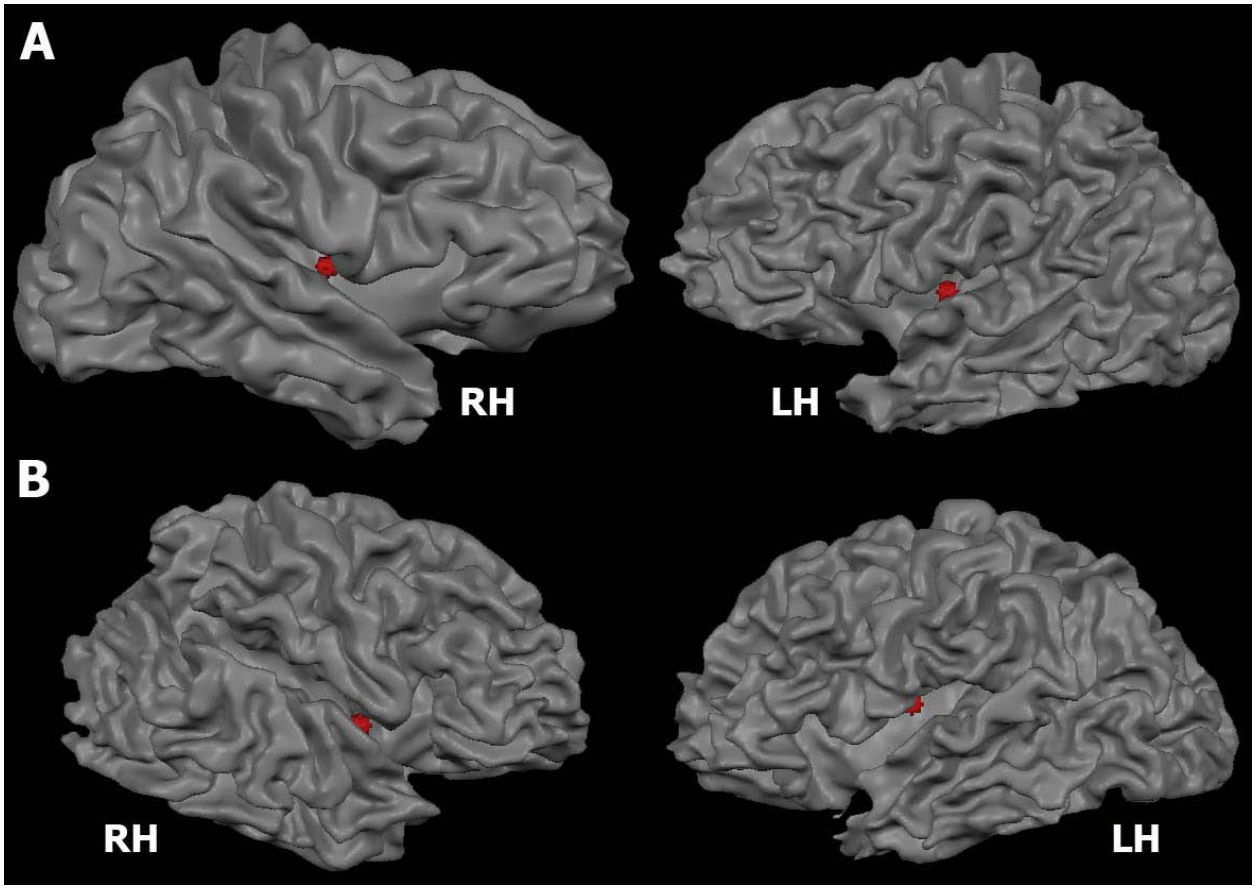
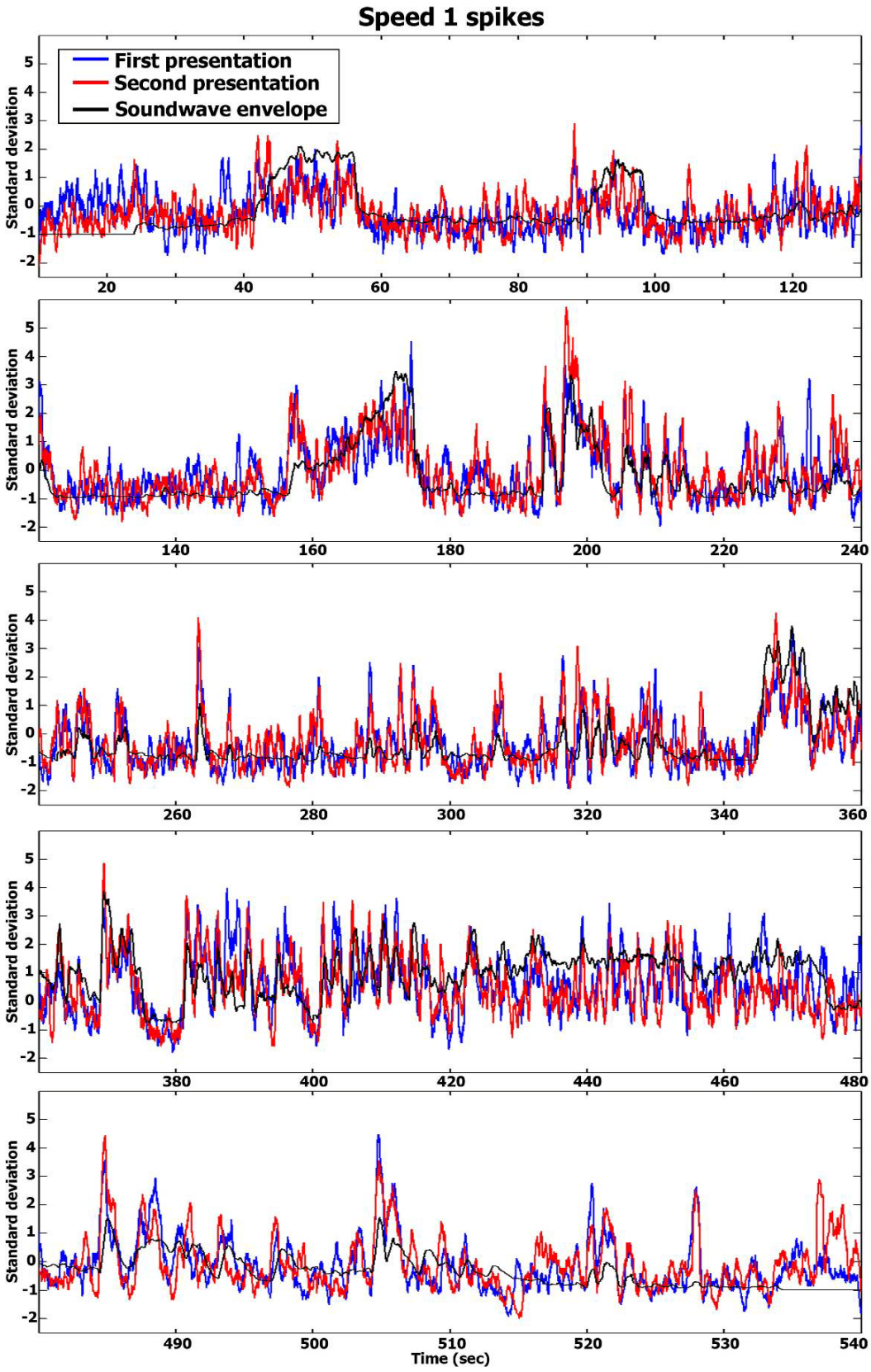
Supplementary material for Mukamel et. al ‘*Invariance of firing rate and field potential dynamics to stimulus modulation-rate in human auditory cortex*’

