Supplementary material to accompany the manuscript:

"*High-frequency EEG co-varies with spike burst patterns detected in cortical neurons*"

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1 Estimation of signal-to-noise ratio

The signal-to-noise ration (SNR) in the data was estimated using two methods. The first quantified the amplitude of the phase-locked hf-EEG in relation to the noise level. In order to estimate the former, the responses were first averaged and then RMS in the response window was calculated. The noise level was estimated as an average of RMS calculated in single-trial responses in a window long after the response. This measure may be expressed symbolically:

$$\mathrm{SNR}_{\mathrm{avg}} = \frac{\mathrm{RMS}(E[s_t])}{E[\mathrm{RMS}(n_t)]}, \tag{1}$$

where $E[\cdot]$ denotes expectation value calculated across trials, $\mathrm{RMS}(\cdot)$ denotes root mean square value and s_t and n_t stand for EEG samples in the response and noise window, respectively.

The second measure $\mathrm{SNR}_{\mathrm{st}}$ quantifies the SNR in single trials. To this end, in each trial the RMS in the signal window was divided by the RMS in a putative noise window:

$$\mathrm{SNR}_{\mathrm{st}} = E\left[\frac{\mathrm{RMS}(s_t)}{\mathrm{RMS}(n_t)}\right]. \tag{2}$$

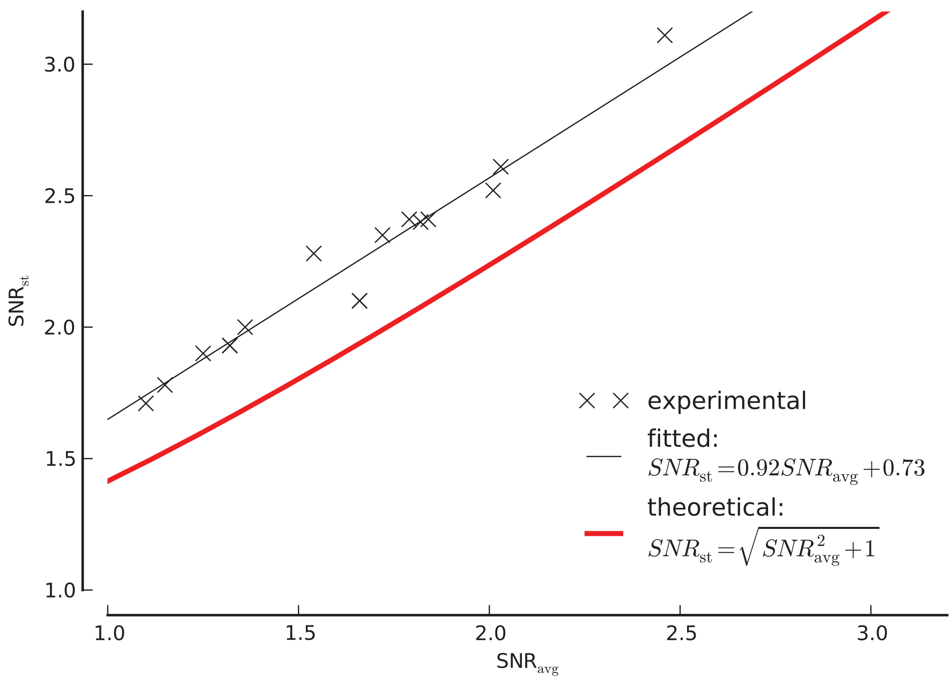
Following the "signal plus noise" model of evoked responses (Bijma et al. 2003) we assume that noise is stationary (i.e. its amplitude does not change in time) and signal and noise are not correlated, then we can derive a simple relation between the two measures:

$$\mathrm{SNR}_{\mathrm{st}} = \sqrt{\mathrm{SNR}_{\mathrm{avg}}^2 + 1} \tag{3}$$

