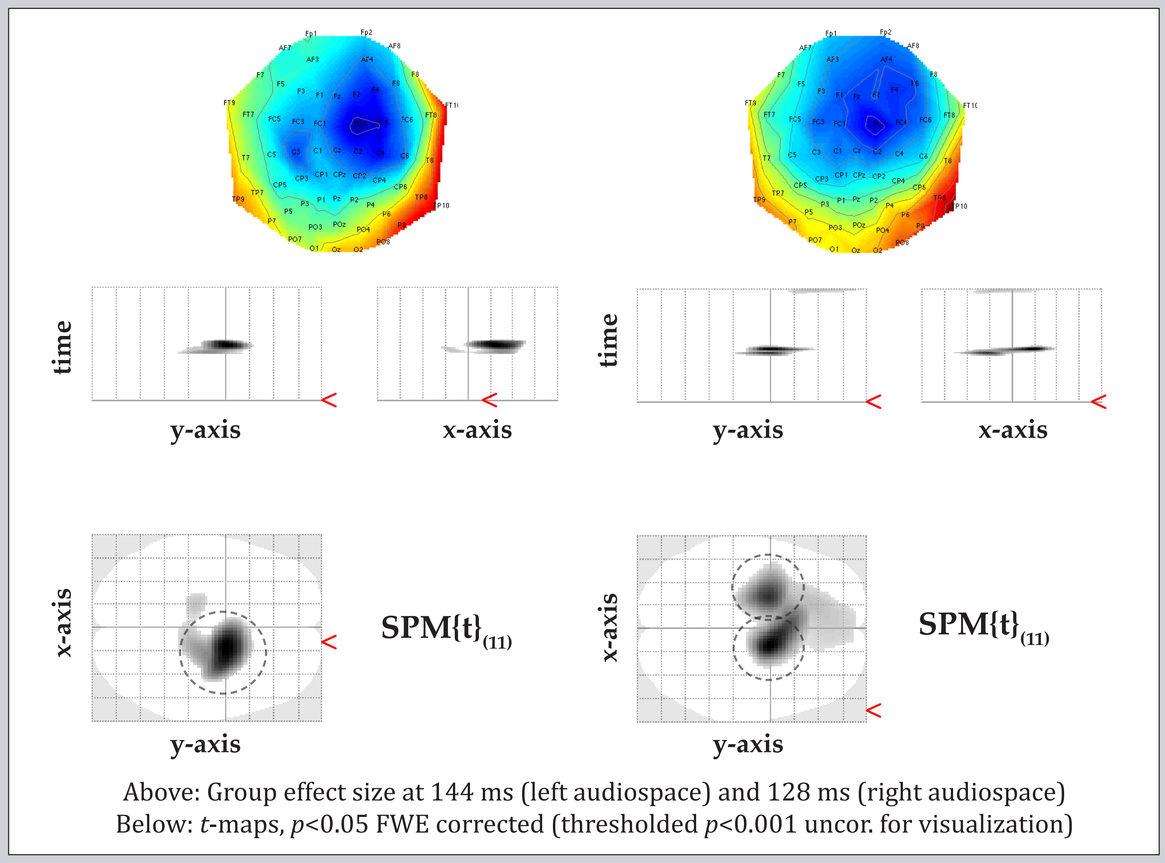




Fixed-effects (FFX) Posterior Model Probability of winning models $p(m|y_{1 \dots n}) = 100\%$

Sensor Statistical Parametric Maps

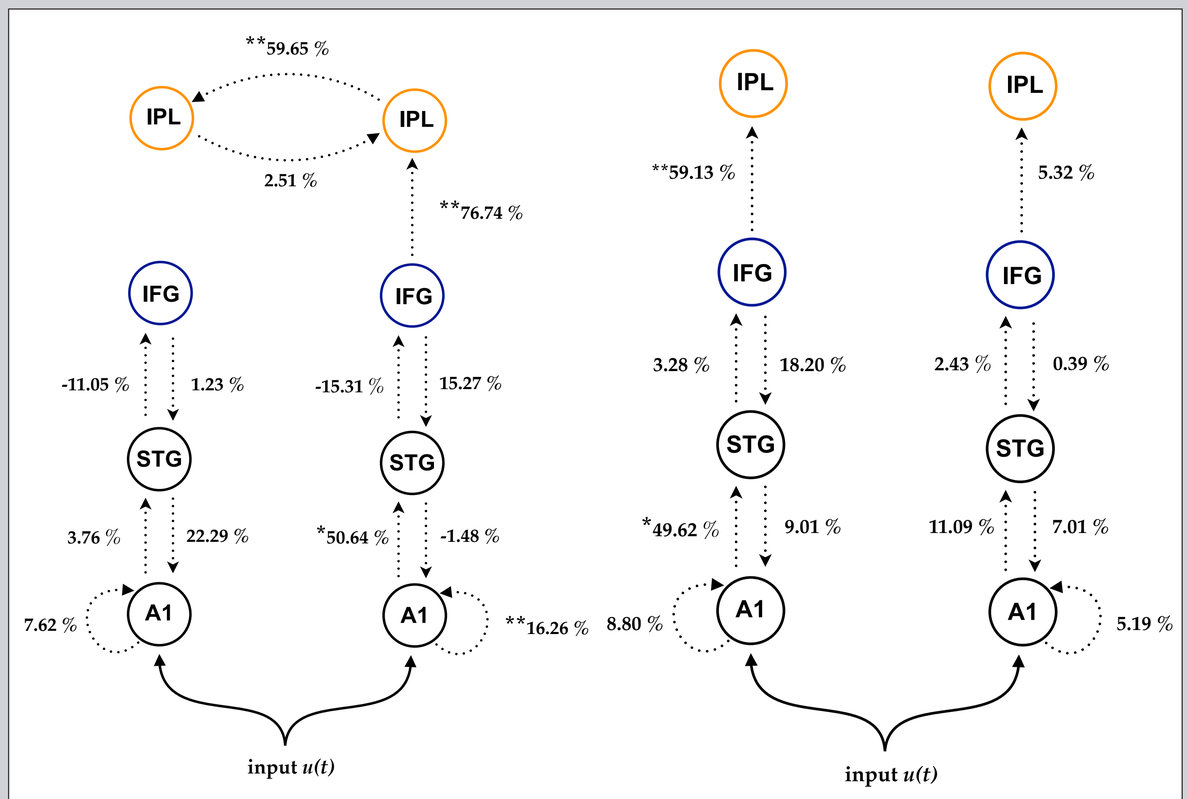
Group-level SPMs of time-averaged responses to left and right stimuli both show a classical mismatch negativity (MMN) at 144 ms (left) and at 128 ms (right). Crucially, an asymmetrical distribution over parietofrontal sensors indicates a spatiotemporal asymmetry at the source level.



Above: Group effect size at 144 ms (left audiospace) and 128 ms (right audiospace)
Below: *t*-maps, $p<0.05$ FWE corrected (thresholded $p<0.001$ uncor. for visualization)

Effective connectivity

Random-effects (RFX) *t*-tests confirmed significant increases in coupling strength between cortical regions in the hemisphere contralateral to the perceived side of audiospace.



Context-dependent changes in coupling strength (%)
*$p<0.05$, ** $p<0.05$ Bonferroni-corrected

Conclusion

We hypothesised an asymmetry in the neuronal network generating responses to left and right auditory space. Both sensor SPMs and Bayesian Model Comparison of DCMs show strong evidence of such an asymmetry in the brain corresponding to the 'Neglect Model'.

References

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