Neuronal communication

through

neuronal coherence.

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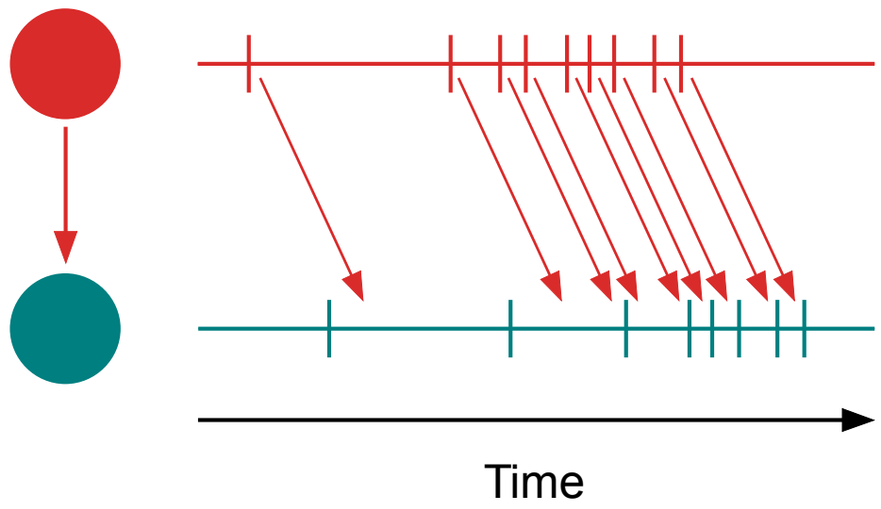
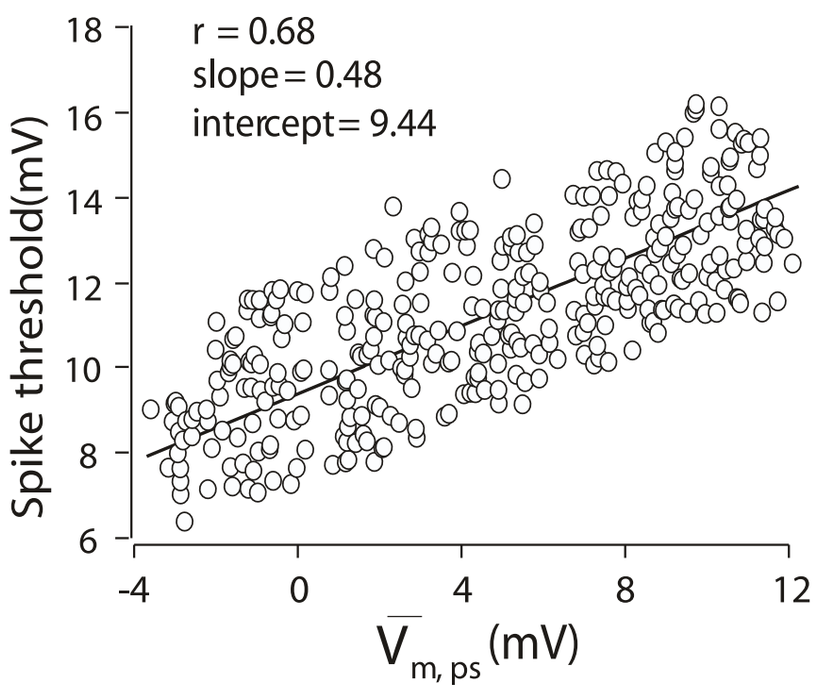
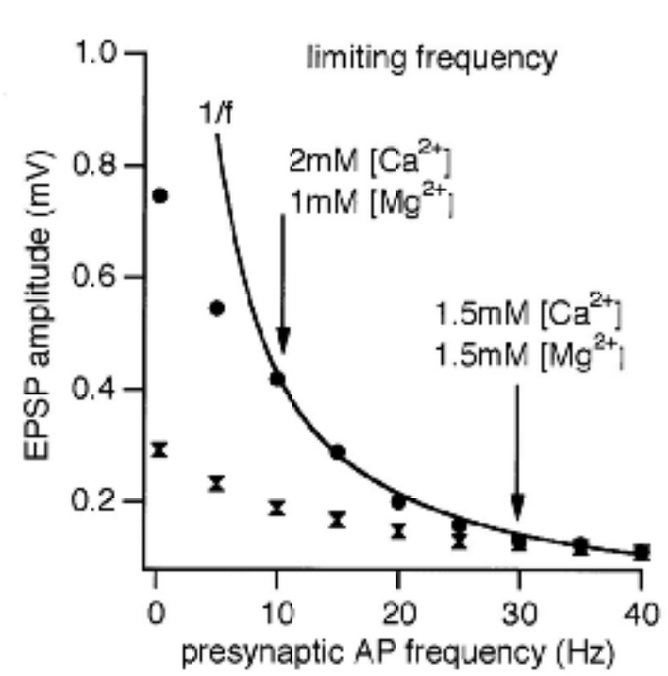
Neuronal communication requires neuronal firing, but is firing rate the communication mechanism?



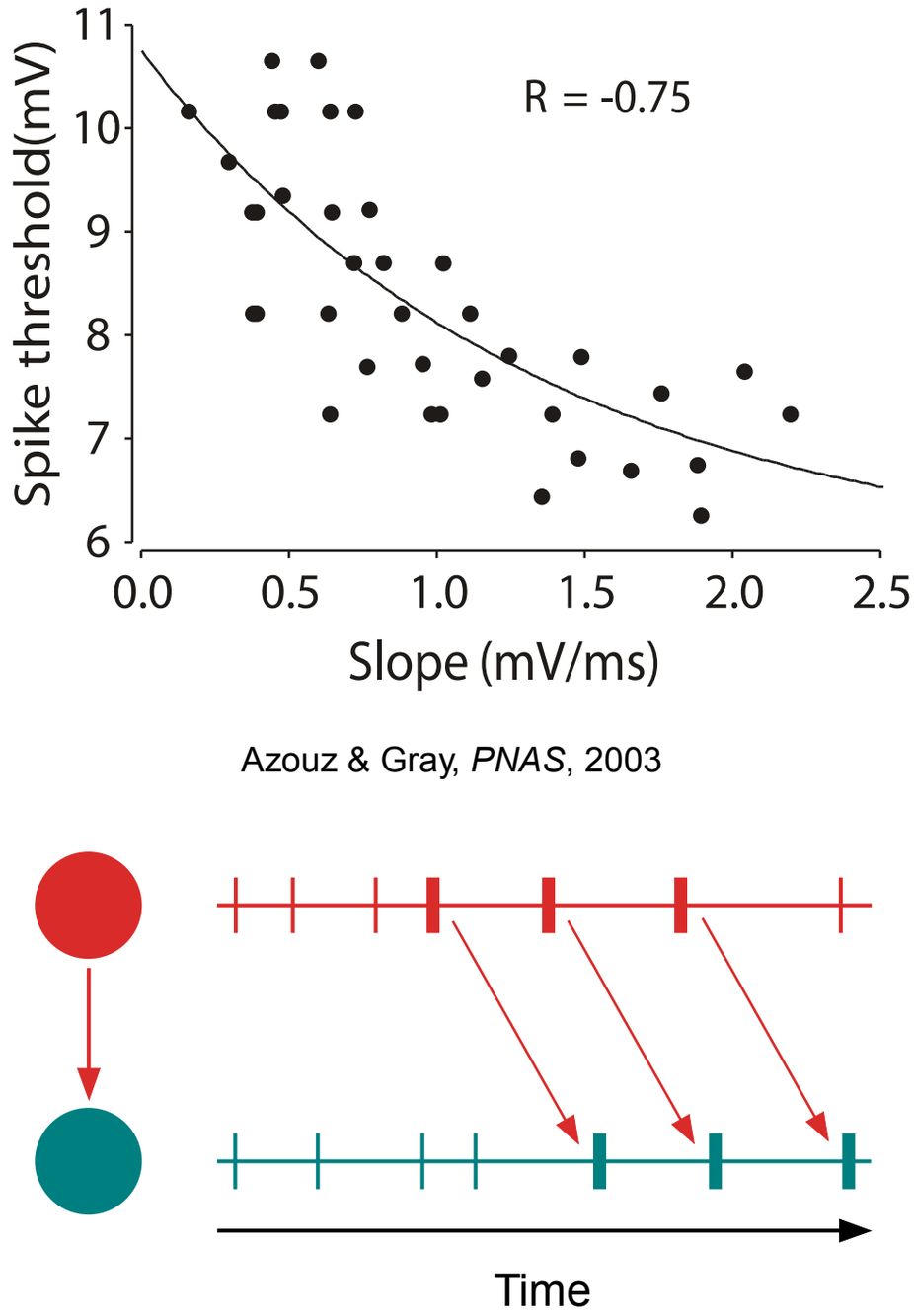


Azouz & Gray, *Neuron*, 2003



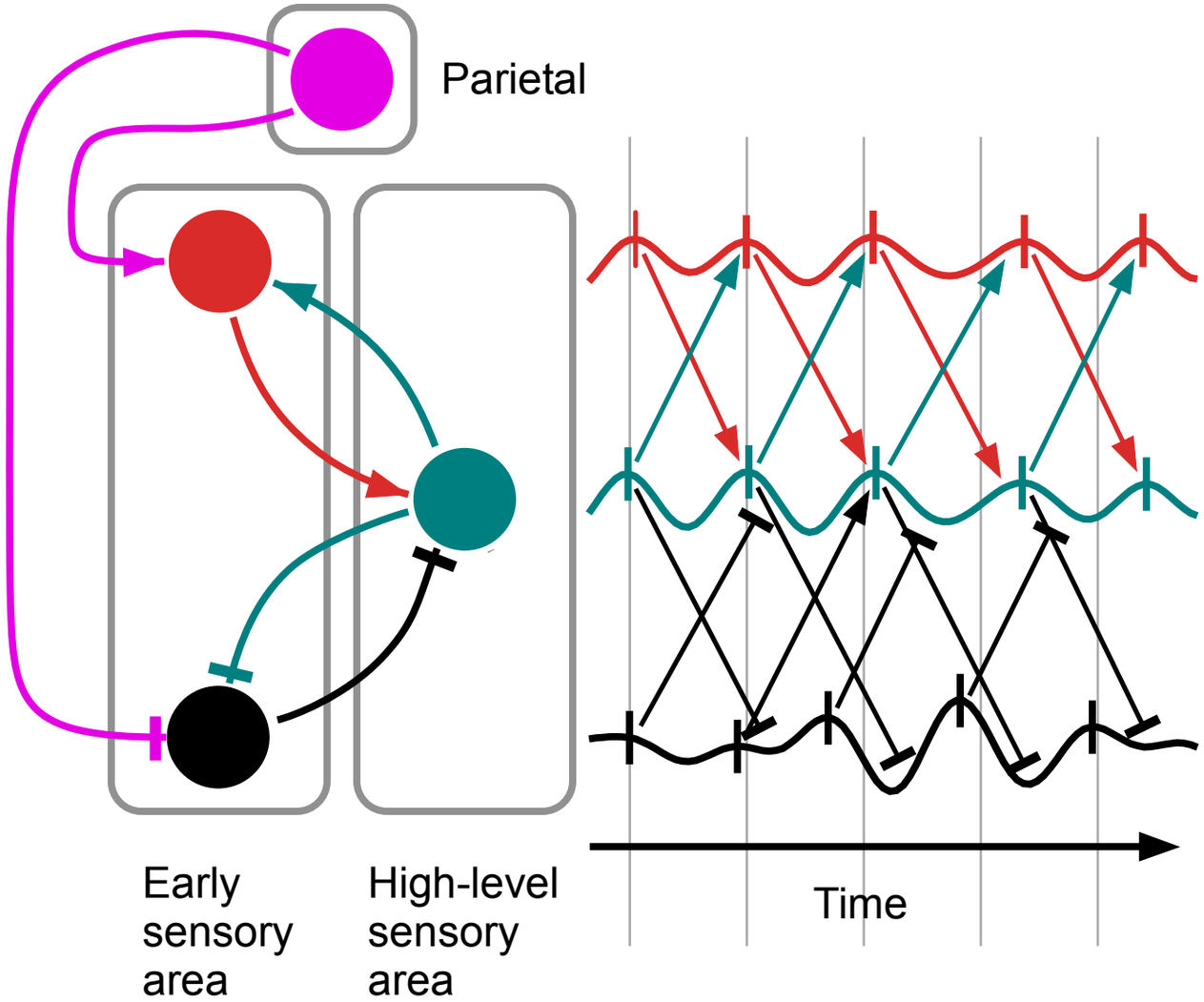
Tsodyks & Markram, *PNAS*, 1997

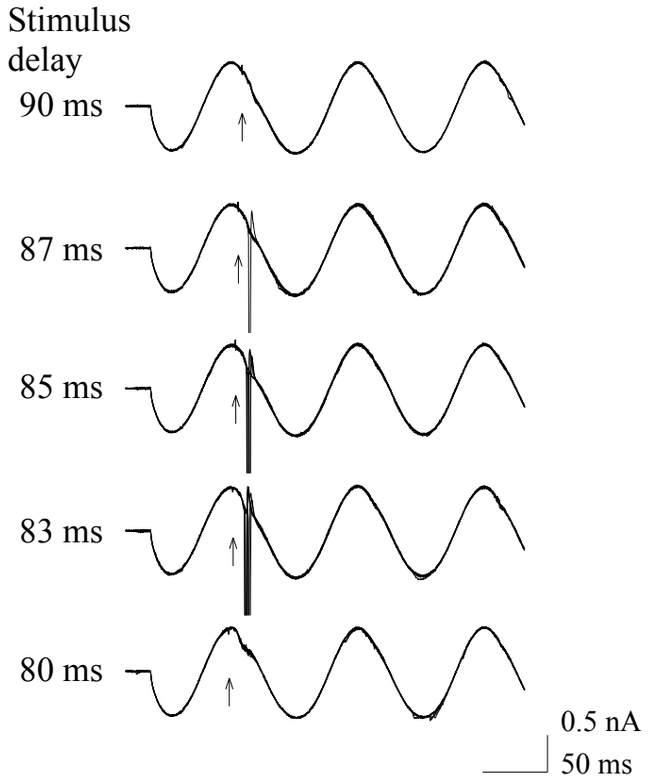
Neuronal communication is certainly supported by local neuronal synchronization.



Azouz & Gray, *PNAS*, 2003

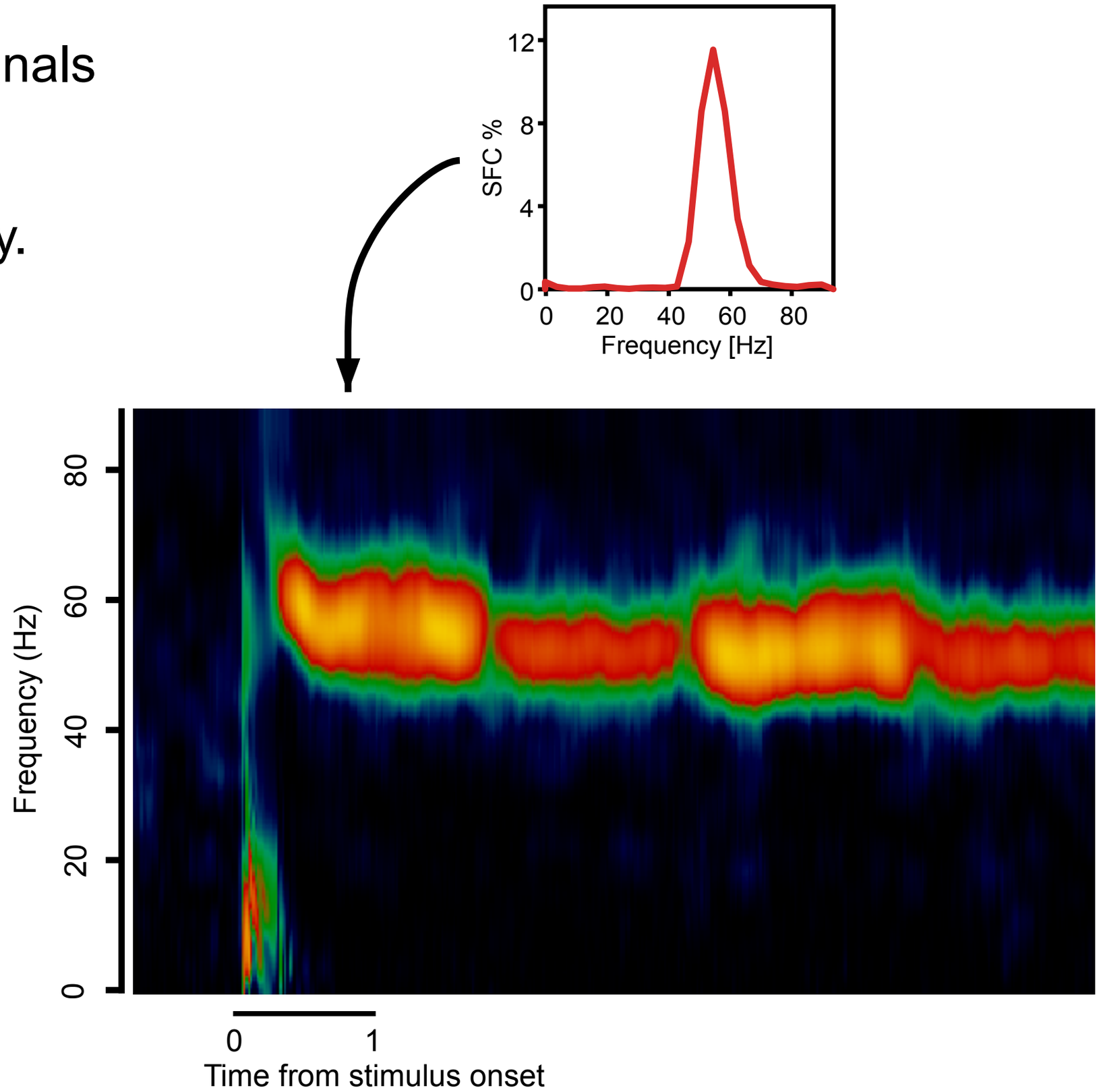
Coherence between communicating groups renders communication effective and selective.