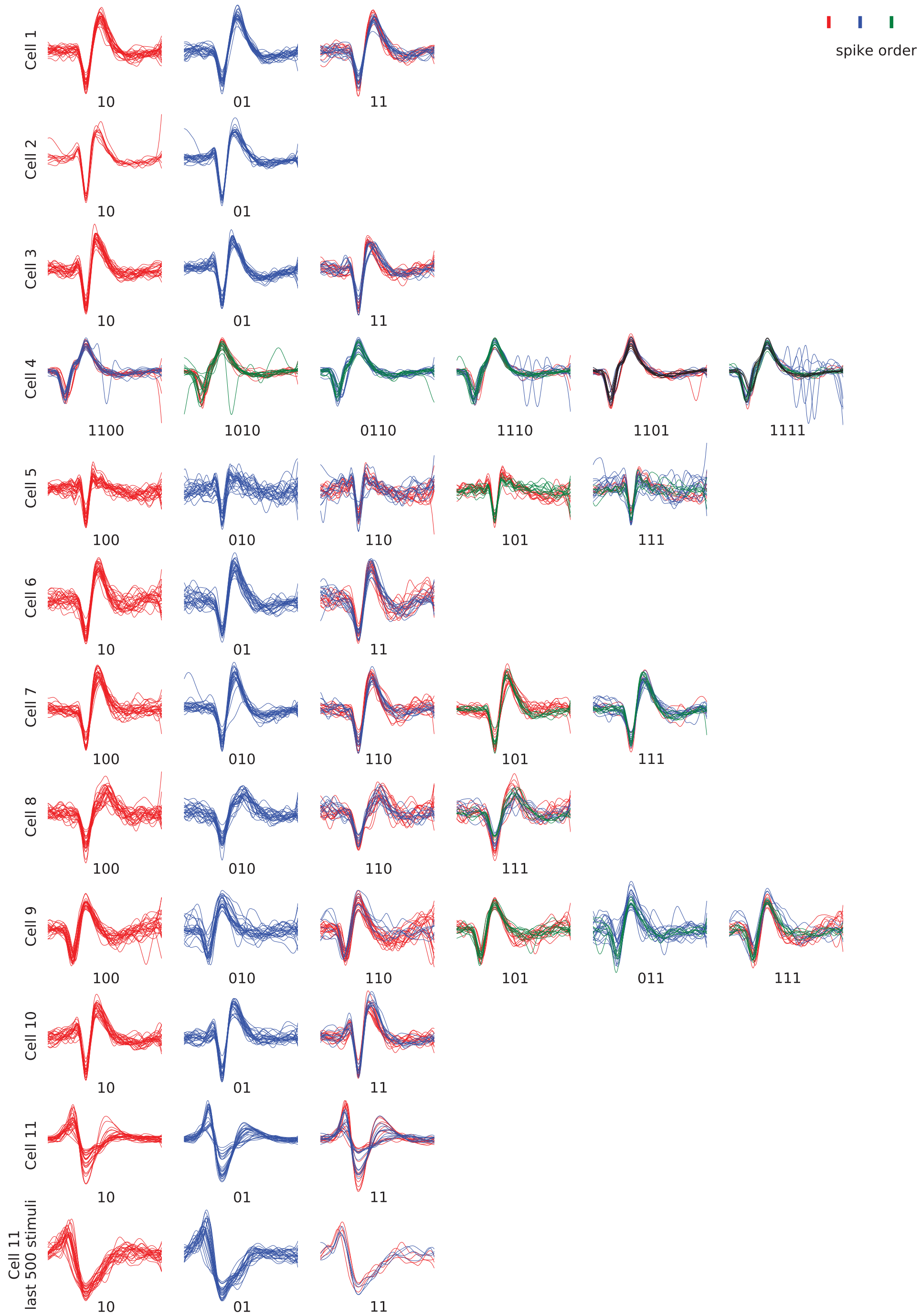
The experimental value of $\mathrm{SNR}_{\mathrm{st}}$ was larger than value predicted from equation (3), which means that some of the assumption of the "signal plus noise" model do not hold (Supplementary Figure 1). Specifically, this result is evidence that high-frequency components that are not locked to the stimulus may contribute to the single-trial signal. Alternatively, the lower amplitude of hf-EEG wavelet than expected from the average may also result from jitter in the response onset, which causes the partial cancellation of the fast hf-EEG oscillations in the average. In fact, due to the very high frequency of the oscillations under study, a jitter of about 1 ms would suffice to extinguish the oscillations almost completely.

References

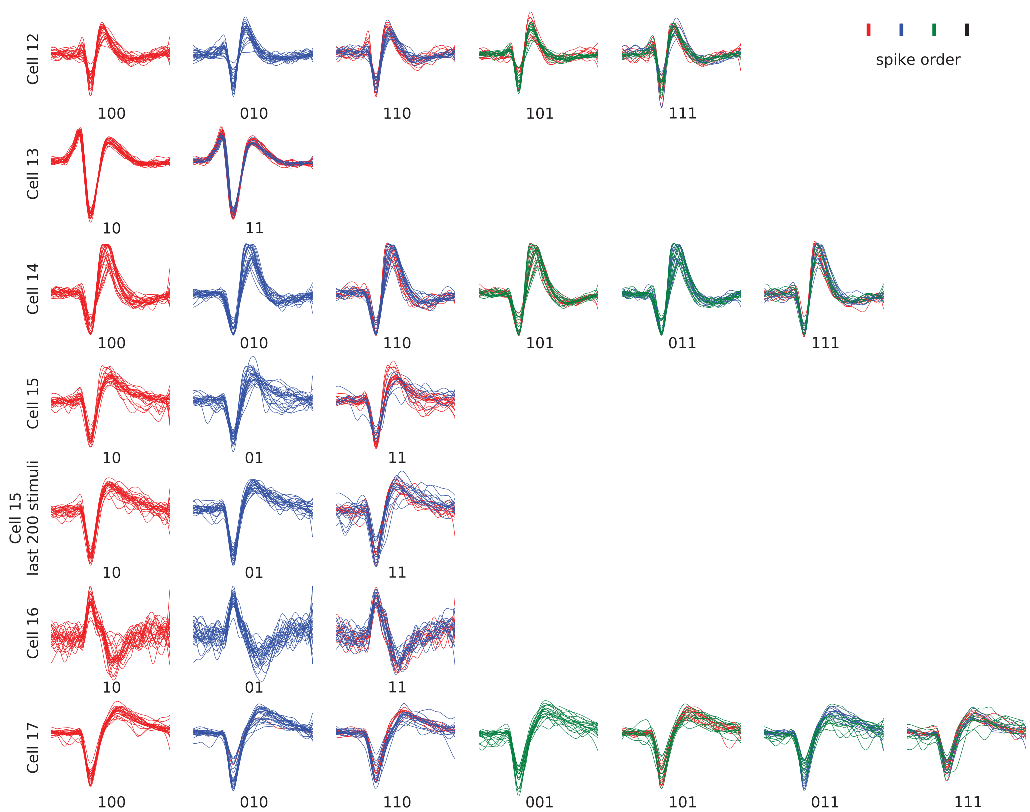
Bijma, F, **de Munck, JC**, **Huizenga, HM**, **Heethaar, RM**. A mathematical approach to the temporal stationarity of background noise in MEG/EEG measurements. *NeuroImage 20*: 233–243, 2003.