Figure S1



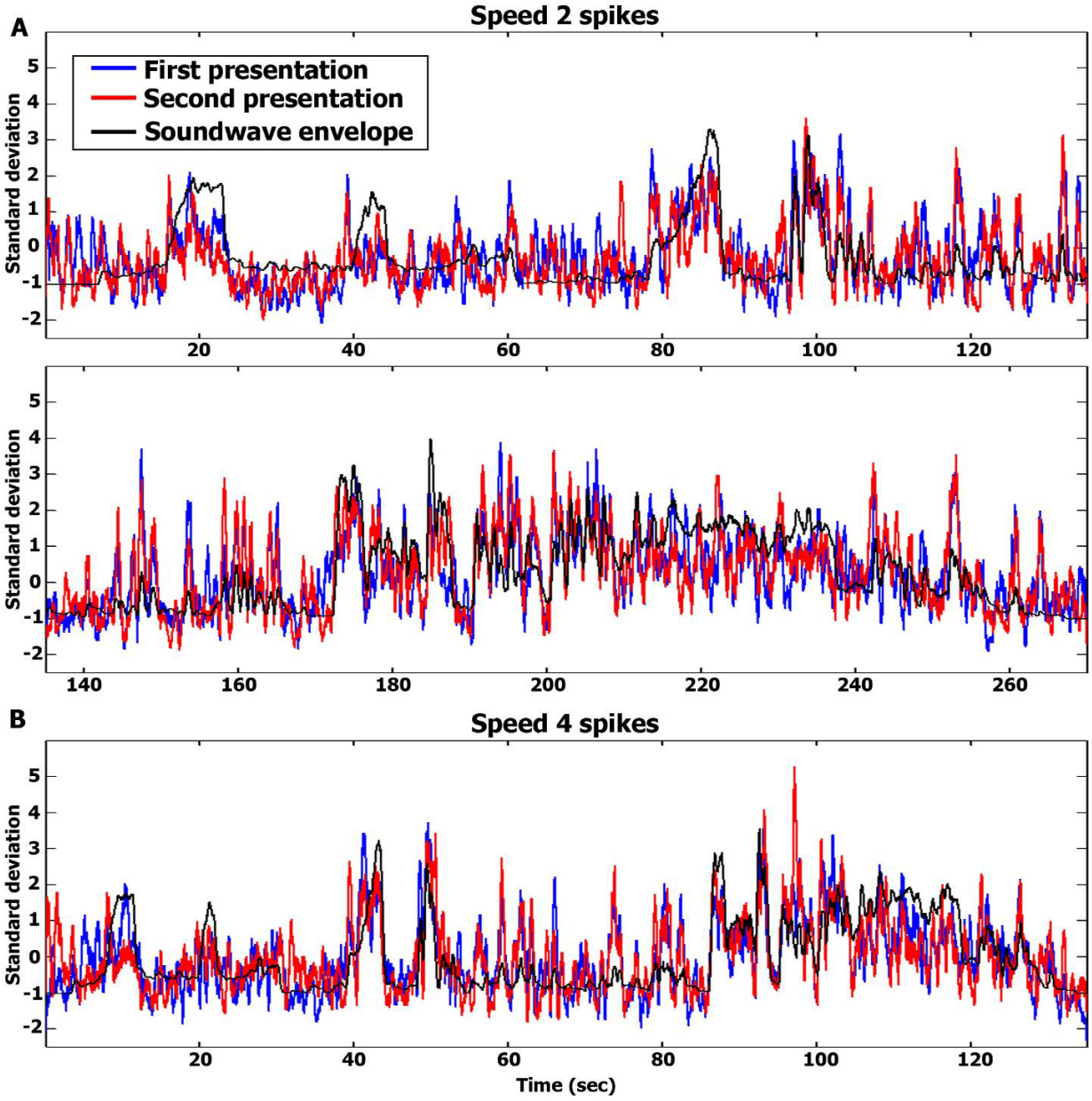
Supplementary figure 1: Anatomical location of electrodes (red) in Patient 1 (**A**) and Patient 2 (**B**) rendered on a 3D reconstruction of their brains. For 2D MRI and Talairach coordinates see Figure 1, and Table 1.

Figure S2


Speed 1 spikes
First presentation
Second presentation
Soundwave envelope
Standard deviation
Time (sec)