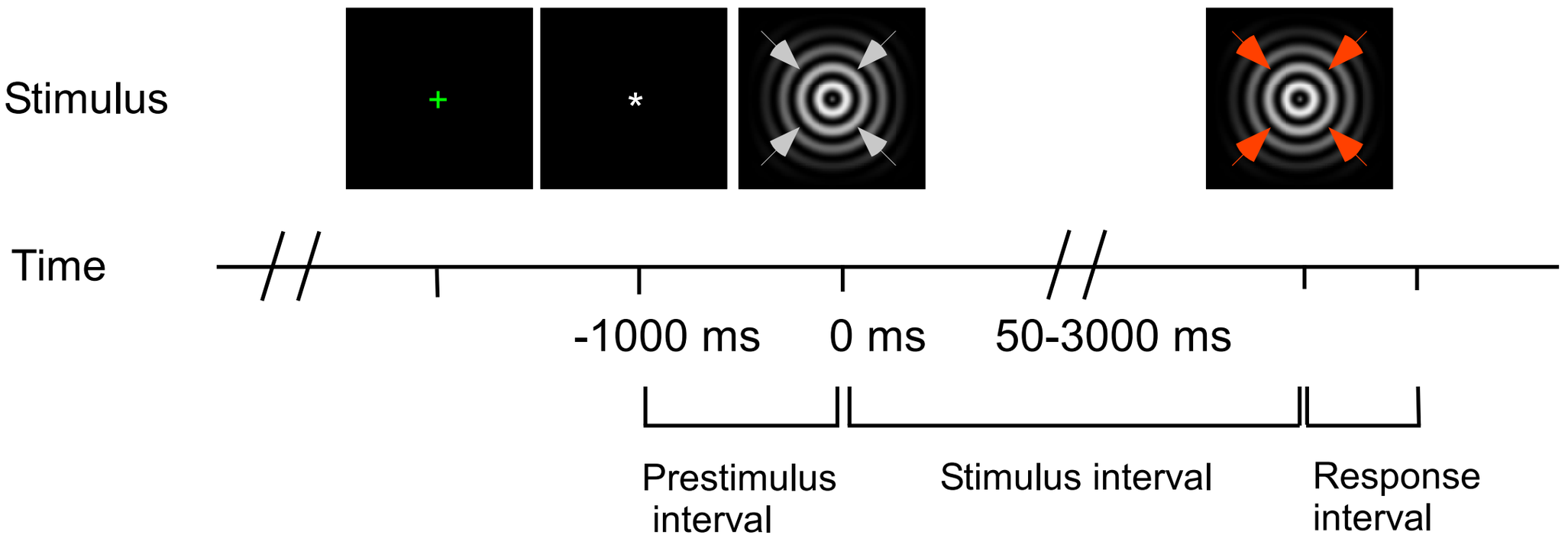


Volgushev, Chistiakova, Singer, *Neuroscience,* 1998.

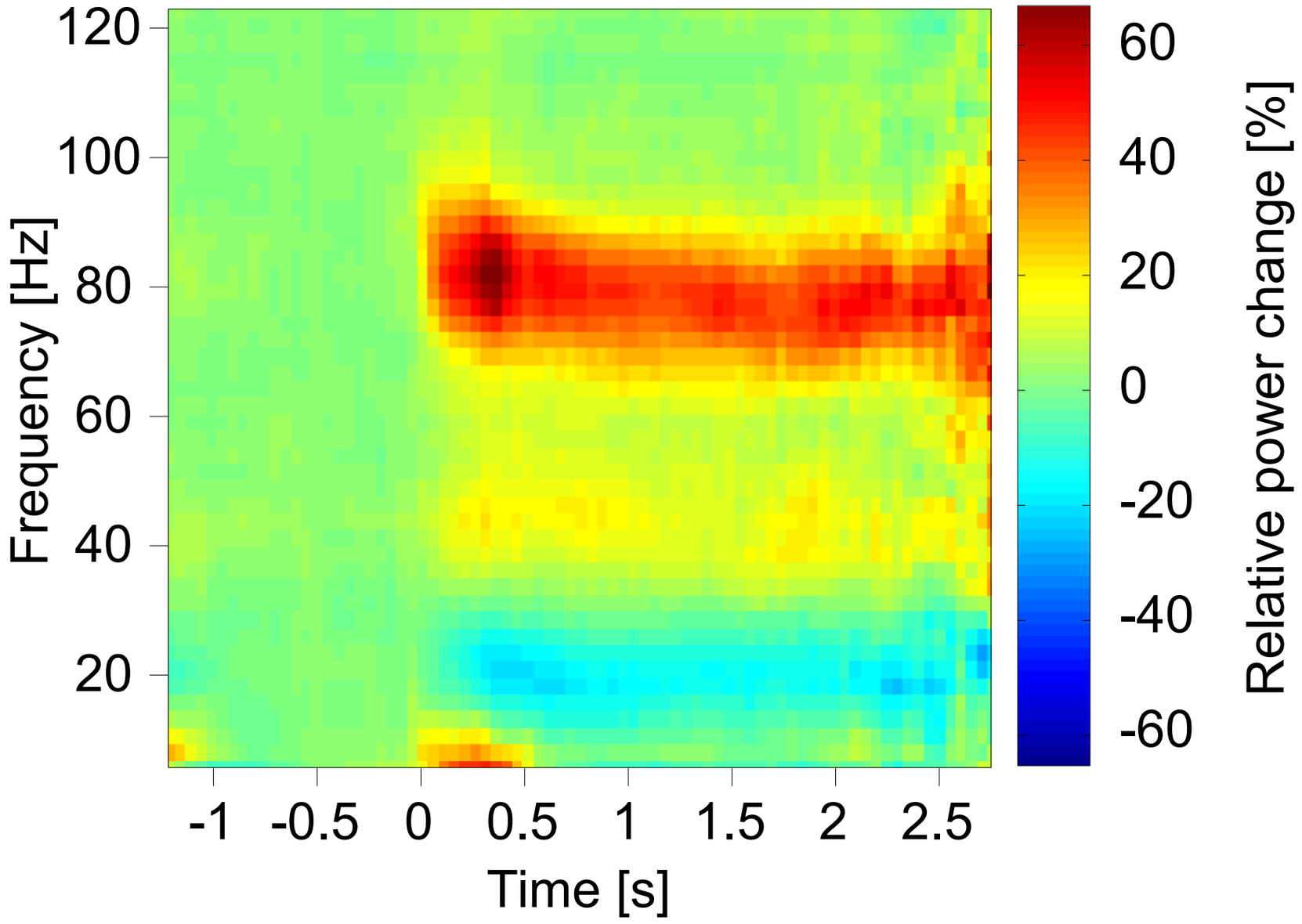
Cat visual cortex signals visual stimulation through sustained gamma-band activity.



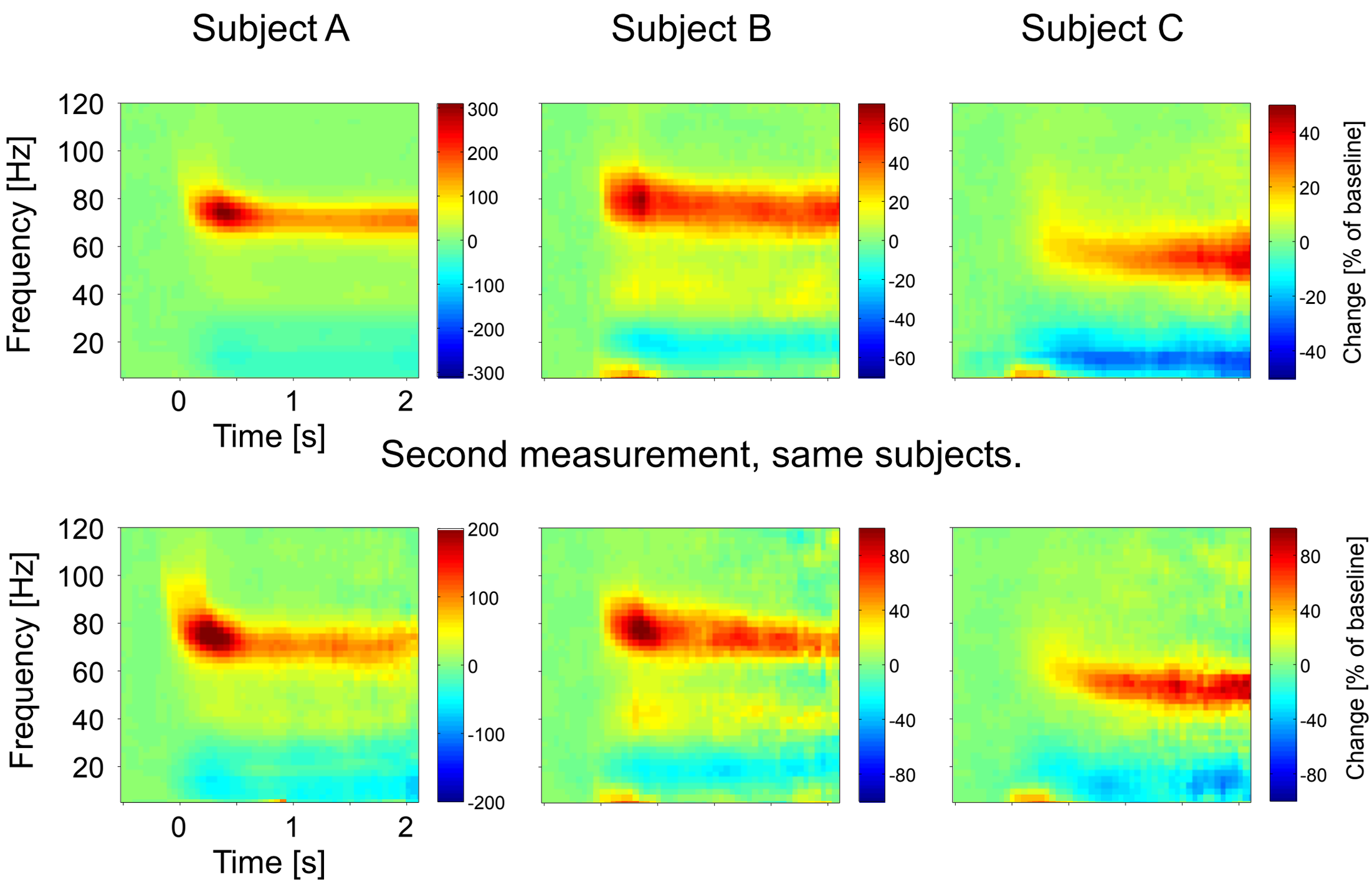
The MEG paradigm



Human visual cortex signals visual stimulation through sustained gamma-band activity.