Supplementary Figure 1: Comparison of signal-to-noise ratio calculated from average (SNR_{avg}) and single trials (SNR_{st}). Single-trial SNR estimated from the data (crosses and the fitted line) is larger than the value predicted from the SNR in the average (bold red line). The difference between theoretical and experimental measure indicates that non-phase-locked components may contribute to single-trial responses or that temporal jitter in the responses diminishes the response amplitude in the average.



Supplementary Figure 2: Spike waveshapes (*t.b.c.*)



Supplementary Figure 2: Spike waveforms (*continued*). Each row represents a different cell. Spikes are sorted according to spike patterns they compose (columns) and latency window in which they occurred (only order information is preserved and represented by means of colours – for colour key see legend in the upper right corner). Spike waveforms and amplitudes are generally consistent across spike patterns and consecutive spike windows (see also Methods). Small differences visible in some of the shapes are caused by drift of spike shape parameters during the recording and/or by overlapping spikes. The effects of the drift are especially pronounced in spike waveforms of Cells 11 and 15, where the shape changes gradually over time probably due to small displacement of the electrode. Spike waveforms of these cells extracted from a stationary period of the recording (see the additional spike waveform rows for these cells) show no significant deviations. However, PSTH of spikes recorded at the beginning and at the end of the experiment are nearly identical and thus they most likely reflect activity of the same cell. Similarly, the amplitude of spikes in Cell 17 change slightly over the experiment, but their shapes and relation to the stimulus are not greatly affected.

Supplementary Table 1: Summary of the dataset used in the analysis. *Recording*: cell an subject index; *Brainstem Recording*: "Yes" indicates that another macroelectrode was injected into pyramidal tract to monitor subcortical input variations (see Methods); SNR_{spk}: spike signal-to-noise ratio (see Methods); *IsoScore*: isolation score (see Methods); # *PSTH peaks*: number of distinct peaks identified in the overall PSTH histogram; # *patterns*: number of identified spike patterns (n); # *pairs*: number of different spike pattern pairs ($= \frac{n(n-1)}{2}$); # *trials*: total number of stimulation trials.

Recording		Brainstem	Sorting Quality		Spike Responses			
Cell ID	Subject	Recording	$\mathrm{SNR}_{\mathrm{spk}}$	IsoScore	# PSTH peaks	# patterns	# pairs	# trials
Cell 1	I	Yes	3.09	0.995	2	4	6	1084
Cell 2	I	Yes	5.04	0.998	2	3	3	119
Cell 3	I	Yes	2.51	0.982	2	4	6	1105
Cell 4	I	Yes	3.83	0.953	4	7	21	1481
Cell 5	I	Yes	2.06	0.915	3	6	15	1279
Cell 6	I	Yes	2.30	0.975	2	4	6	1329
Cell 7	I	Yes	2.42	0.949	3	6	15	1329
Cell 8	I	Yes	2.27	0.919	3	5	10	1013
Cell 9	I	Yes	3.52	0.955	3	7	21	1013
Cell 10	I	Yes	2.43	0.969	2	4	6	1029
Cell 11	I	Yes	1.84	0.995	2	4	6	903
Cell 12	I	Yes	2.46	0.966	3	6	15	1005
Cell 13	I	Yes	2.90	0.993	2	3	3	148
Cell 14	I	Yes	2.60	0.992	3	6	15	1096
Cell 15	II	No	1.09	0.963	2	4	6	1596
Cell 16	II	Yes	2.19	0.825	2	4	6	150
Cell 17	II	No	2.66	0.939	3	8	28	956
Sum			–	–	–	85	188	–
Sum (with brainstem)			–	–	–	73	154	–
Mean/*Median*			2.66	0.958	*2*	*4*	*6*	*1029*
Std.dev.			0.85	0.041	–	–	–	–
Min			1.09	0.825	2	3	3	119
Max			5.04	0.998	4	8	28	1596