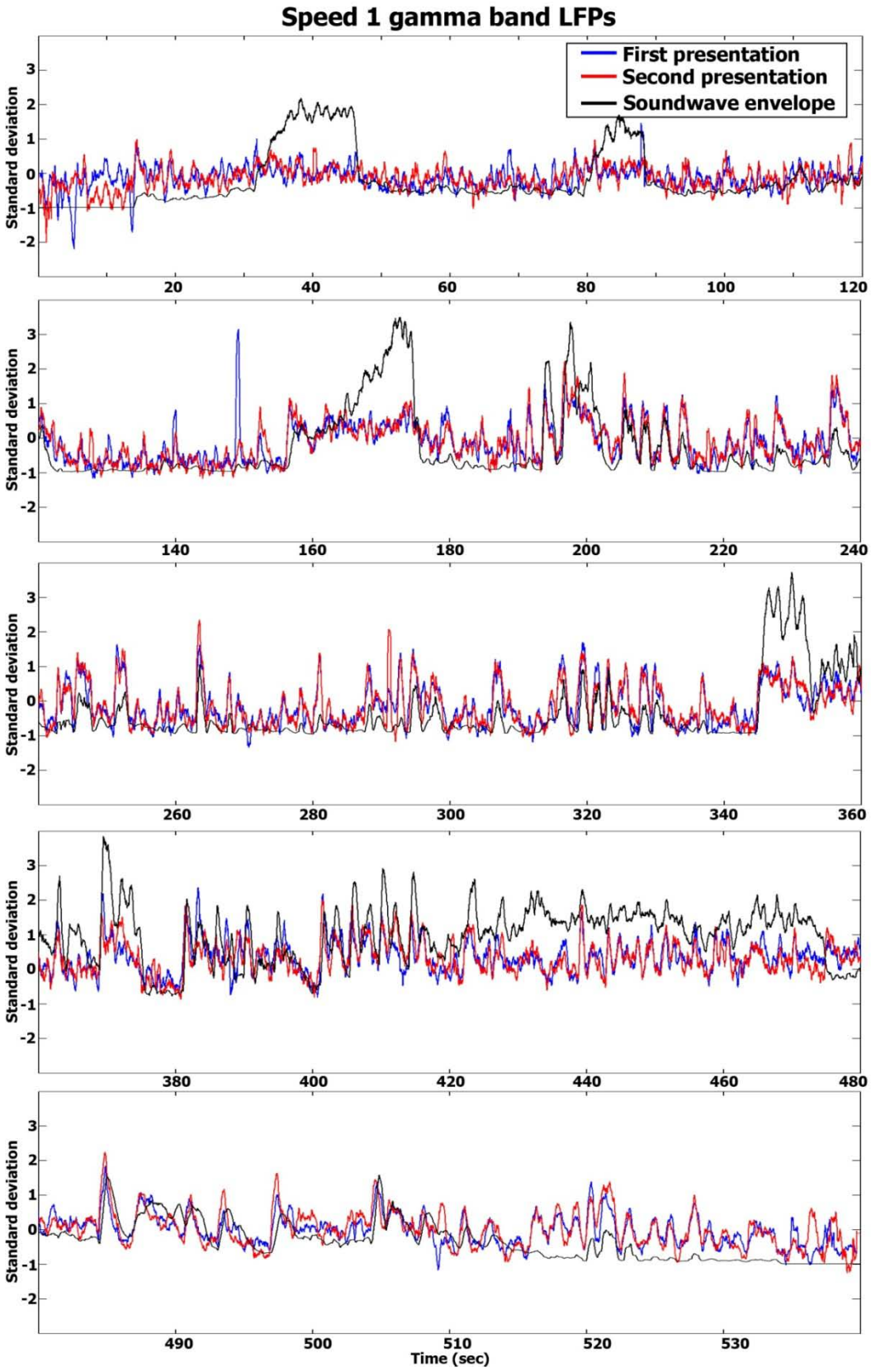
Supplementary figure 2: Reproducibility of spiking activity across two repeated stimulations. Average time course of all 25 responsive neurons during the first (blue) and second (red) normal speed presentation of the movie. Before averaging, the time courses of each neuron was smoothed with a 500ms square bin. Black trace represents the sound wave envelope also smoothed with a 500ms square bin (see methods). All traces are plotted in standard deviation scale (after z-score normalization).

Figure S3



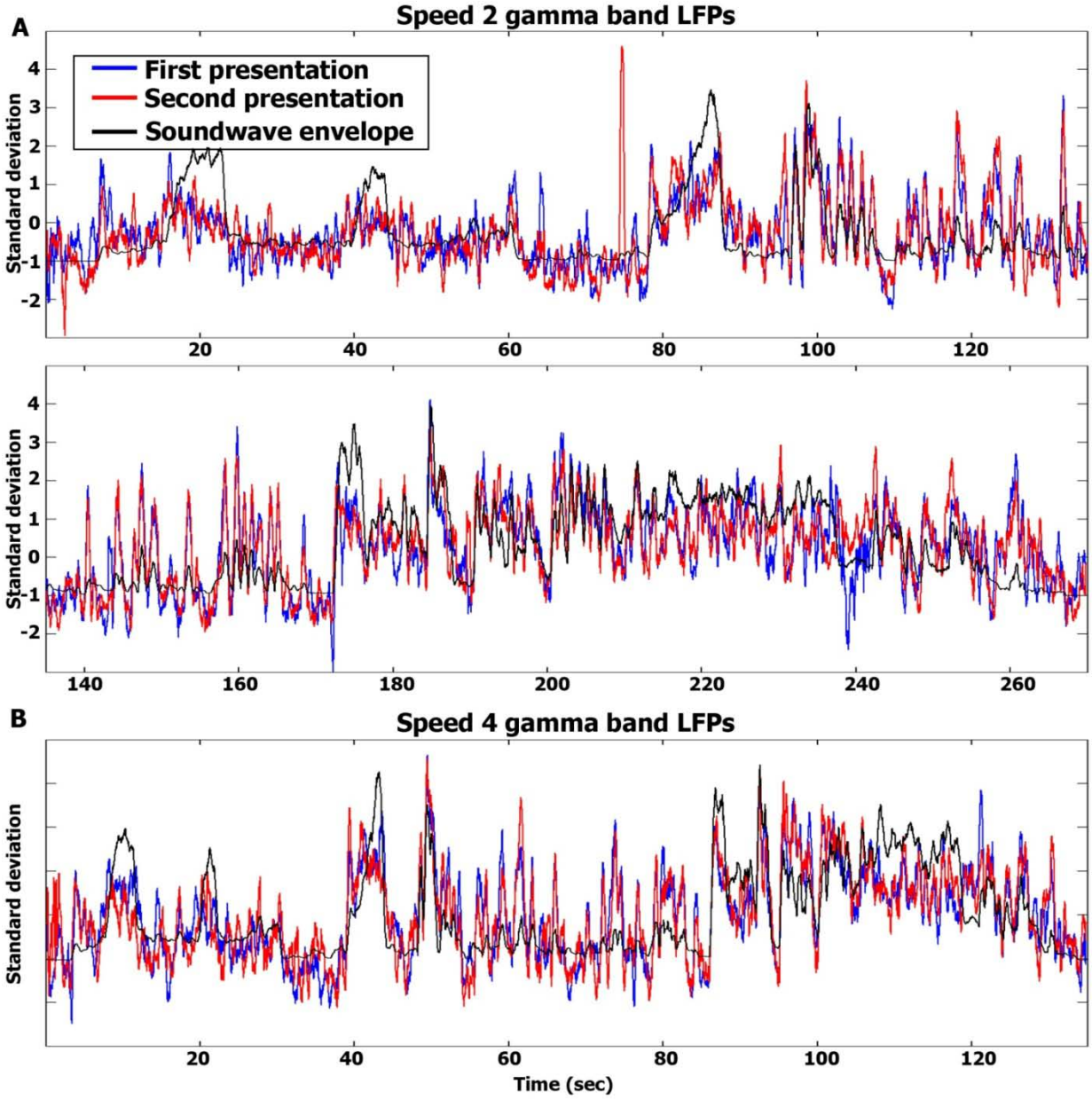
Supplementary figure 3: Same as supplementary figure 2 for the double (**A**) and quadruple (**B**) speeds.