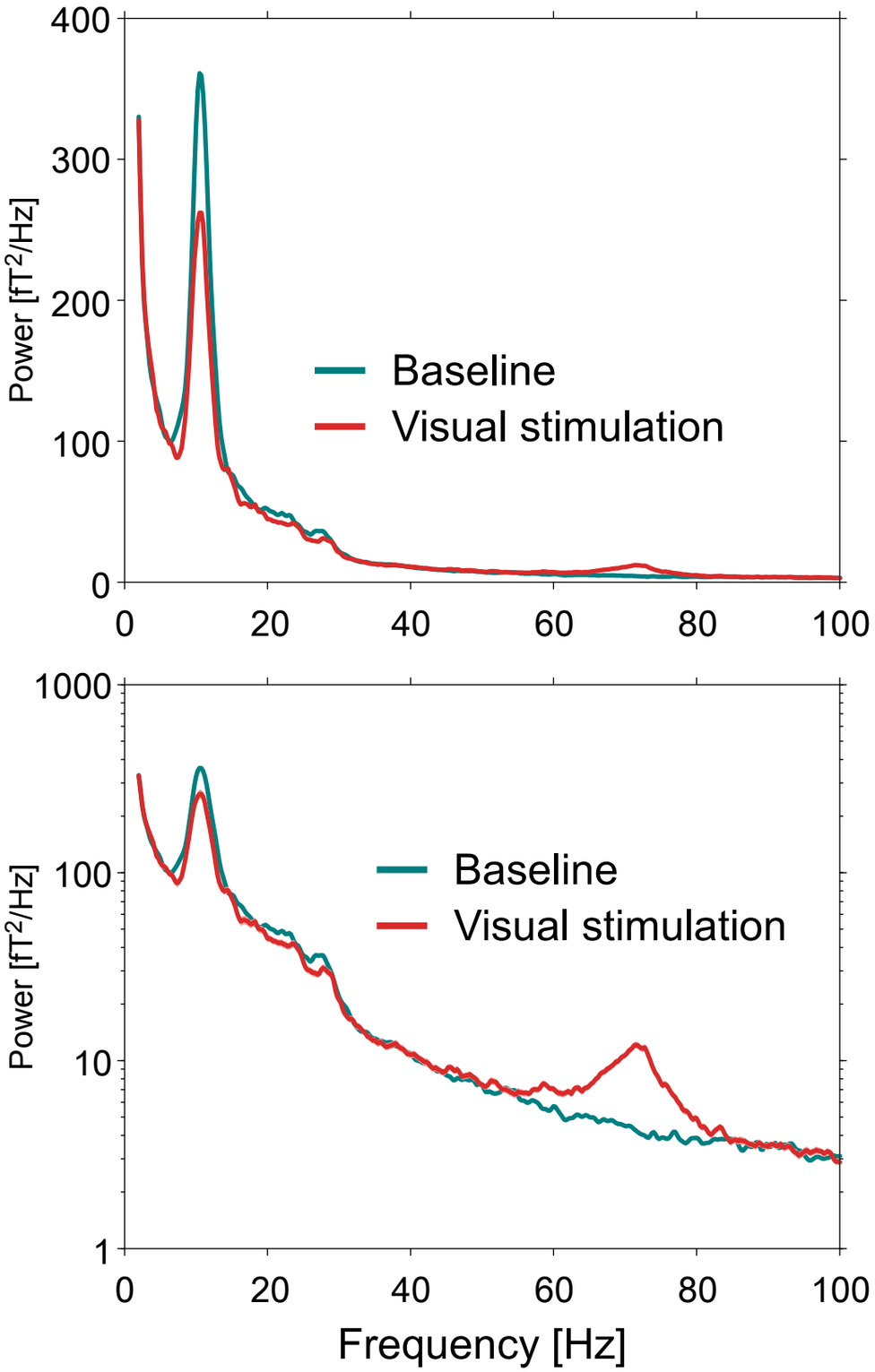


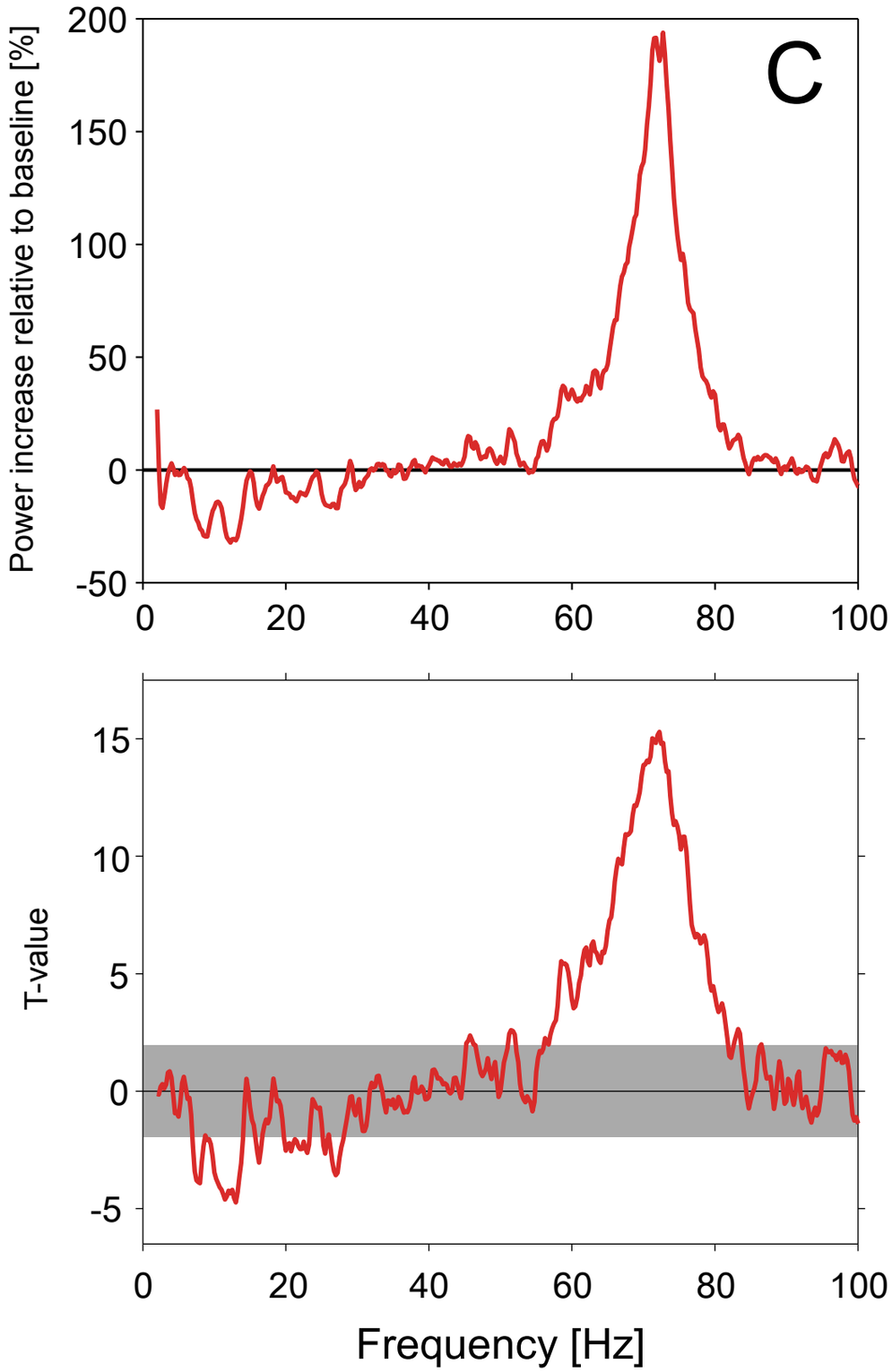
The spectro-temporal signature of human visual processing



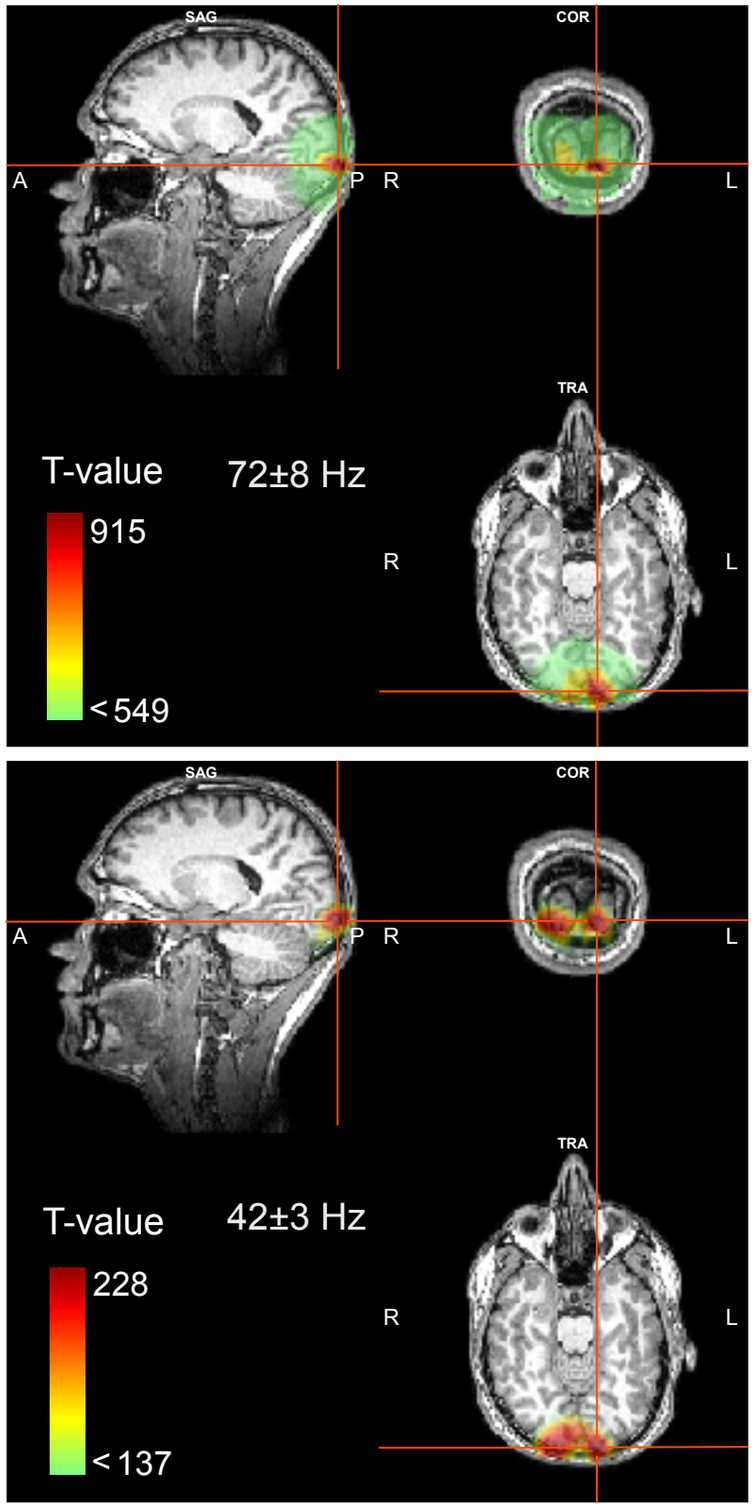
Second measurement, same subjects.

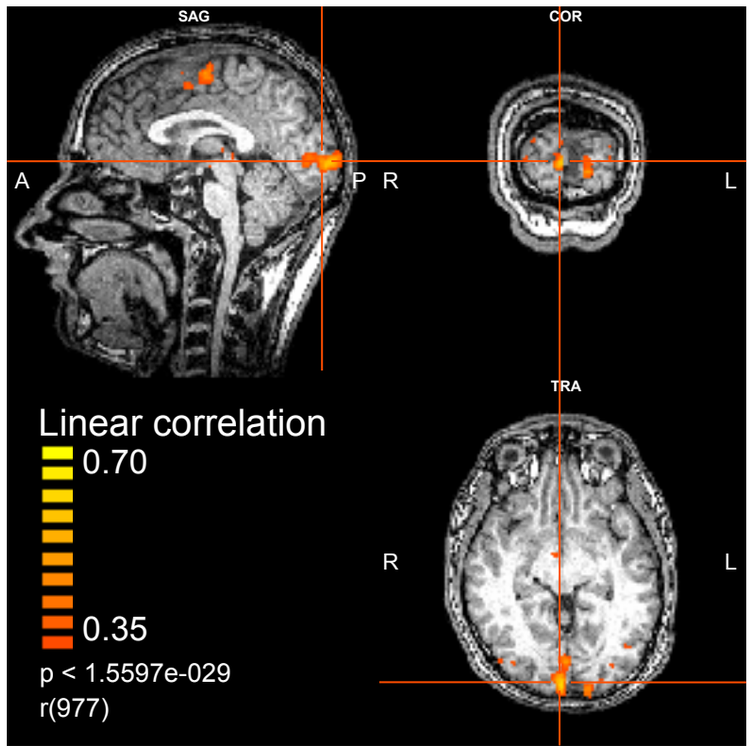
Visually induced human gamma-band activity studied with MEG

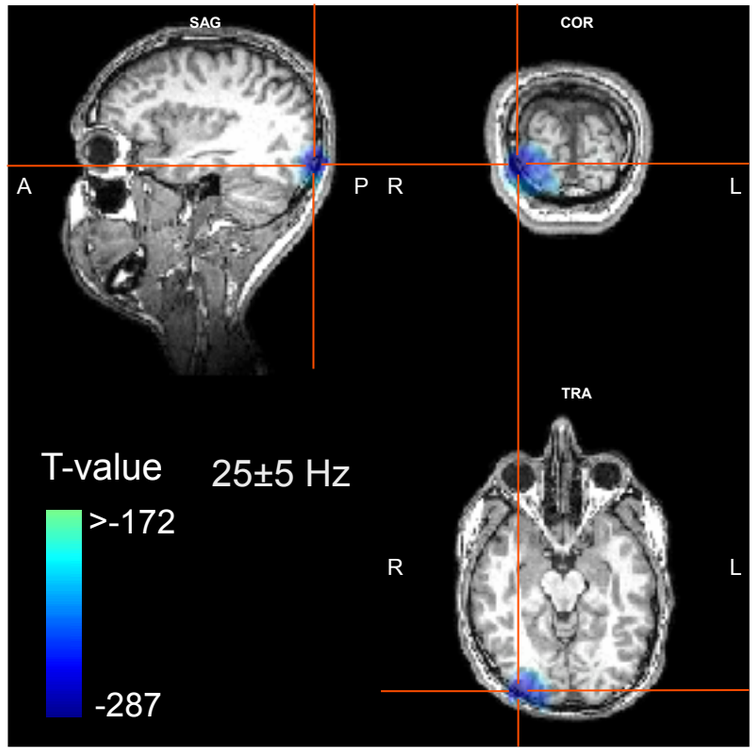


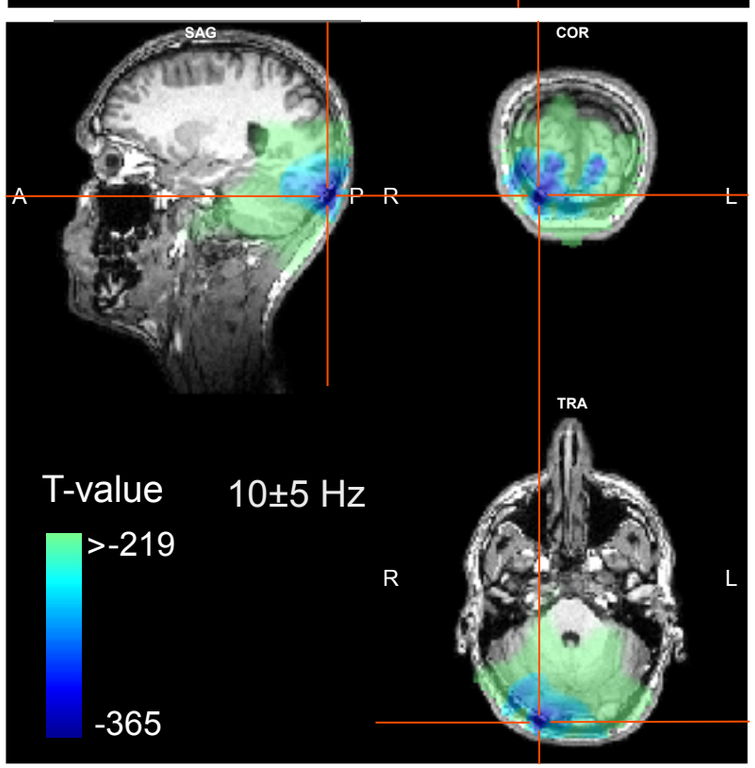


High- and low-frequency gamma-band activity have overlapping sources and localize similar to the BOLD signal but different from alpha- and beta-supressions.

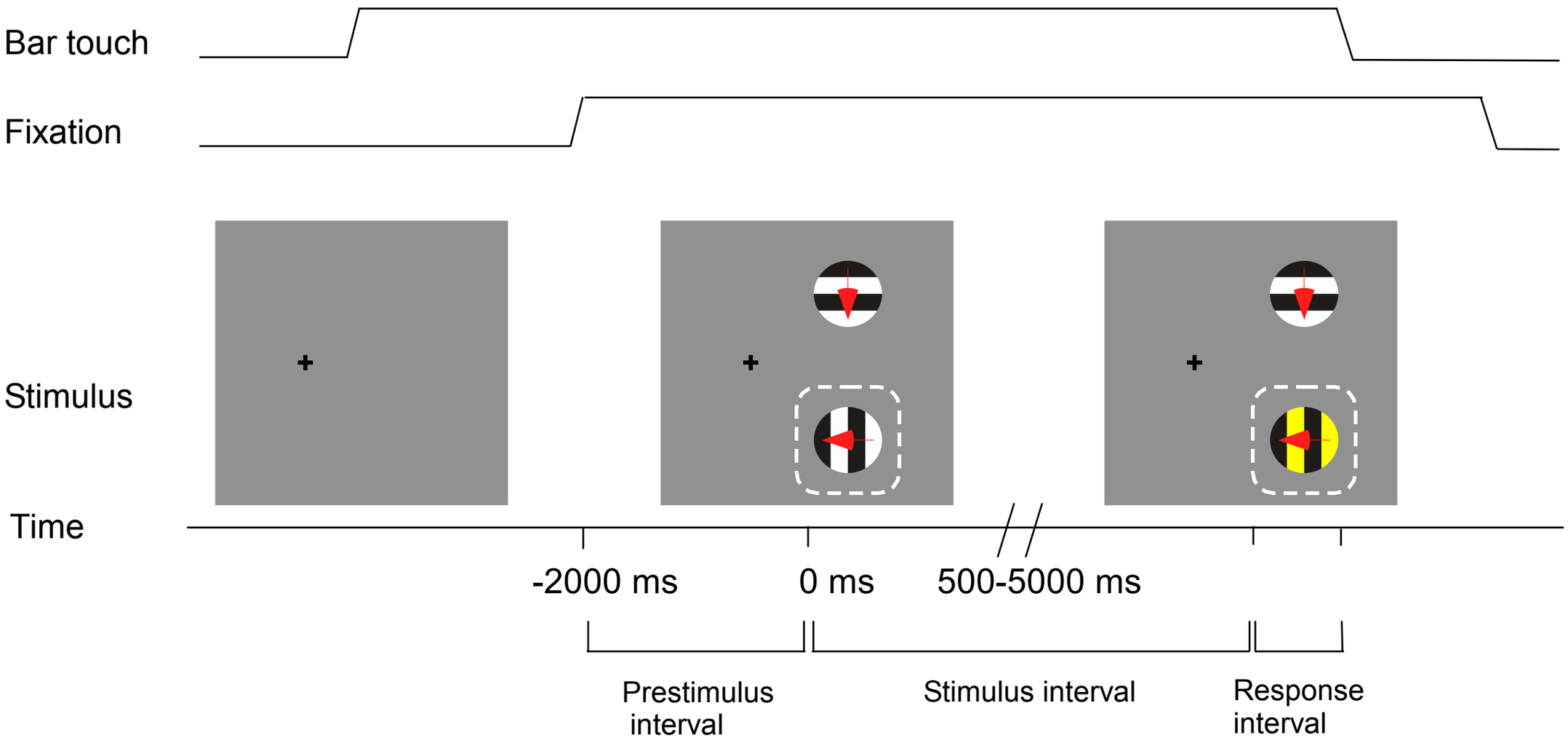






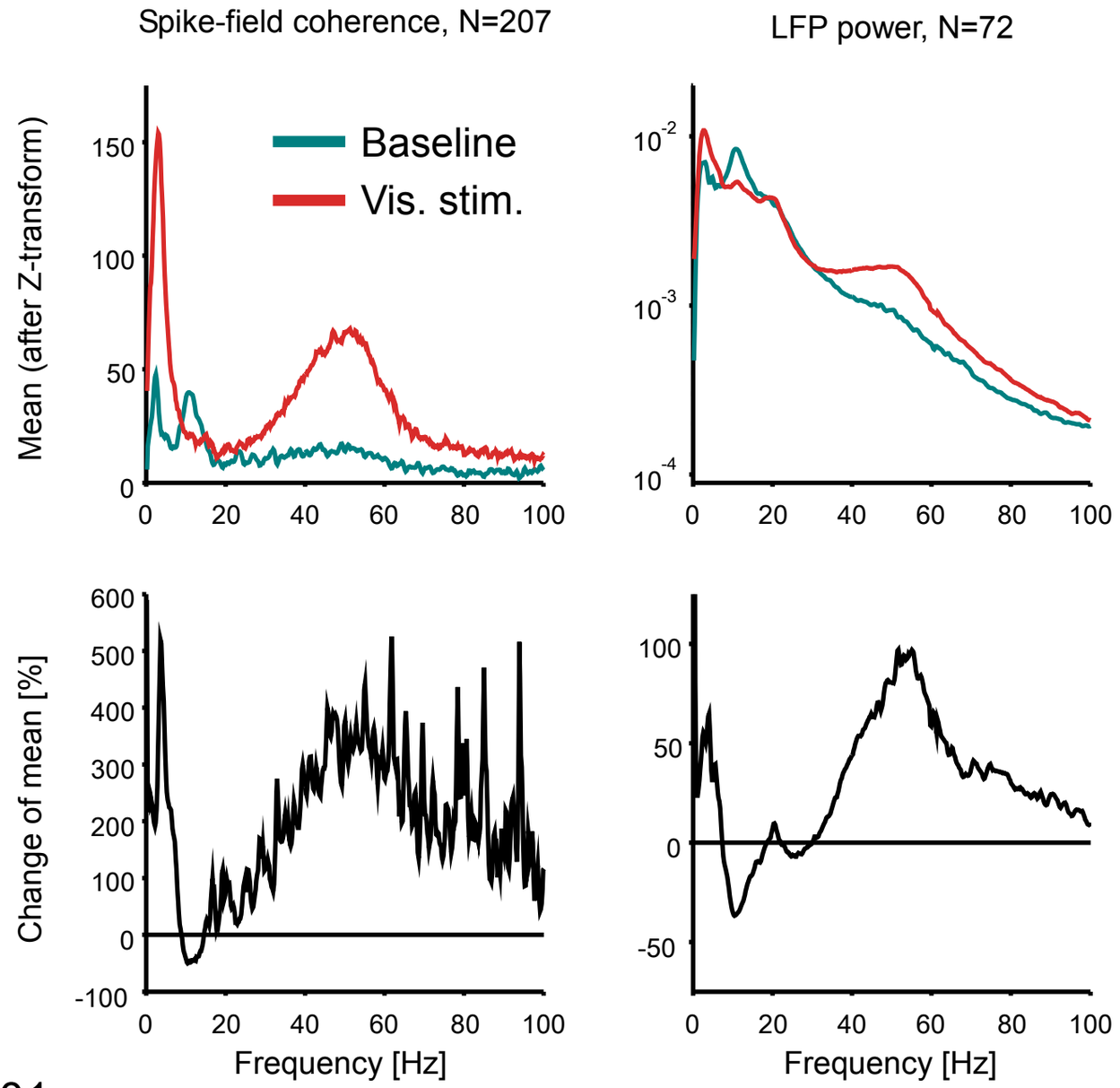


The monkey attention paradigm



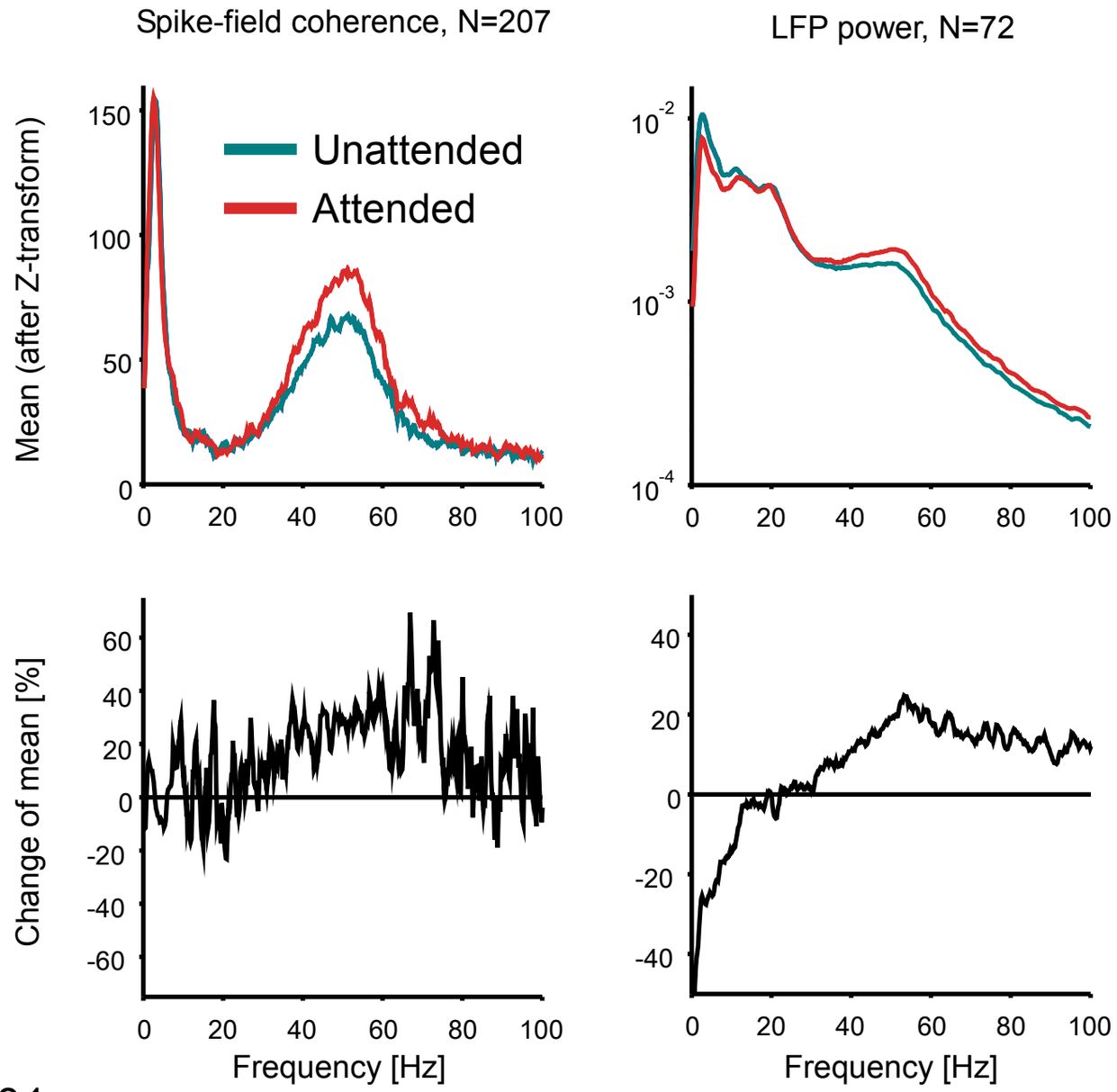
Fries et al., *Science*, 2001

Monkey area V4 signals visual stimulation through local gamma-band synchronization.



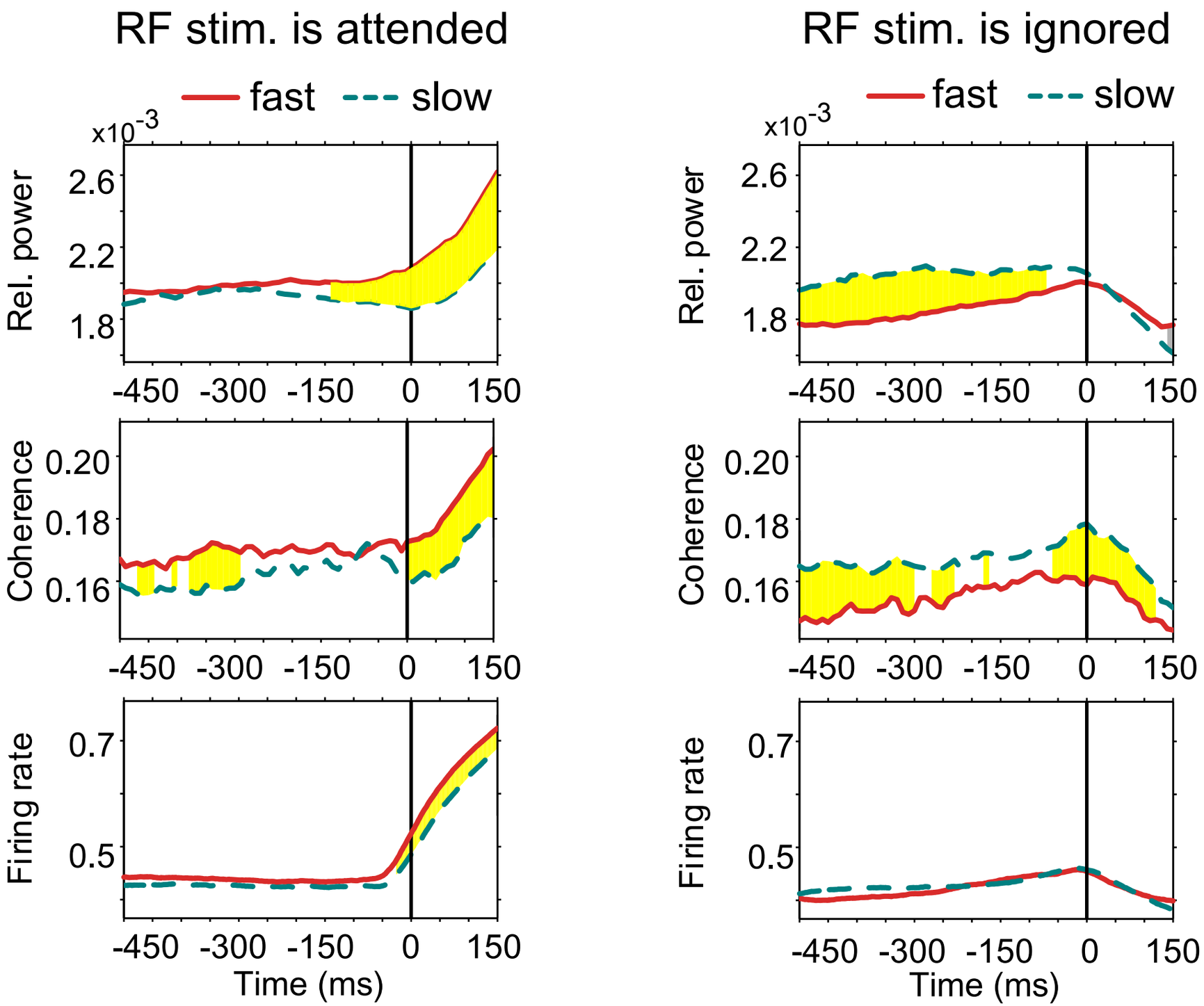
Fries et al., *Science*, 2001

Spatial selective visual attention enhances local gamma-band synchronization in monkey V4.



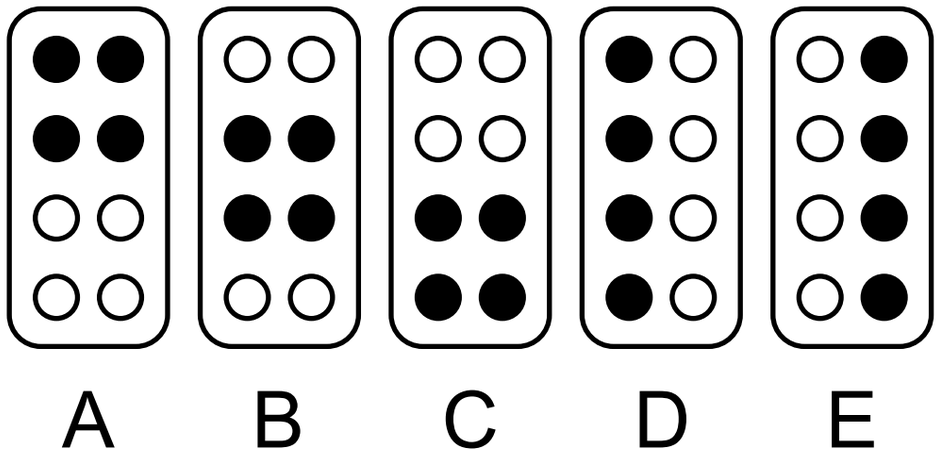
Fries et al., *Science*, 2001

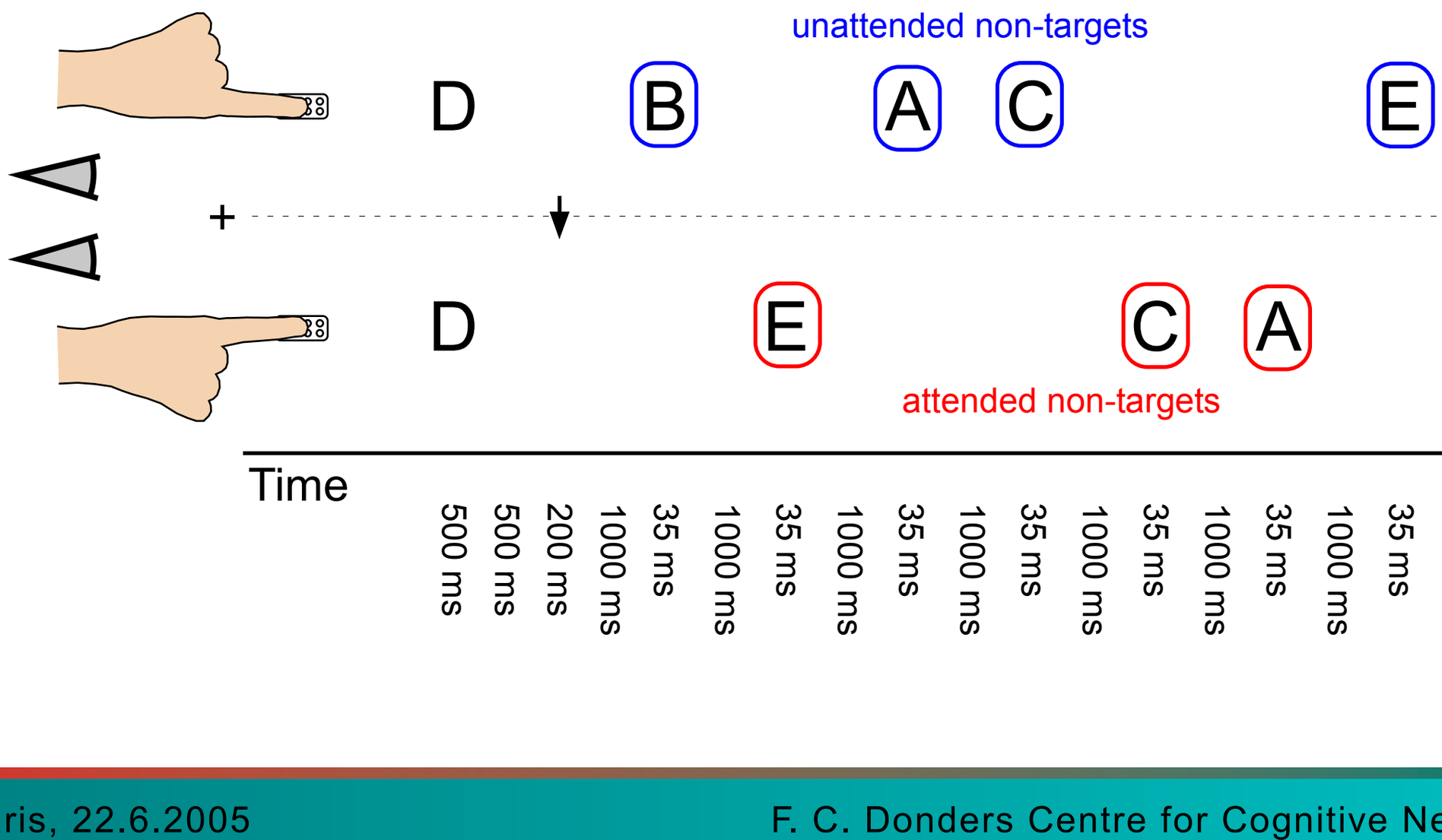
Gamma-band activity in monkey V4 predicts change detection efficiency.