Figure S4


Speed 1 gamma band LFPs
First presentation
Second presentation
Soundwave envelope
Standard deviation
Time (sec)

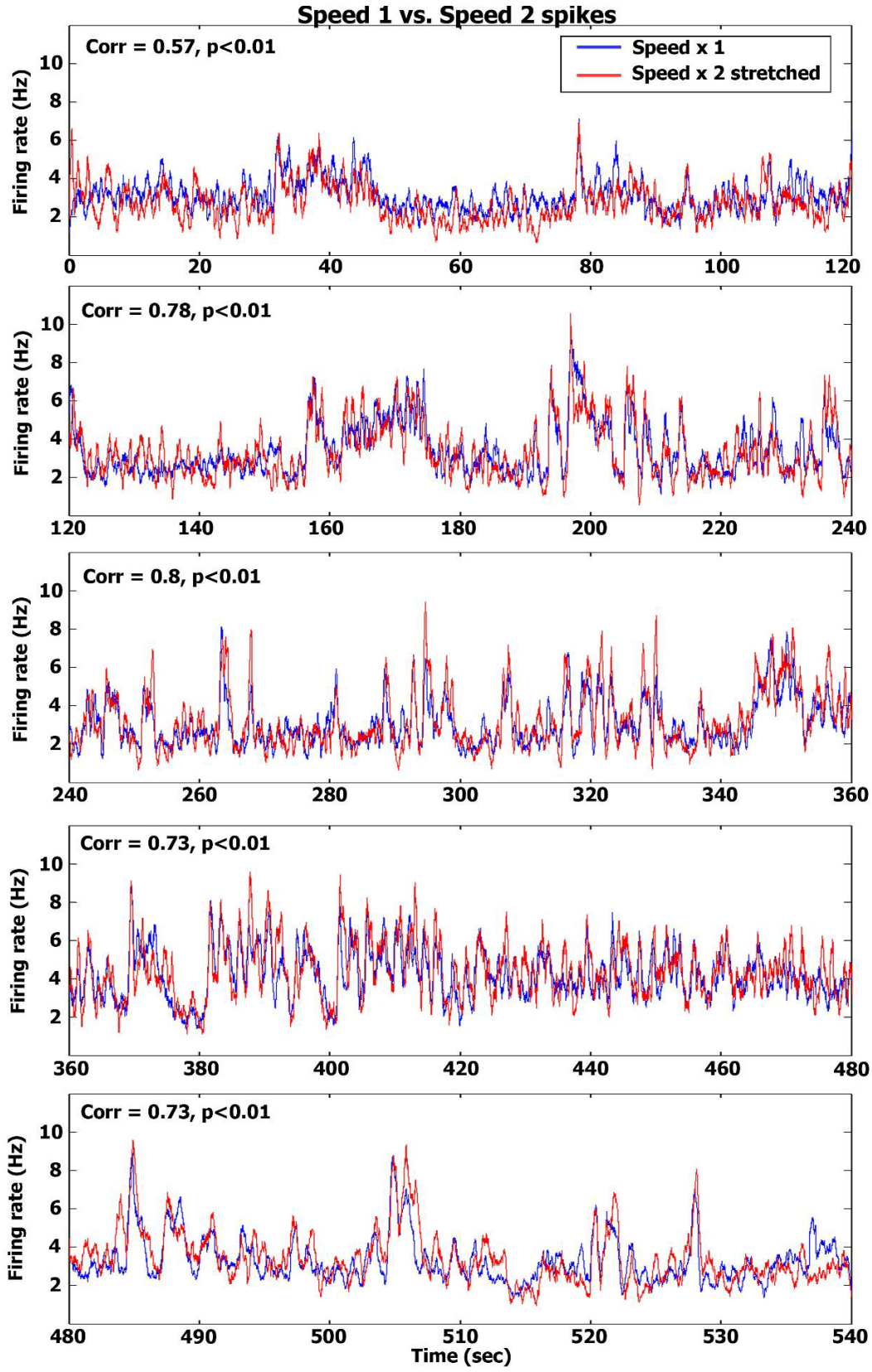
Supplementary figure 4: LFP reproducibility in the high gamma band across two repeated stimulations. Average time course of 21 LFP channels during the first (blue) and second (red) normal speed presentation of the movie. Before averaging, the absolute value of the signal from each electrode was smoothed with a 500ms square bin. Black trace represents the absolute of the sound wave down sampled from 41.1kHz to 1kHz by taking the sum of all values in 1ms bins. Similar to the LFPs, the resulting signal was smoothed with a 500ms square bin. All traces are plotted in standard deviation scale (after z-score normalization).