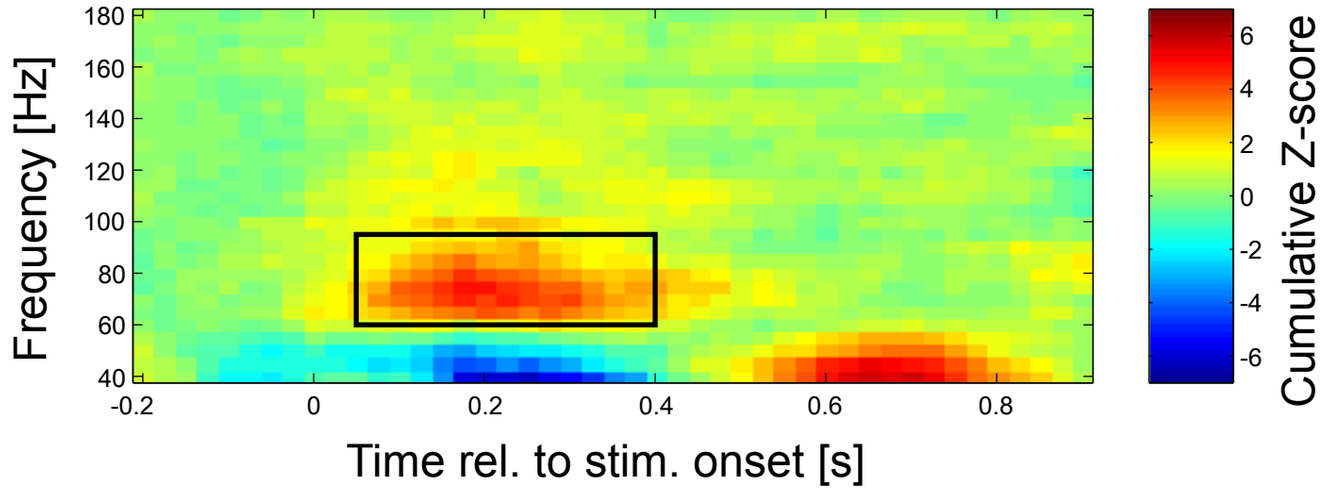
The spatial selective tactile delayed matching to sample task.

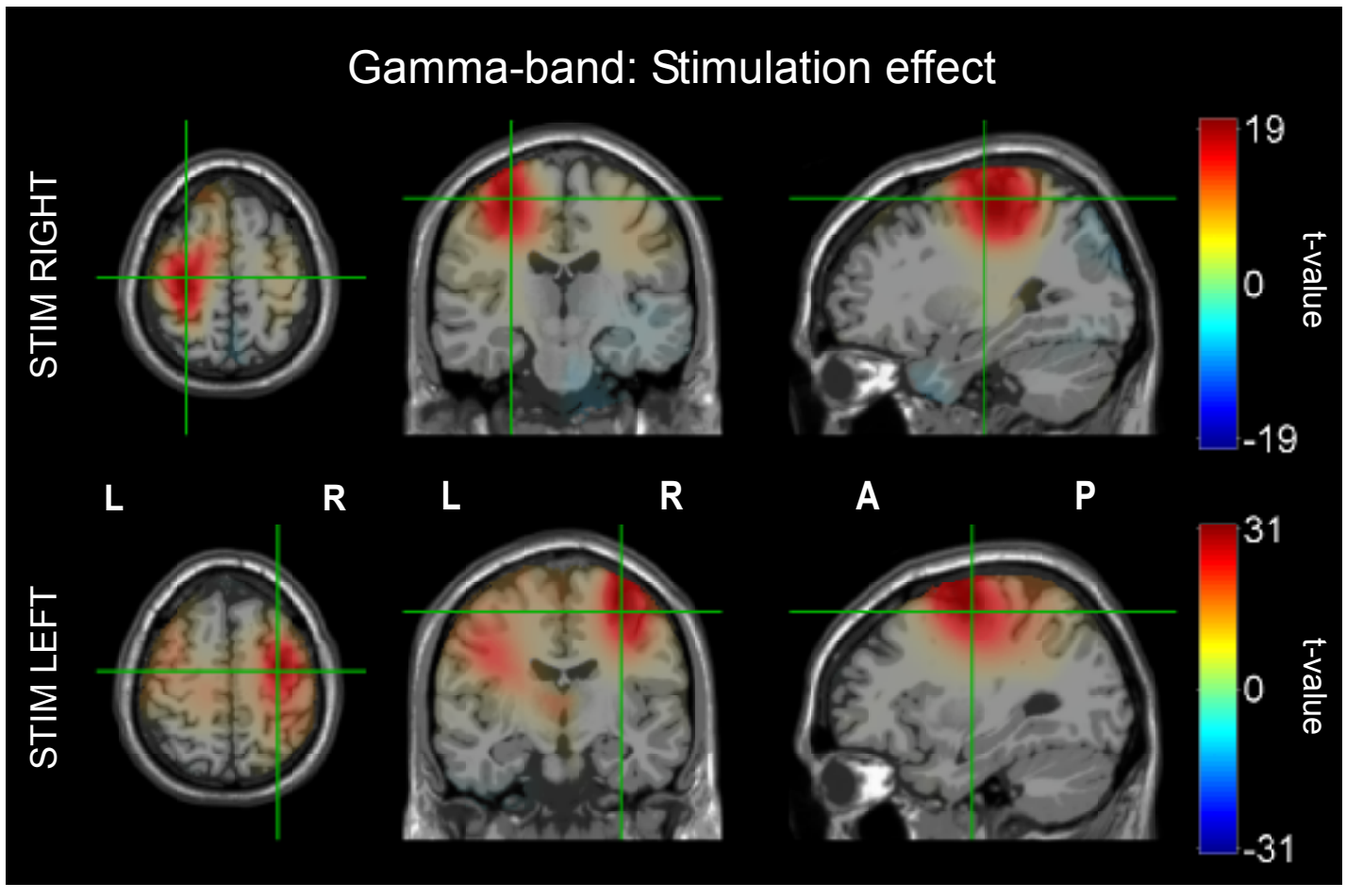
The different tactile patterns used:



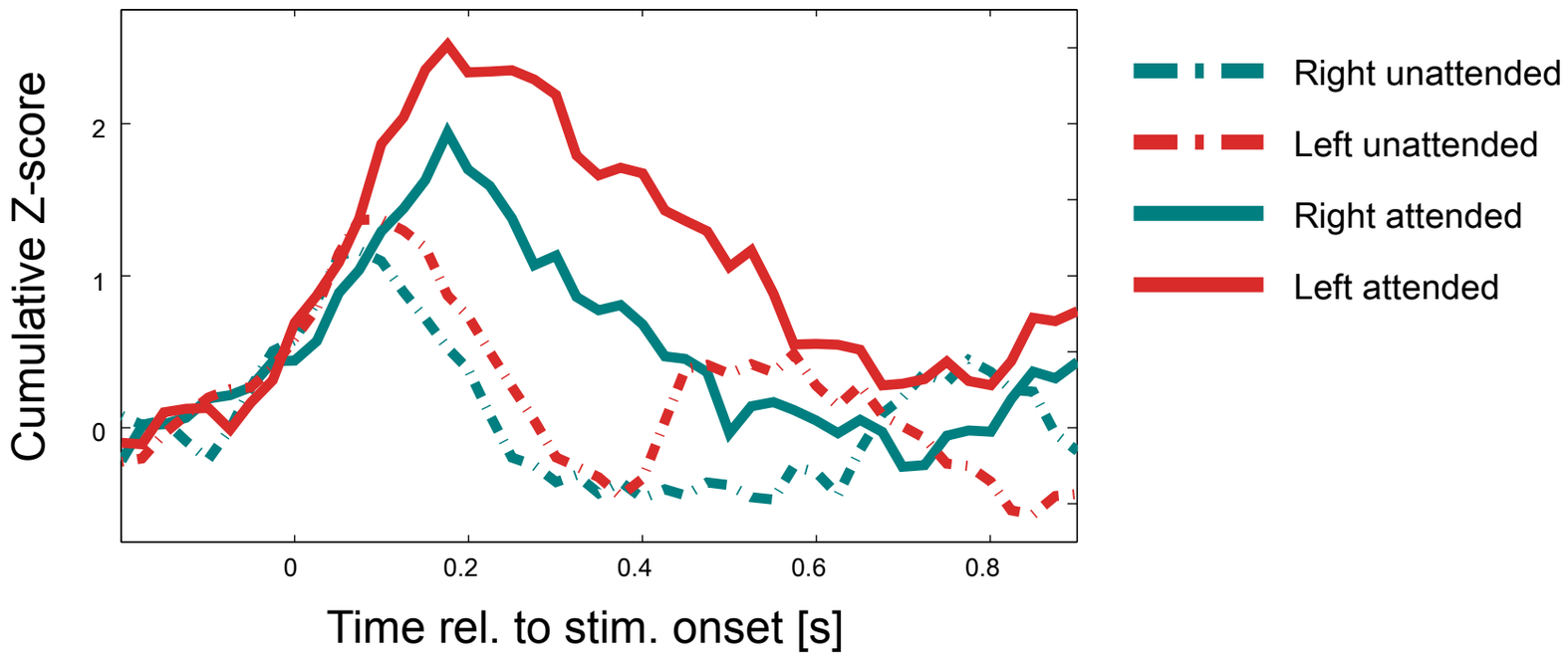


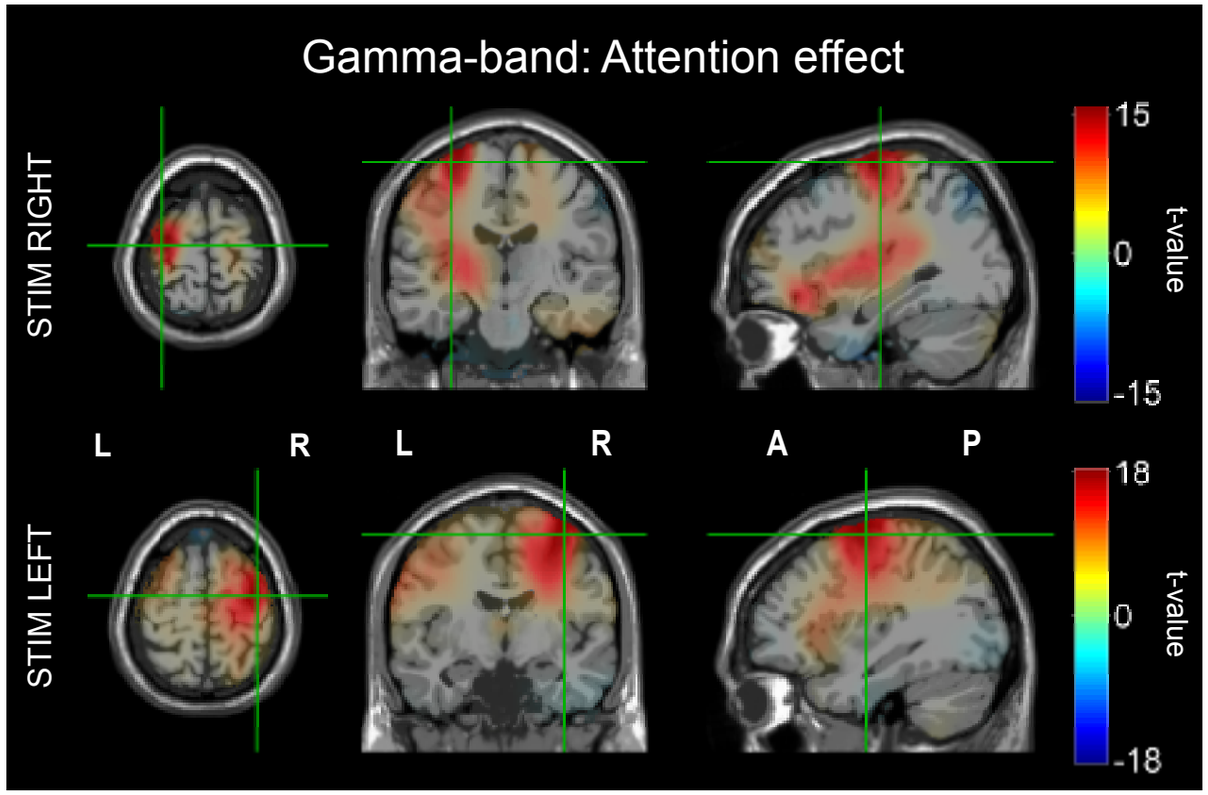
Tactile stimulation leads to an increase of gamma-band activity mainly in contralateral S1.



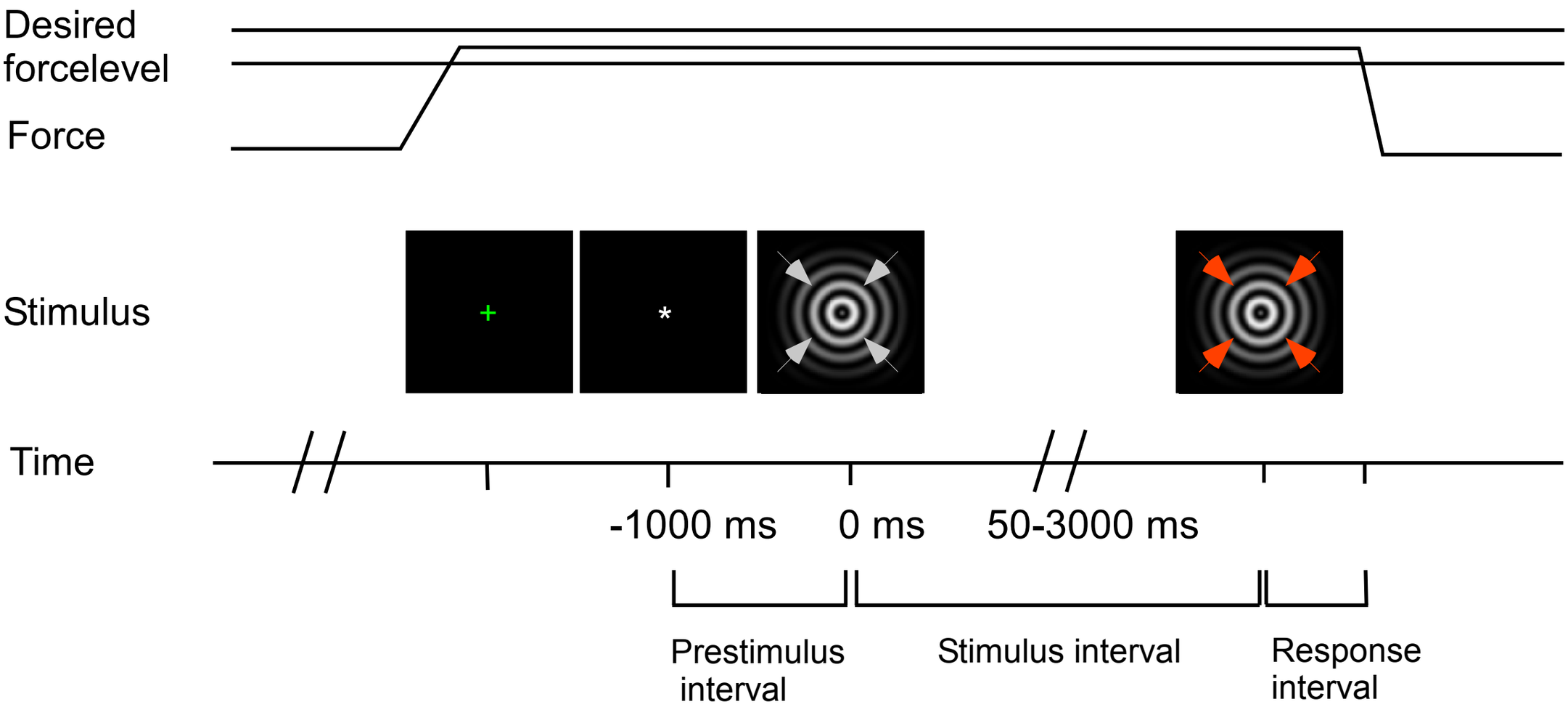


Attention enhances the somatosensory gamma-increase.



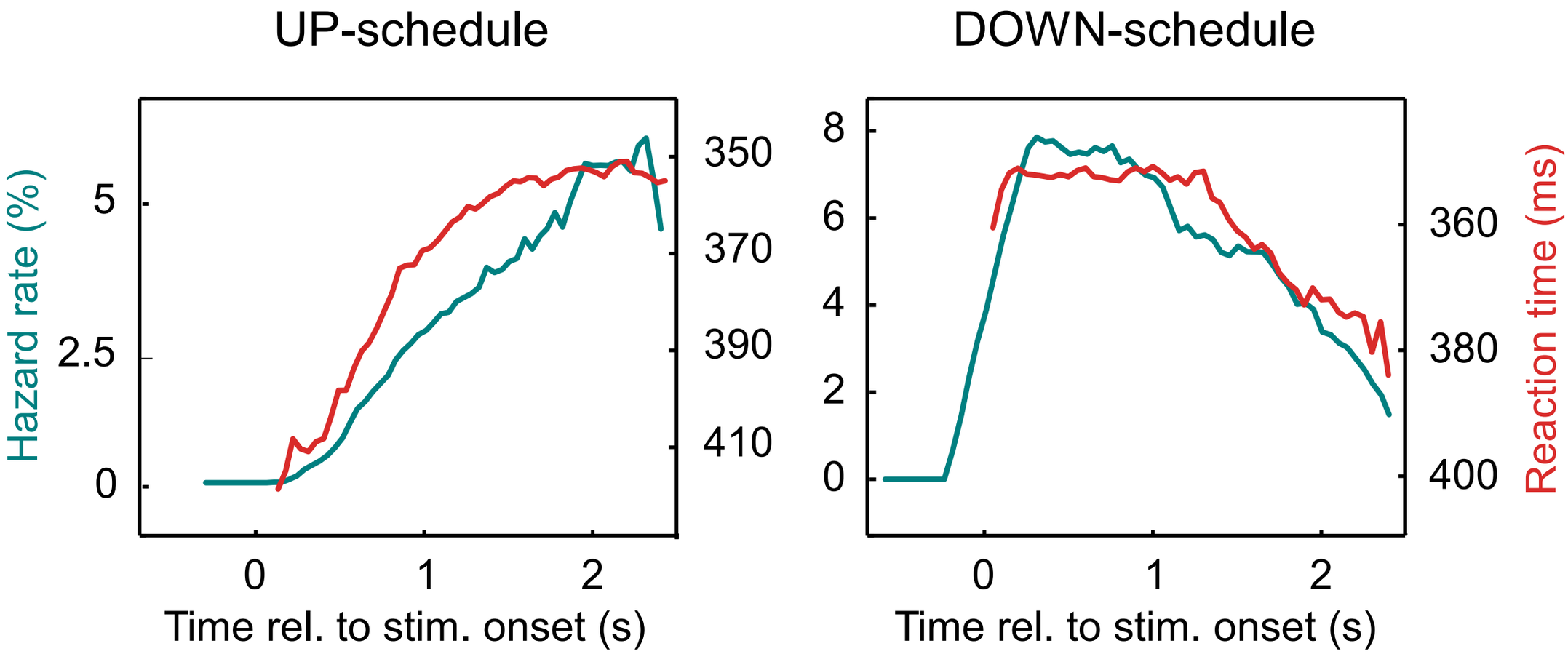


The MEG/EMG paradigm



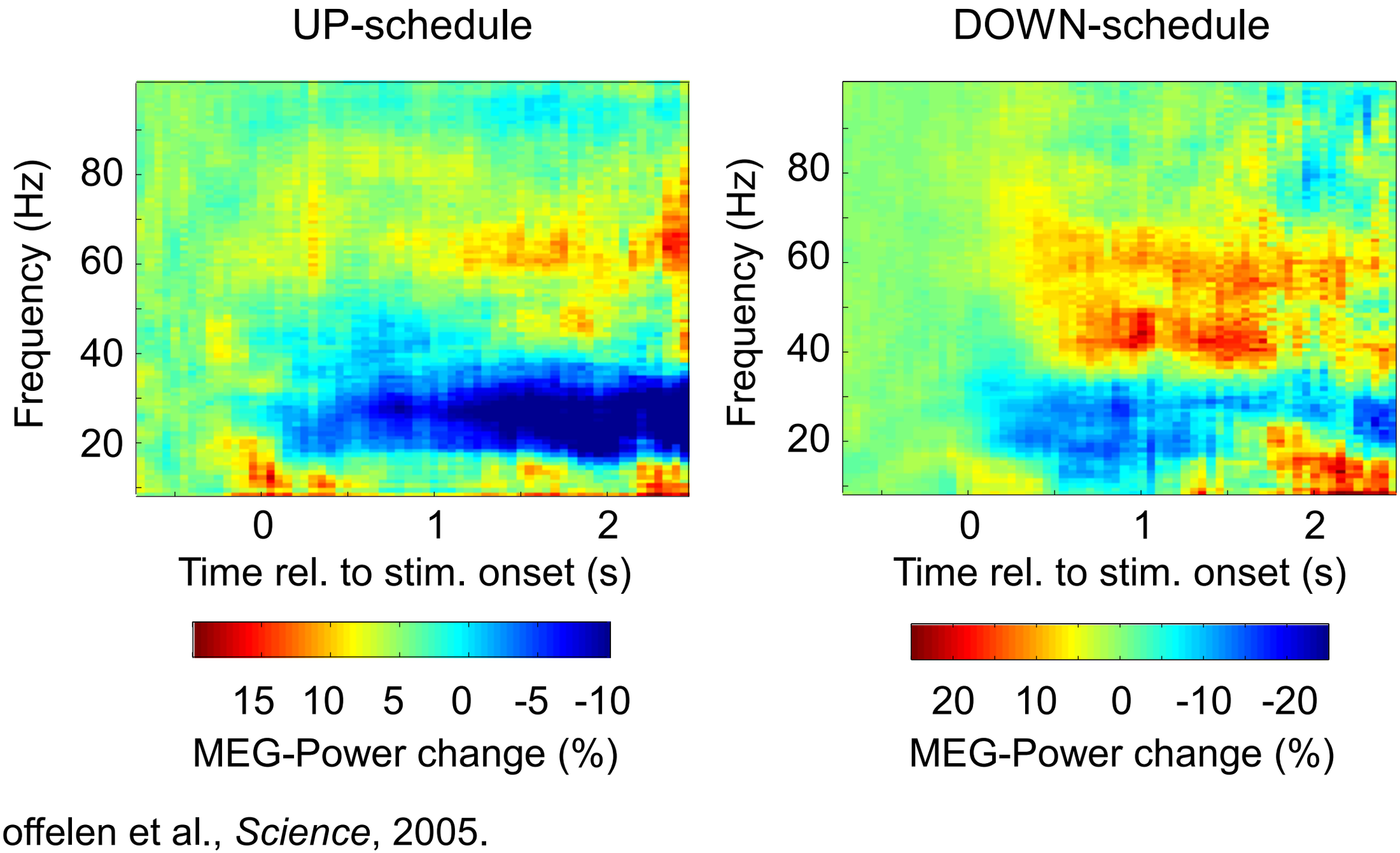
Schoffelen et al., *Science*, 2005.

The hazard rate modulates reaction times.



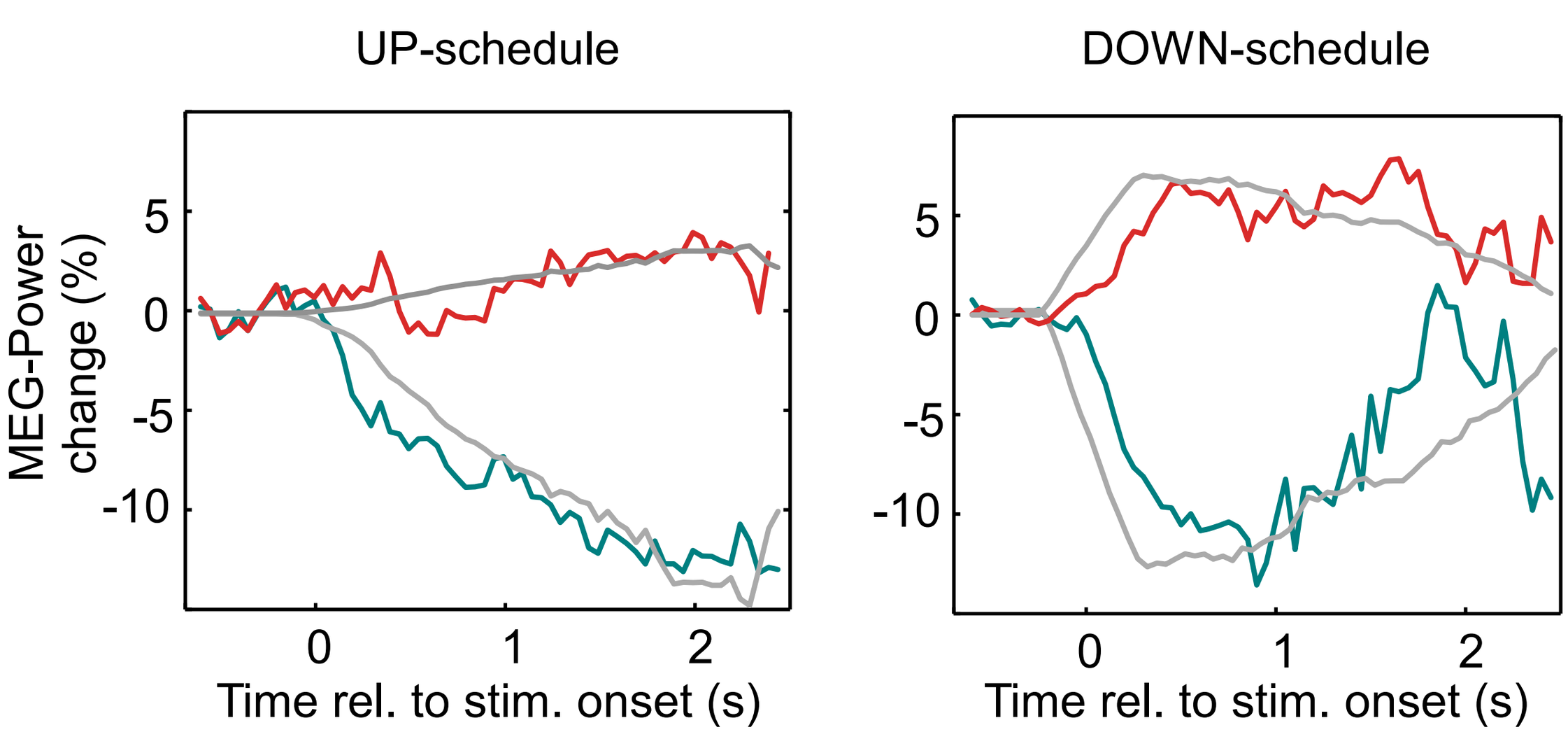
Schoffelen et al., *Science*, 2005.

The hazard rate modulates motor cortical oscillatory neuronal activity.



Schoffelen et al., *Science*, 2005.

The hazard rate modulates motor cortical oscillatory neuronal activity.

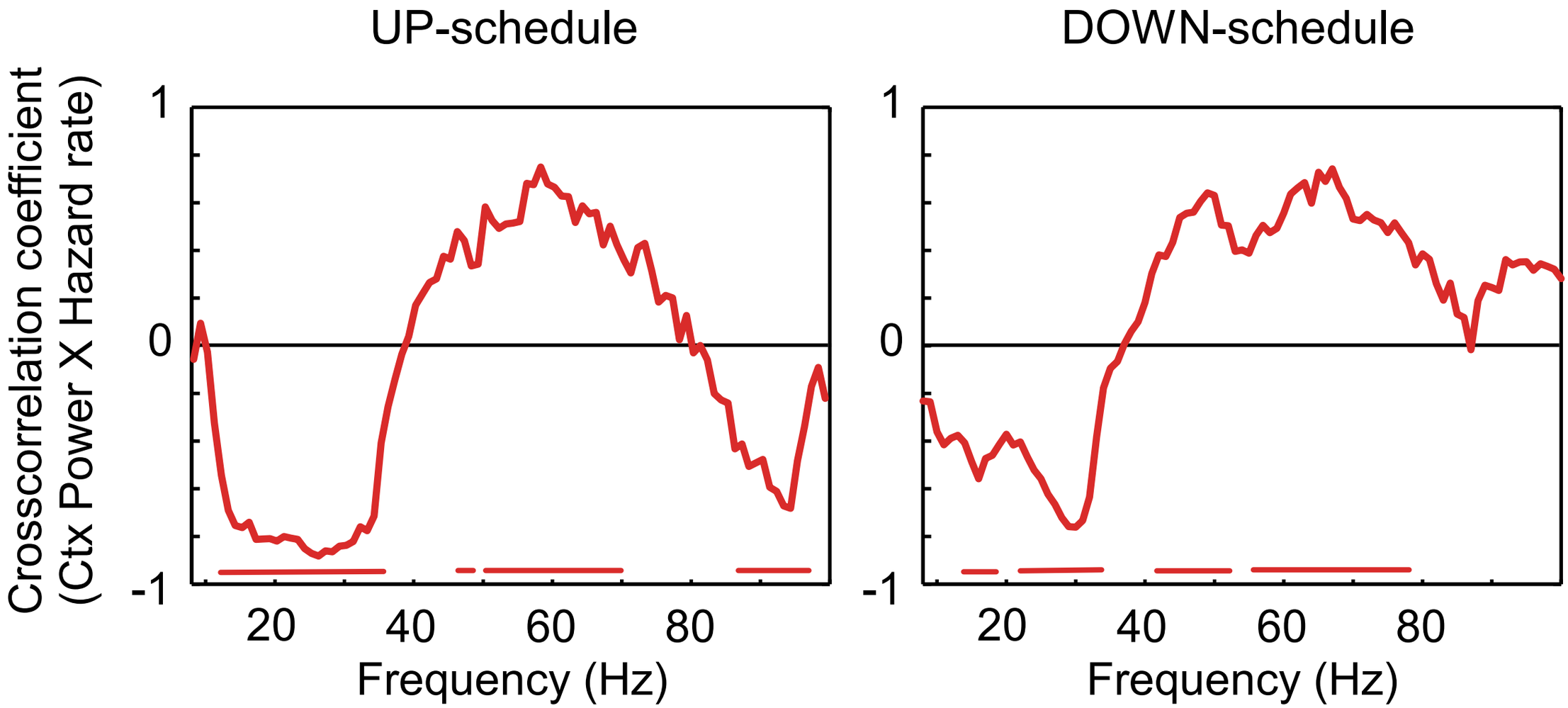


Power in the beta-band (15 - 30 Hz)

Power in the gamma-band (40 - 80 Hz)

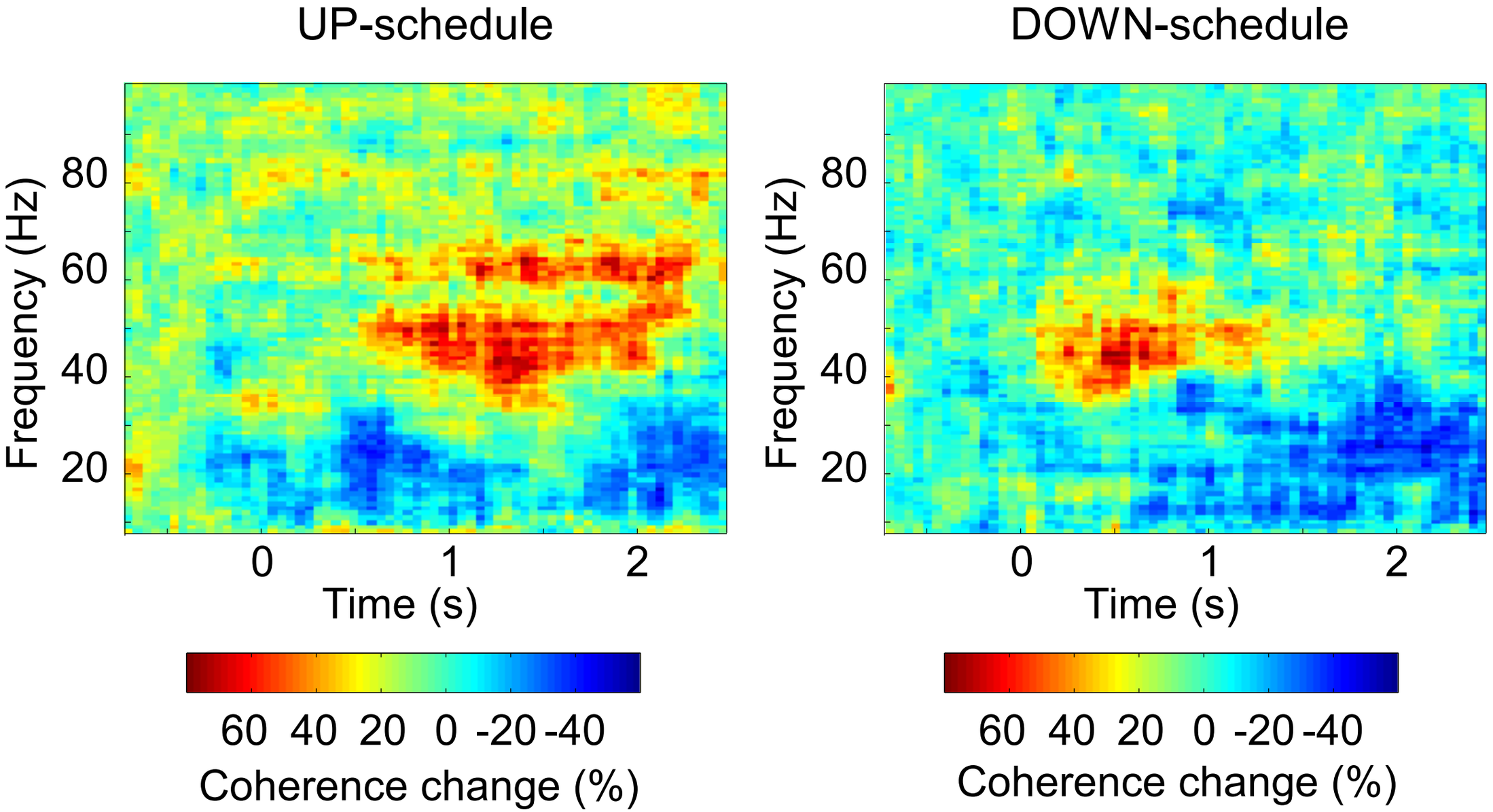
Schoffelen et al., *Science*, 2005.