Figure S5



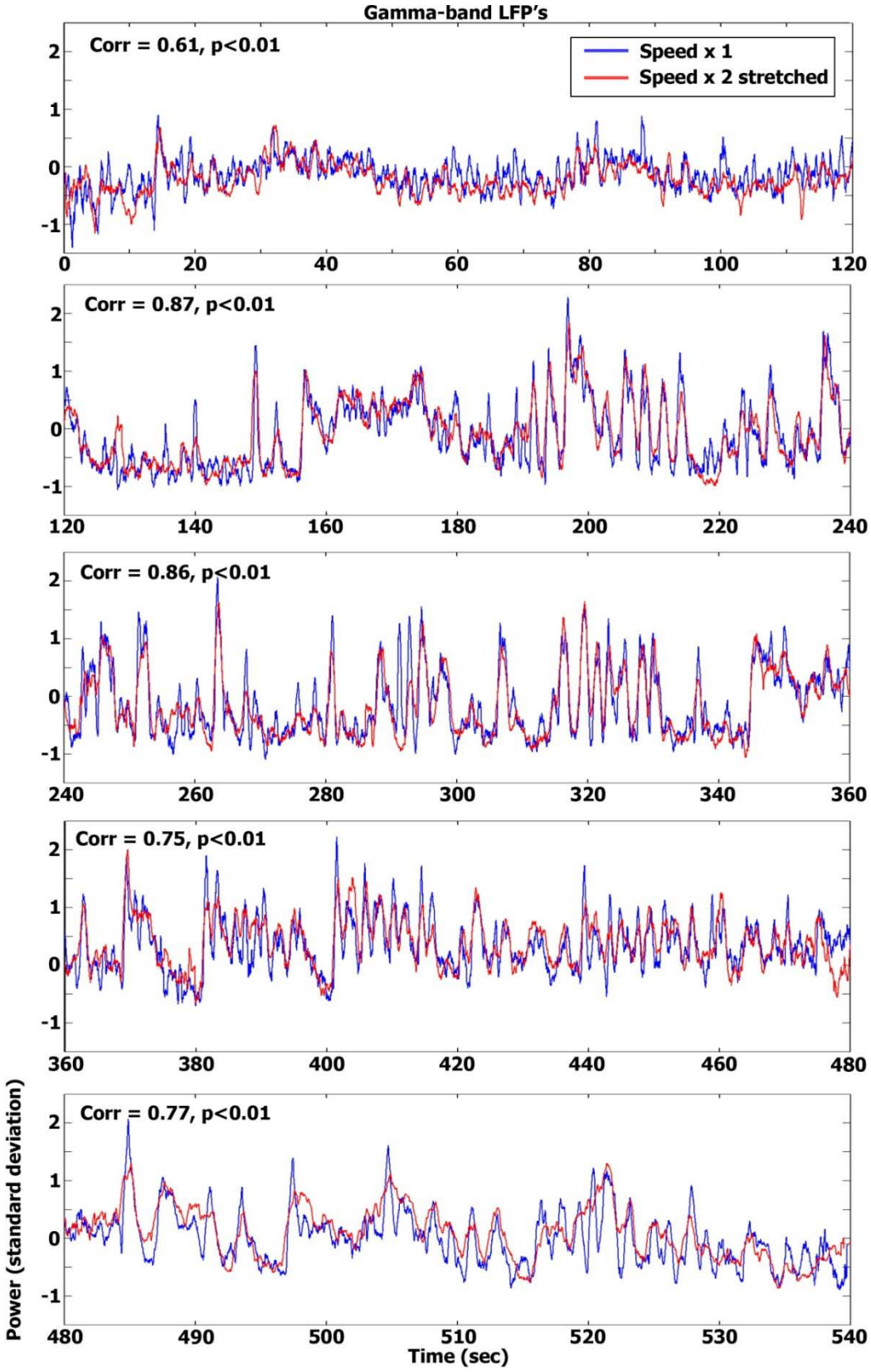
Supplementary figure 5: Same as supplementary figure 4 for the double (**A**) and quadruple (**B**) speeds.

Figure S6


Speed 1 vs. Speed 2 spikes
Corr = 0.57, p<0.01
Speed x 1
Speed x 2 stretched
Corr = 0.78, p<0.01
Corr = 0.8, p<0.01
Corr = 0.73, p<0.01
Corr = 0.73, p<0.01
Firing rate (Hz)
Time (sec)

Supplementary figure 6: Stretch analysis - spikes. Average time course of spike trains from all responsive neurons (N = 25) during normal speed stimulation (blue trace) superimposed on the average time course during double speed stimulation stretched in time (red trace; see methods). All time courses were smoothed with a 500ms square bin. The traces represent the time course for the entire duration of the experiment. Correlation values and significance levels are given for each time segment shown.

Figure S7


Gamma-band LFP's
Corr = 0.61, p<0.01
Speed x 1
Speed x 2 stretched
Corr = 0.87, p<0.01
Corr = 0.86, p<0.01
Corr = 0.75, p<0.01
Corr = 0.77, p<0.01
Power (standard deviation)
Time (sec)

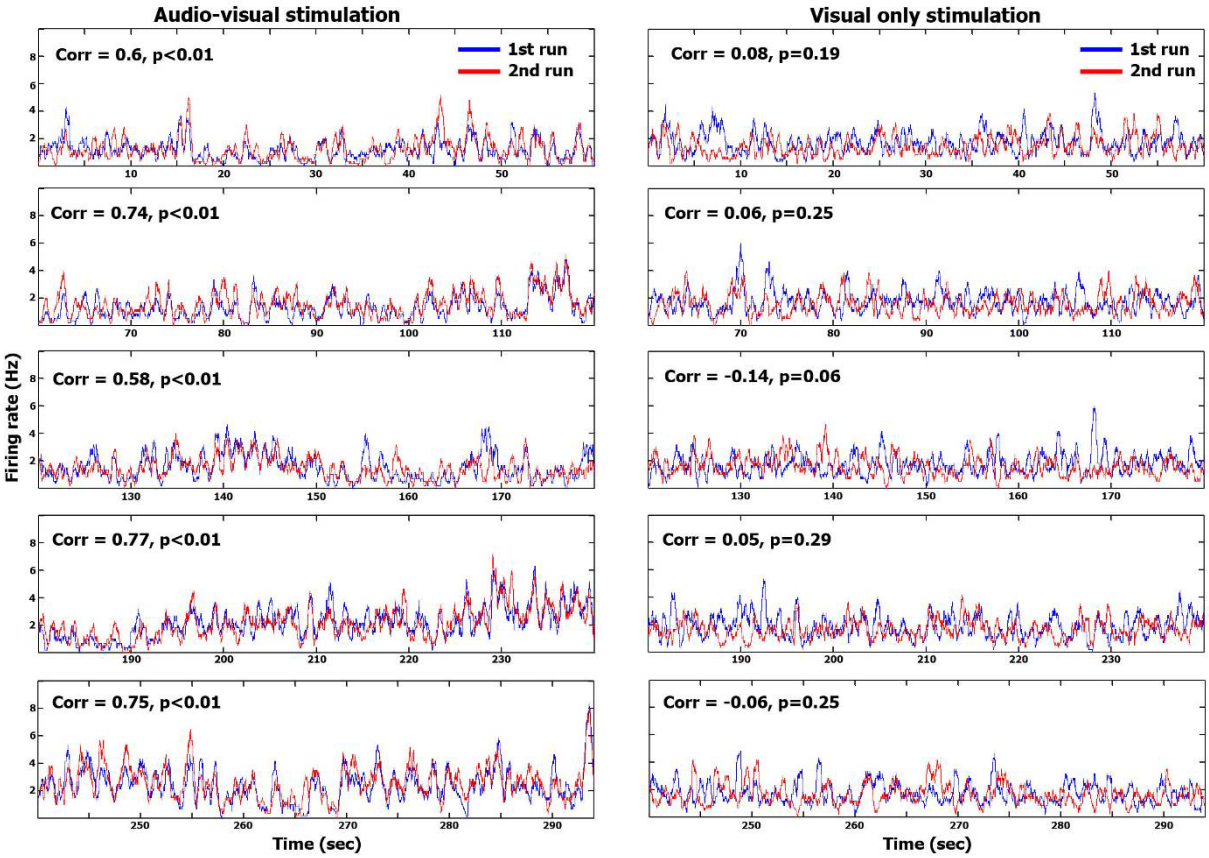
Supplementary figure 7: Stretch analysis – LFP's. Similar to supplementary figure 6, average time course of high gamma-band LFP's (N = 21) during normal speed stimulation (blue trace) superimposed on the average time course during double speed stimulation stretched in time (red trace; see methods). All time courses were smoothed with a 500ms square bin. The traces represent the time course for the entire duration of the experiment. Correlation values and significance levels are given for each time segment shown.