The hazard rate differentially correlates with motor cortical activity in the beta- and gamma-bands.



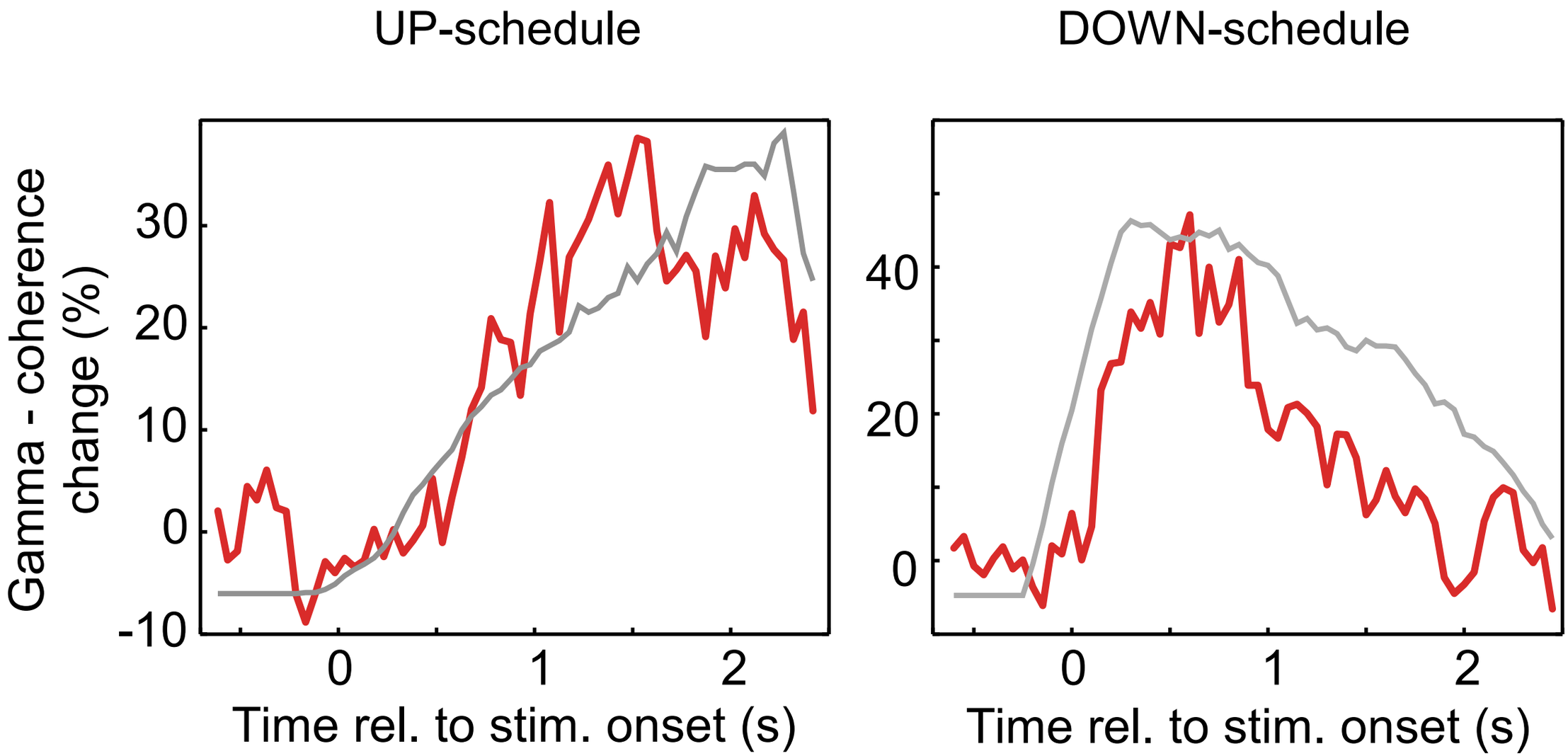
Schoffelen et al., *Science*, 2005.

The hazard rate modulates cortico-spinal coherence.



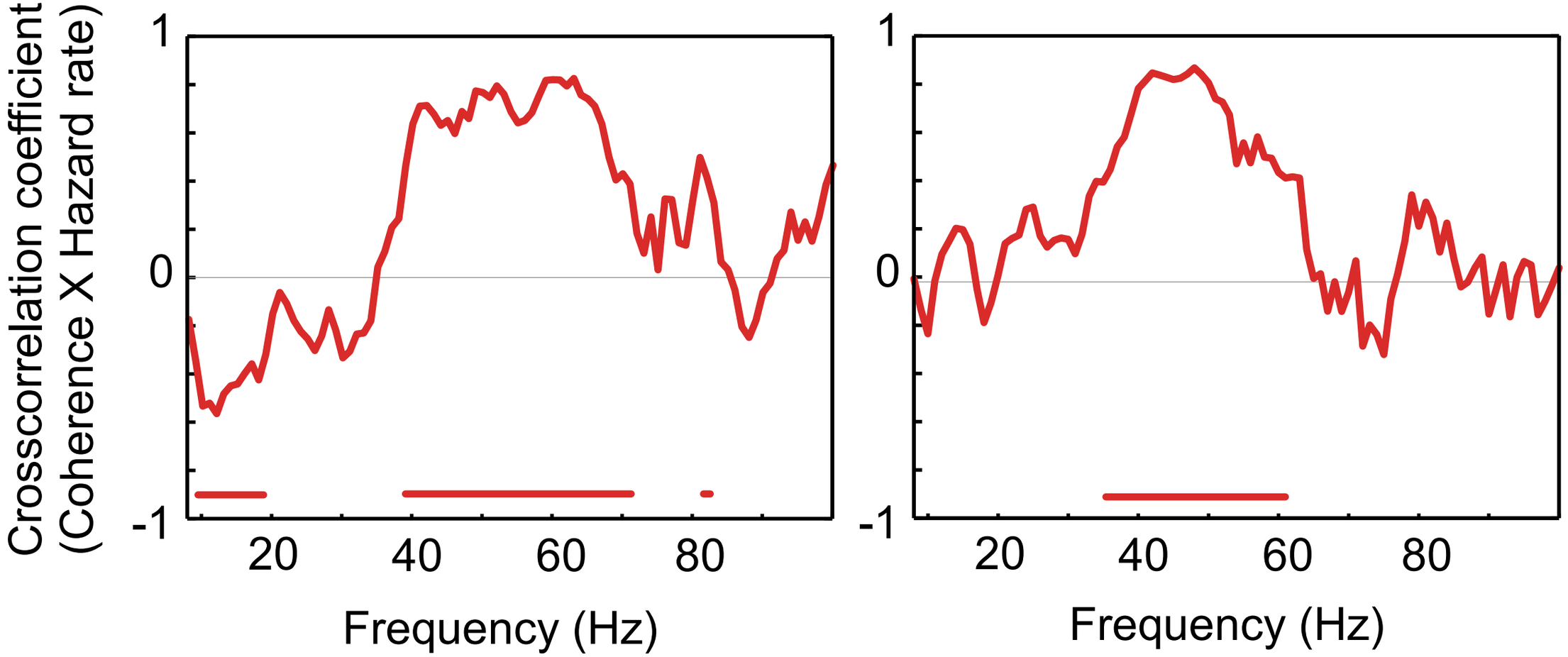
Schoffelen et al., *Science*, in press.

The hazard rate modulates cortico-spinal gamma-band coherence.



Schoffelen et al., *Science*, 2005.

The hazard rate selectively correlates with cortico-spinal gamma-coherence.



Schoffelen et al., *Science*, 2005.

Conclusions:

Neuronal groups communicate their specific messages to other groups by sending out synchronous spikes in the gamma-frequency rhythm.

Gamma-band coherence between neuronal groups amplifies the efficacy of their communication.

Both, synchronization within a neuronal group and coherence between groups is flexibly and dynamically modulated. This seems to be one mechanism through which cognitive operations like attention modulate effective synaptic gain.

Local- and long-range gamma-band coherence in the visual and in the motor system predicts behavior. This suggests a functional role.

We still need to test whether selective coherence results in selective communication and we need to better understand the mechanisms that generate and modulate long-range coherence.

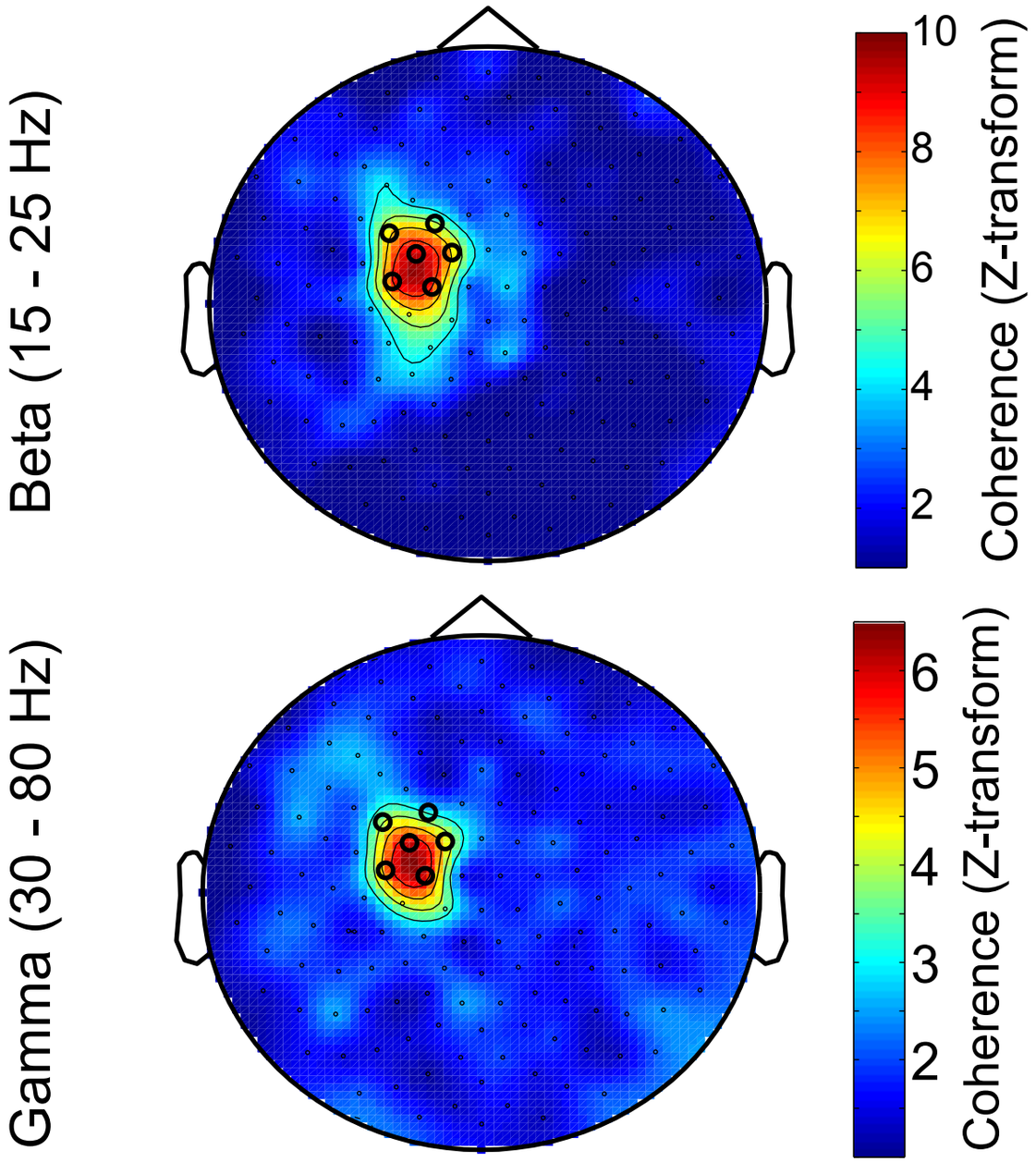
Links:

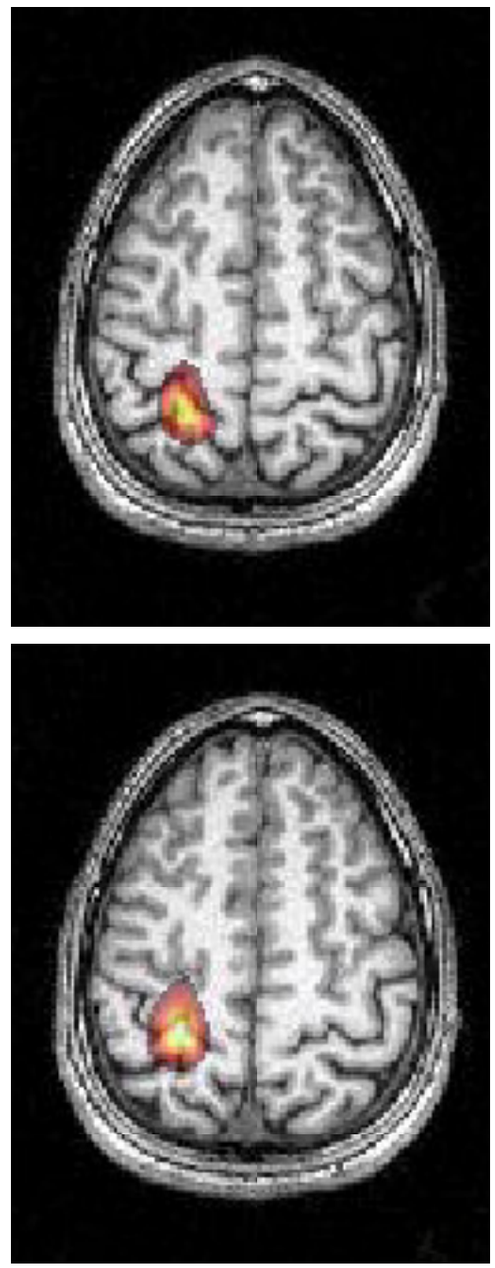
The software used is available in the FieldTrip open source Matlab toolbox: http://www.ru.nl/fcdonders/fieldtrip.

The cortical regions coherent with the spinal cord at beta- and gamma-frequency are very similar.

Planar gradiometers (grand average)

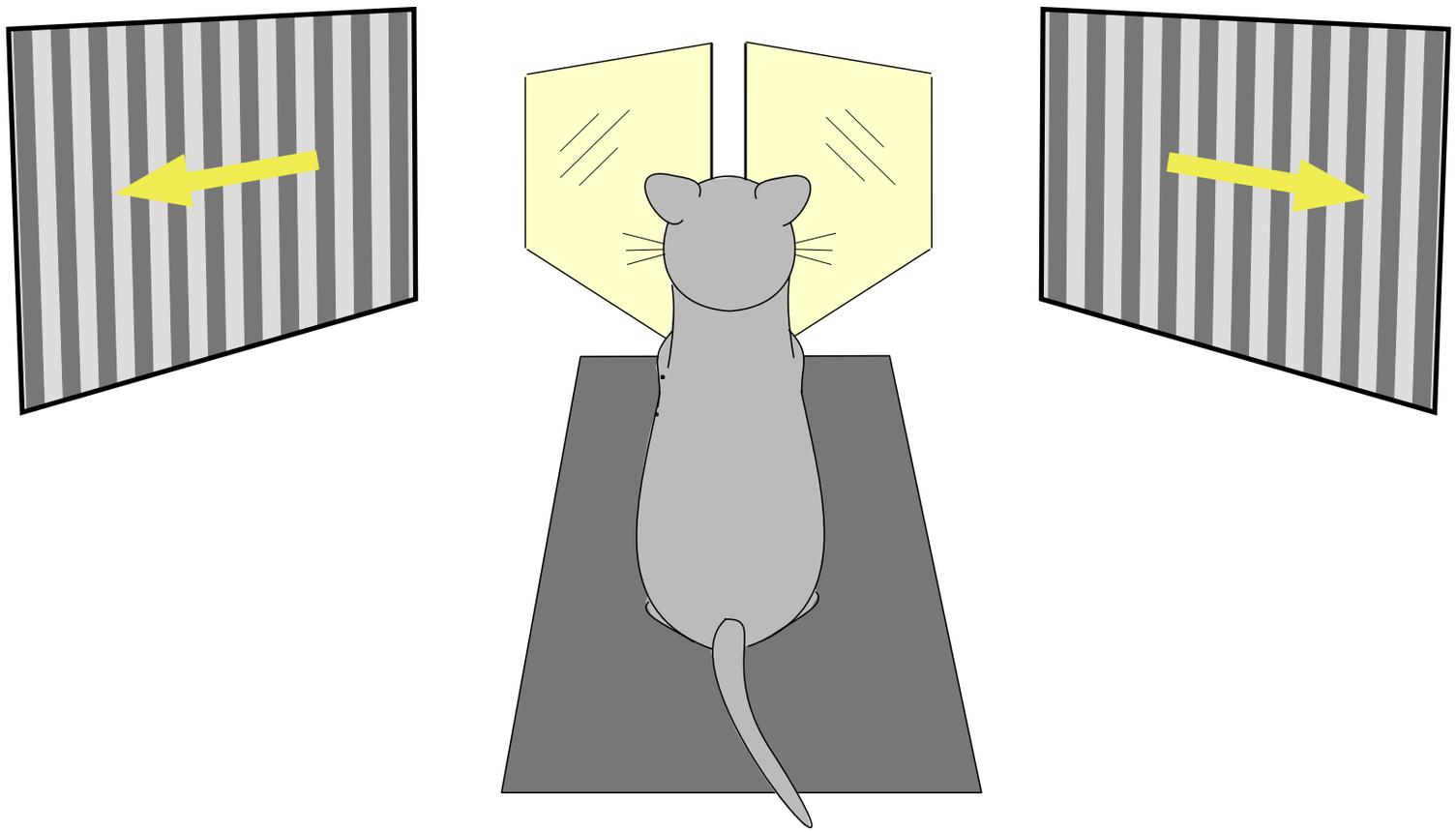
Sources (single subject)





Schoffelen et al., *Science*, in press.