Table S1

	Session	# of recorded cells in Right (Left) hemisphere	# of responsive cells in Right (Left) hemisphere	Average AV1-AV2 correlation	Average AV1-VO1 correlation	Average VO1-VO2 correlation
Patient 1	1	0 (6)	0 (6)	0.32	0	0
	2	2 (10)	2 (6)	0.24	0.05	NA
	3	3(8)	1 (6)	0.24	0.05	NA
Patient 2	1	5 (0)	4 (0)	0.2	0.05	0.04
Total	4	10 (24)	7 (18)	0.25	0.03	0.01

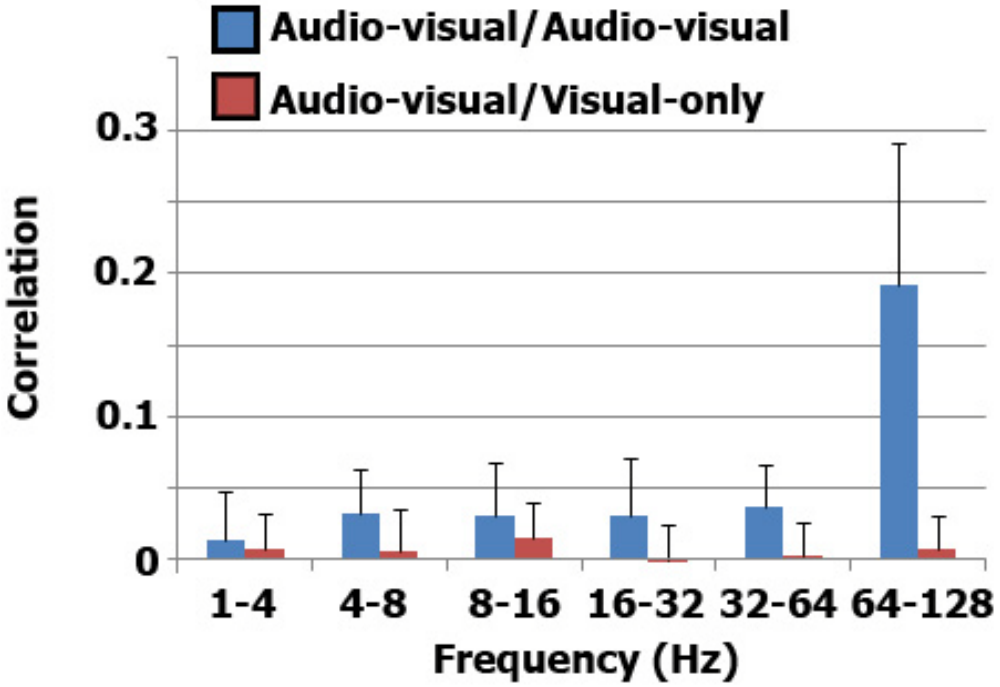
Supplementary Table 1: Number of recorded cells and average correlation levels of spike trains (binned at 200ms) between: first and second audio-visual stimulations (AV1-AV2); first audio-visual stimulation and visual-only stimulation (AV1-VO1); first and second visual-only stimulations (VO1-VO2). The movie used in the first session in patient 1 was ‘Pretty woman’, and the movie ‘Sister Act 2’ was used in sessions 2 and 3. The ‘Good, the Bad and the Ugly’ was used with Patient 2.

Figure S8



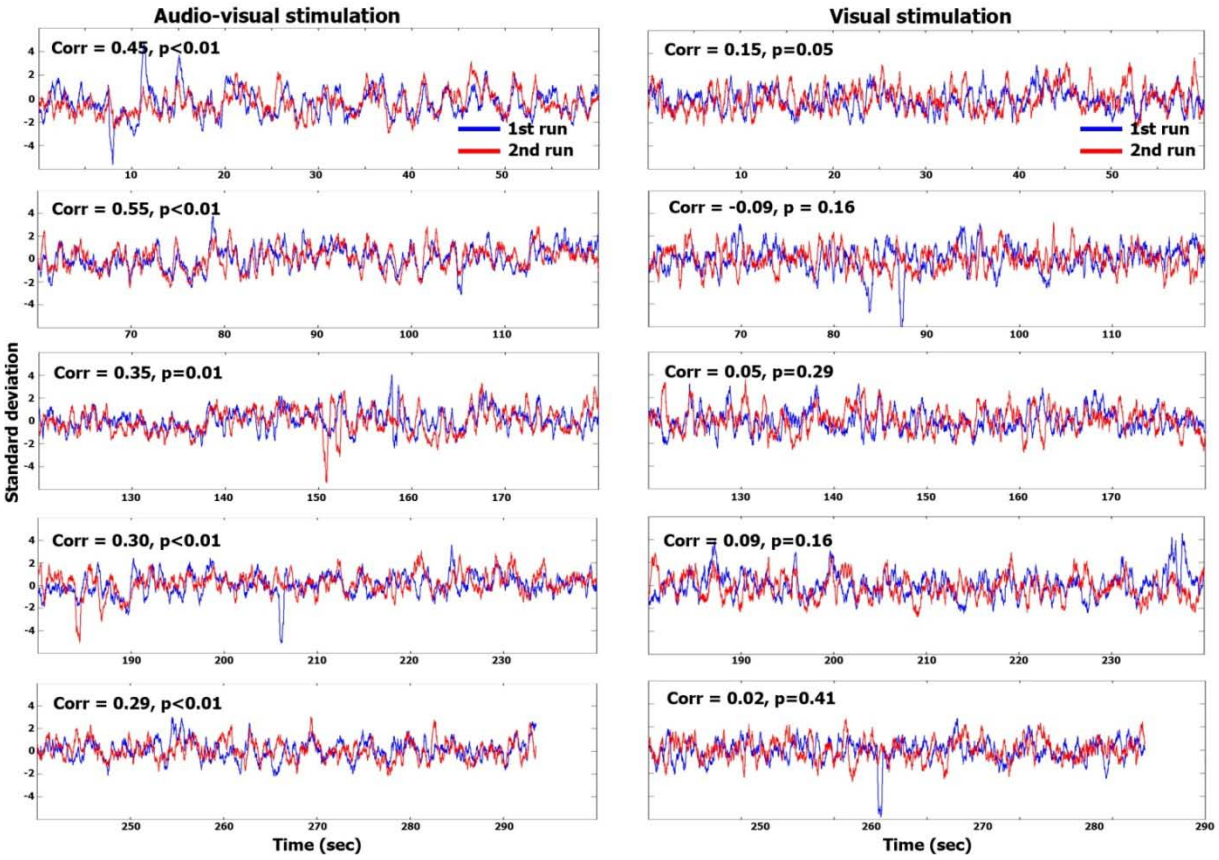
Supplementary figure 8: Average spiking activity of 6 neurons recorded during one session with Patient 1 during audio-visual stimulation (left) and visual only stimulation (right). Blue and red traces represent the average time course during first and second repeats of the stimulation. Correlation levels between runs and significance for each time segment are in the upper left corner.