Interocular rivalry



Gamma-band synchronization in primary visual cortex is modulated by perceptual stimulus awareness.

Neurons activated by the dominant eye

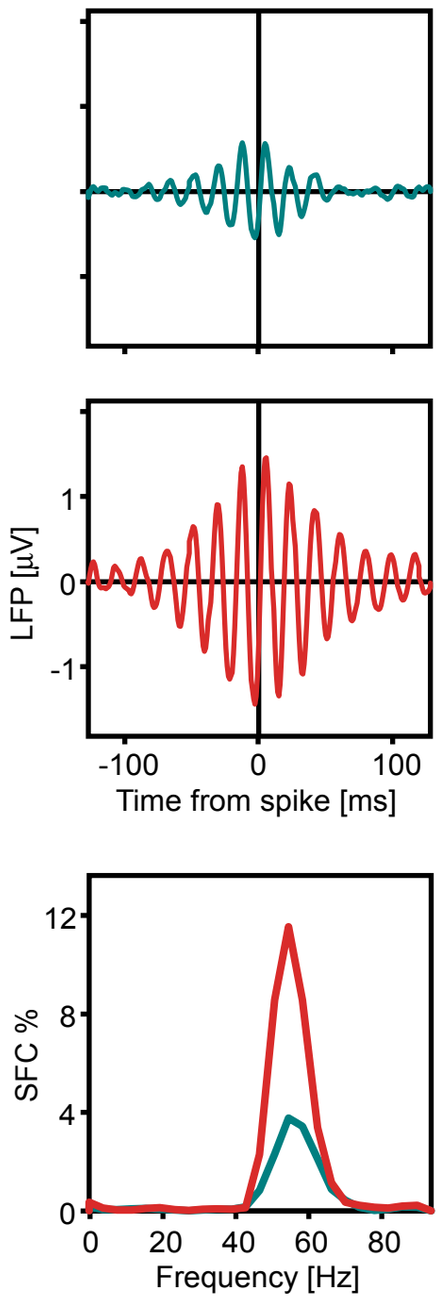
Neurons activated by the non-dominant eye

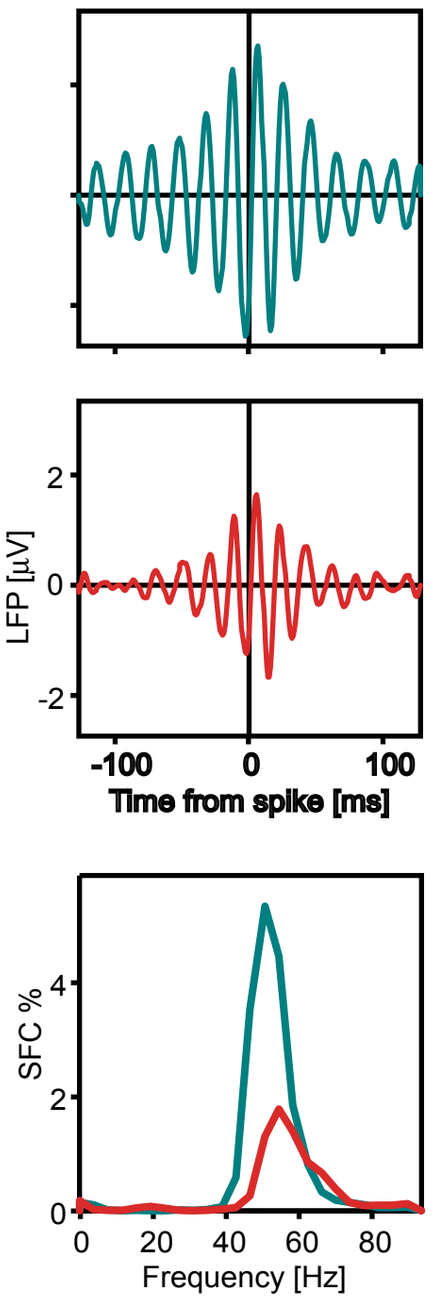
Dominant eye stimulus is the only stimulus

Non-dominant eye stimulus is the only stimulus

Dominant eye stimulus is actively selected during rivalry

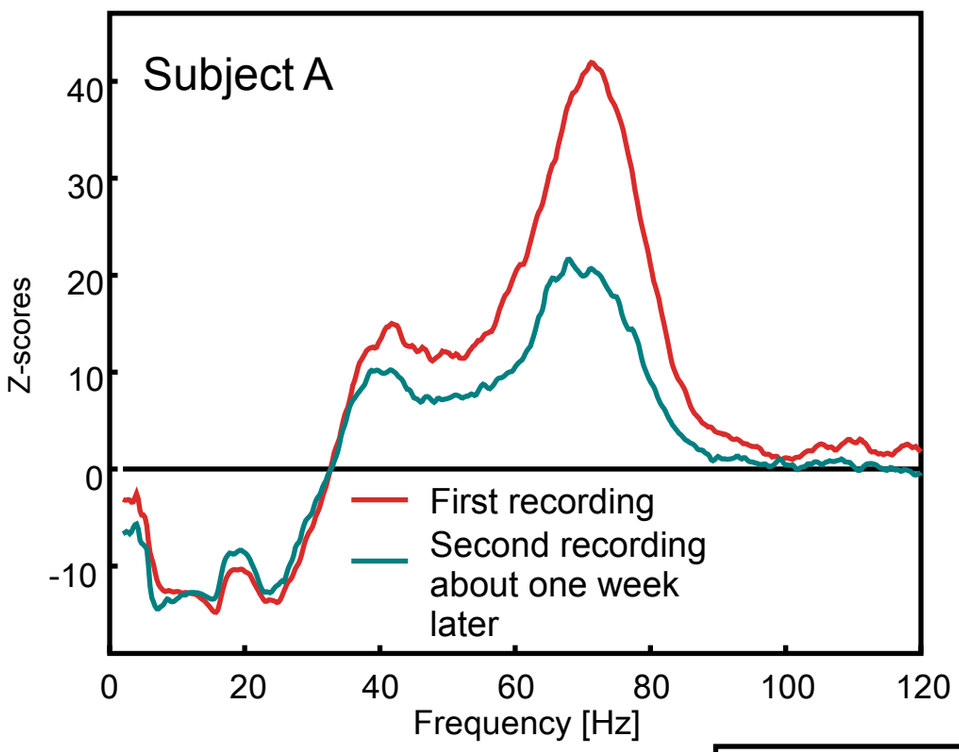
Non-dominant eye stimulus is actively suppressed during rivalry

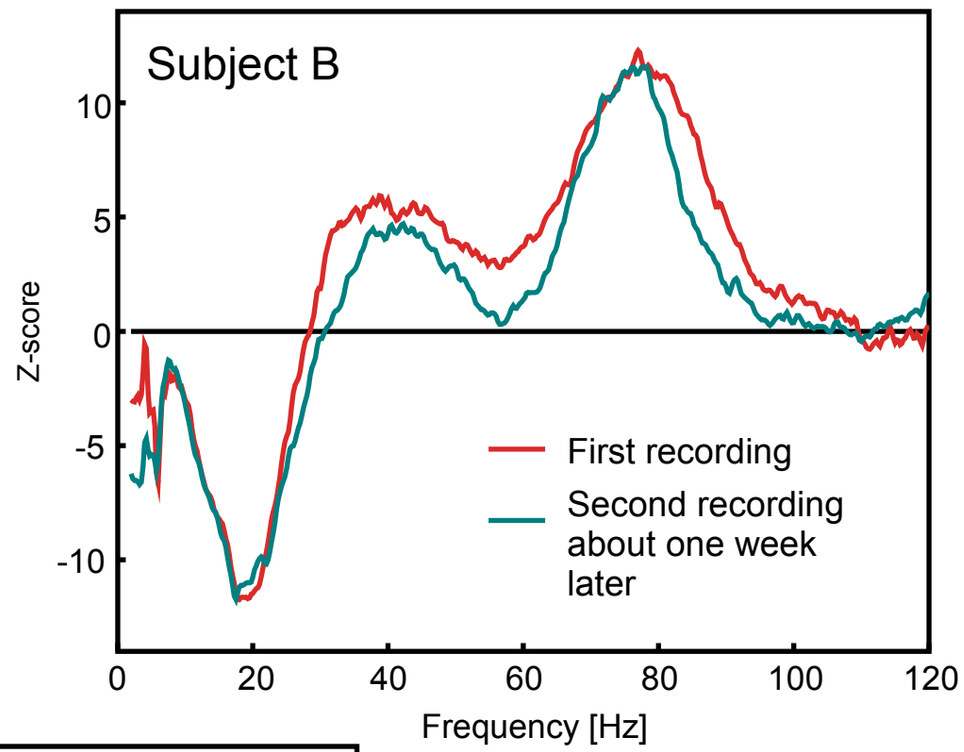


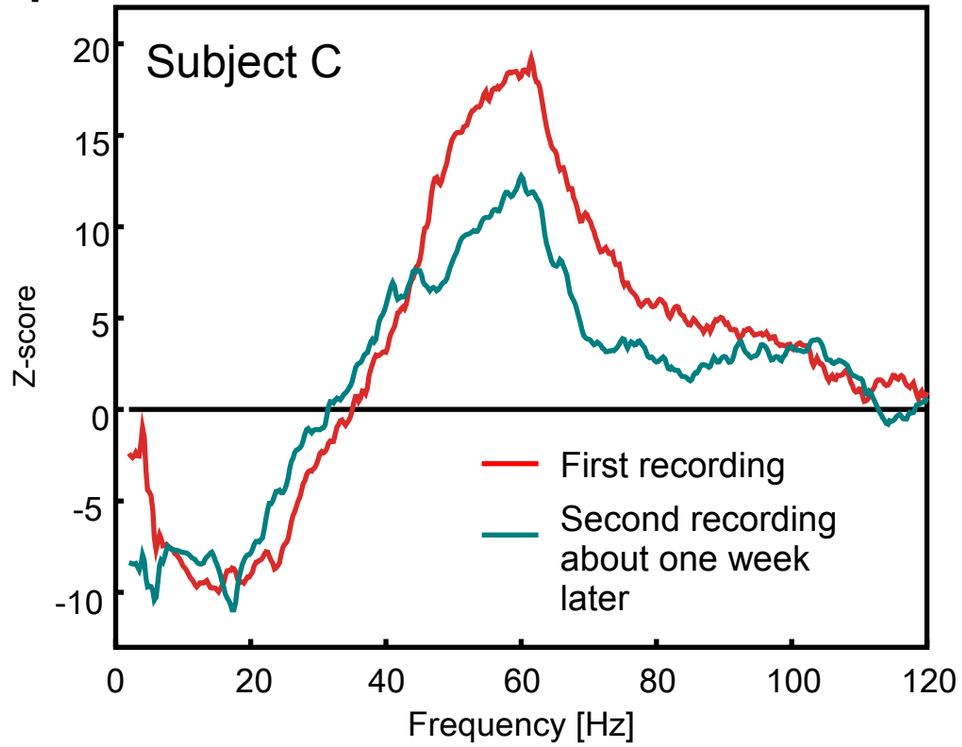


Fries et al., *J. Neurosci.*, 2002

The spectral signature of human visual processing

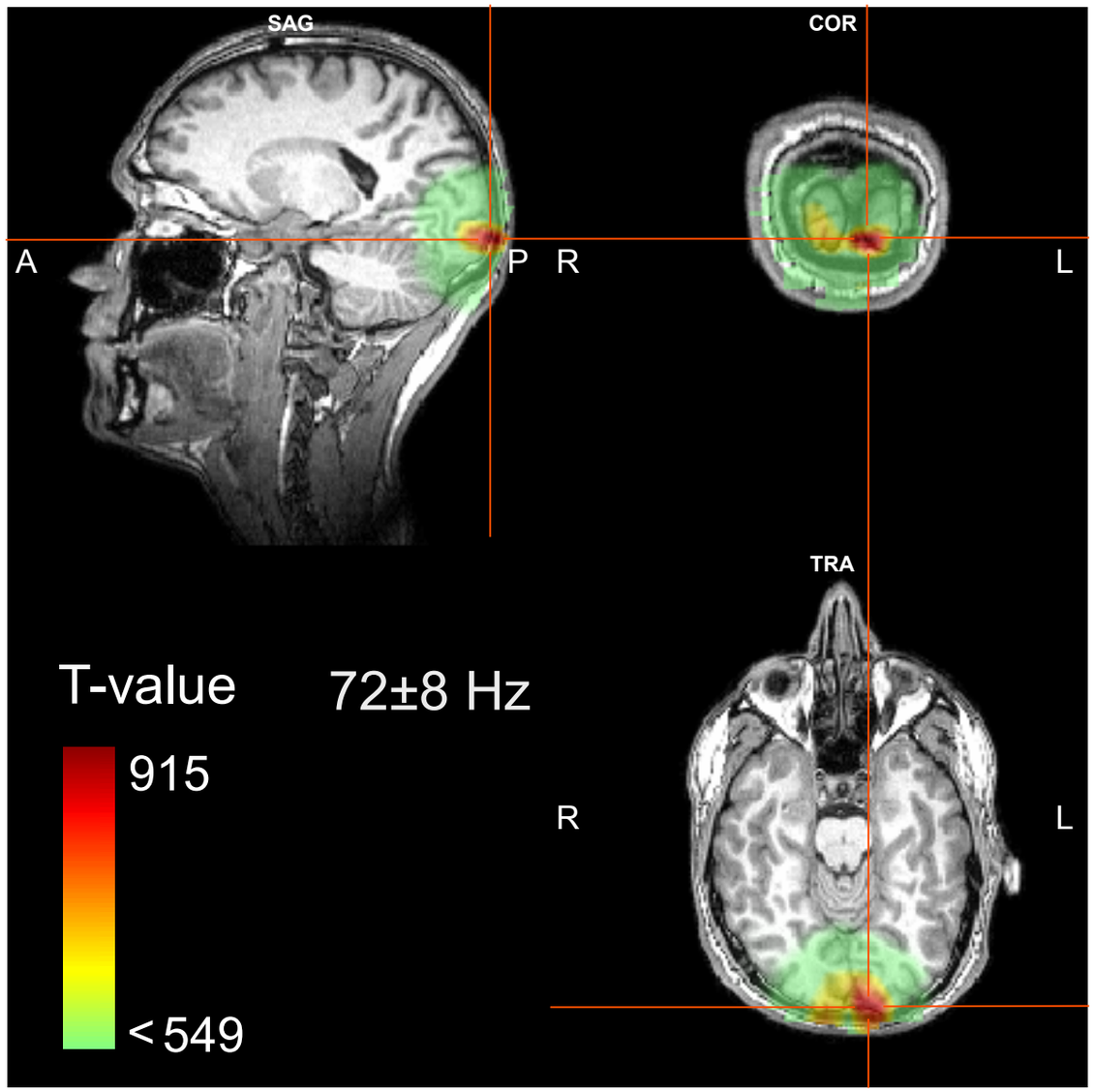






Strength and localization of gamma-band activity are very reliable over sessions.

One subject, first session



Same subject, one week later.