Figure S9



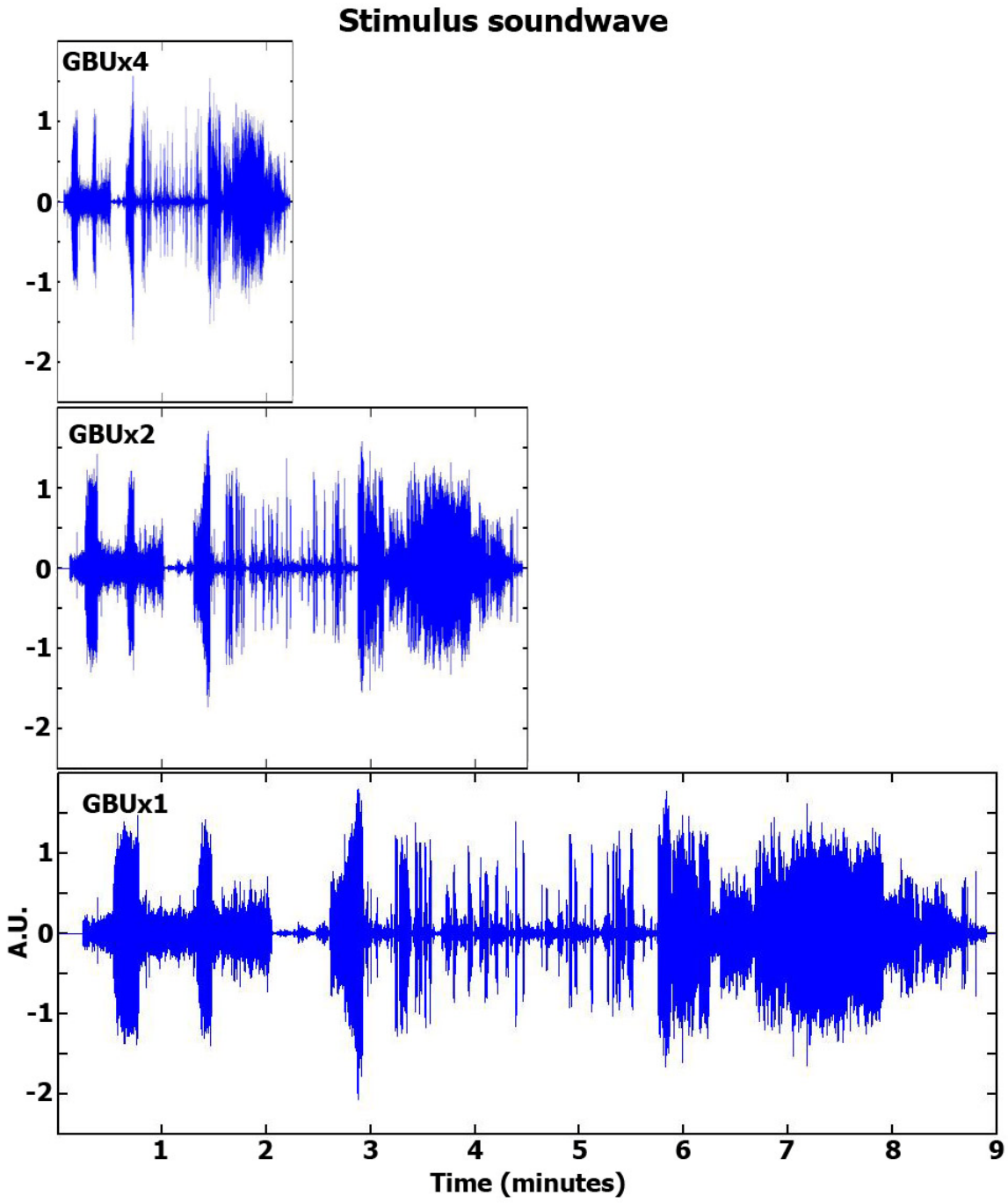
Supplementary figure 9: Correlation of LFP during audio-visual and visual-only stimulation. For each patient we had 2 repeats of the audio-visual stimulation and at least one repeat of visual-only stimulation (see methods). The graphs represent the mean correlation across all LFP channels between the two audio-visual stimulations (blue) and between the audio-visual and visual-only stimulation (red) for the different frequencies. LFP time courses were binned using a 200ms window. Error bars denote standard deviation across electrodes (N = 21)

Figure S10



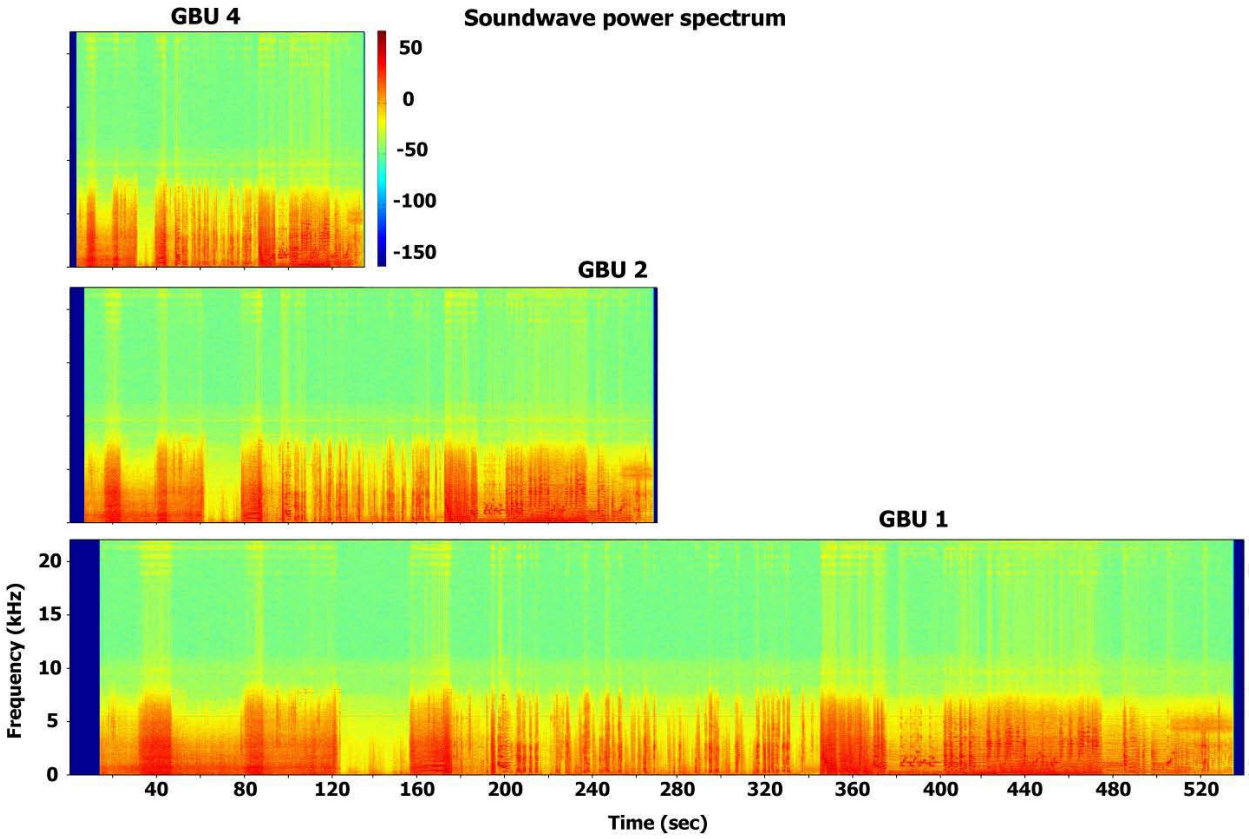
Supplementary figure 10: Average gamma band LFP time course of 6 channels recorded simultaneously during one session with Patient 1. Left panels - audio-visual stimulation and right panels - visual only stimulation. Blue and red traces represent the average time course during first and second repeats of the stimulation. Correlation levels between runs and significance for each time segment are in the upper left corner of each panel.

Figure S11



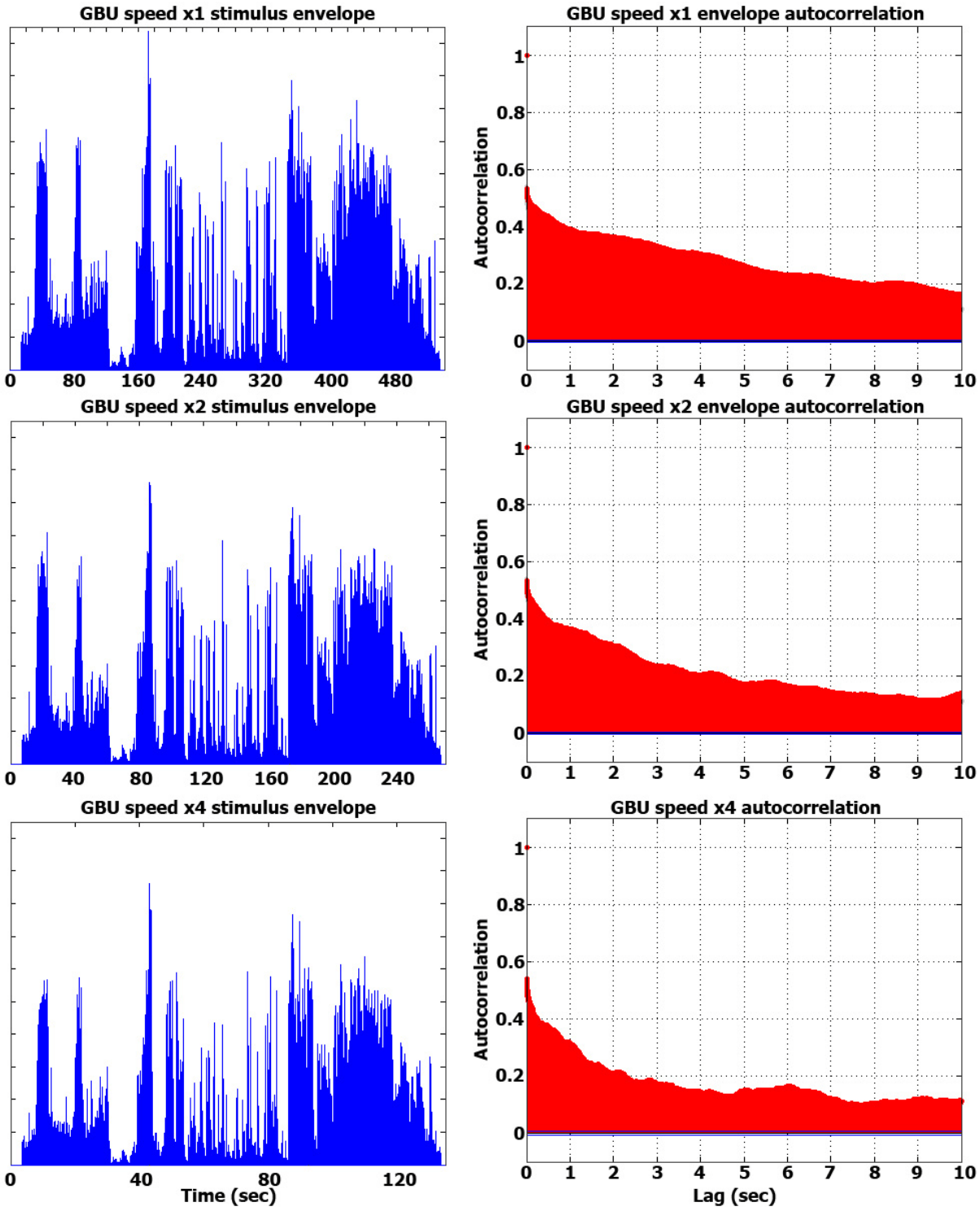
Supplementary figure 11: Waveforms of soundtrack during normal (bottom), double (middle) and quadruple (top) speed stimulation.

Figure S12



Supplementary figure 12: Power spectra of normal (bottom), double (middle), and quadruple speed soundtracks. Power was computed using the Fourier transform on one second windows with an overlap of 0.5 seconds.

Figure S13



Supplementary figure 13: Stimulus envelope (left column) and its auto-correlation (right column) for the normal (top), double (middle) and quadruple (bottom) speed movies.