Supplemental Material

Supplementary Figure 1. Cluster analysis of the spontaneous activity patterns recorded in the barrel cortex of 50 newborn rats (n=1461 oscillatory events). The primary frequency (maximal frequency) and the duration of the oscillatory activity were used as parameters for the cluster analysis using the k-means clusteringalgorithm. (A) Raster plots with 2, 3, 4 and 5 clusters (i to iv). (B) The Silhouette validation technique was used to analyse the cluster validity. Grouping the data in 3 clusters resulted in the highest silhouette value.

Supplementary Figure 2. Correlation of oscillatory field potentials with multiunit activity (MUA) in phase-dependent manner. (A) Spindle burst field potential (upper trace) and corresponding MUA (middle trace) recorded in a P3 rat. Blue vertical lines mark single unit activity which surpasses the threshold (red horizontal lines in middle trace). Cross-correlation histogram between MUA and field potential of the spindle burst (red dotted lines) reveals close temporal relationship. (B) Same as in (A), but typical example of a gamma oscillation recorded in a P2 rat. Note closer temporal coupling between MUA and field potential when compared to the spindle activity in (A). (C) Same as in (A), but example of a long oscillation recorded in a P4 rat. A 4 second period was used to calculate the cross-correlation histogram between MUA and field potential of the long oscillation. Note the precise coupling of MUA and minimum in field potential. (D) Summary diagram illustrating as box plots the cross-correlation between MUA and field potentials as calculated from 100 spindle bursts (10 pups), 100 gamma oscillations (10 pups) and 3 long oscillations (3 pups). The sampling rate to acquire the data was 20 kHz.

Supplementary Figure 3. Depth profile of spindle burst activity in the barrel cortex of a newborn rat (P0). (A) Simultaneous field potential recordings in the barrel cortex of a P0 rat with 16-channel one shank Michigan electrode (inter-electrode-distance 50 µm) (left traces) and corresponding CSD analysis (middle). The averaged CSD plot (right) was calculated from 54troughs of 10 spindle bursts. Note prominent sink in subplate / layer VI and corresponding source in cortical plate. (B) Another spindle burst recording from the same animal as in (A), but with no activity and no sink in the subplate. The averaged CSD plot was calculated from 19 troughs of 5 spindle bursts.

Supplementary Figure 4. Depth profile of gamma oscillation activity recorded in the barrel cortex of a P1 rat.(A) Simultaneous field potential recordings (left) and corresponding CSD analysis (middle). The averaged CSD plot (right) was calculated from 27troughs of 13 gamma oscillations.Note prominent sink in subplate / layer VI and corresponding source in cortical plate. (B) Another gamma oscillation recorded in the same animal as in (A), but with no activity and no sink in the subplate. The averaged CSD plot was calculated from 33 troughs of 9gamma oscillations. For further details see Suppl. Fig. 3.

Supplementary Figure 5. Depth profile of long oscillationrecorded in the barrel cortex of a P0 rat. (A) Simultaneous field potential recordings (left) and corresponding CSD analysis (middle). The averaged CSD plot (right) was calculated from 43troughs of one long oscillation.Note prominent sink in subplate / layer VI and corresponding source in cortical plate. (B) Another long oscillation recorded in the same animal as in (A), but with no activity and no sink in the subplate. The averaged CSD plot was calculated from 50 troughs of one long oscillation. For further details see Suppl. Fig. 3.

Supplementary Figure 6. MUA in the subplate precedes the oscillatory field potential activity in the cortical plate and correlates with MUA in upper cortical layers. (A) (i) Simultaneous recording of spindle burst activity in cortical plate (upper trace) and MUA in subplate (lower trace) of a P1 rat. Red lines mark peaks of MUA in the subplate. Note that MUA precedes the troughs of the field potential oscillation. (ii) Simultaneous recording of spindle-burst-MUA in cortical plate (iia) and MUA in subplate (iib) of a P1 rat (same data as in (i)). The red dotted line is the 5 fold SD of baseline activity. The lower traces in iia and iib show the detected units (above or below the red dotted line). (iic) Cross-correlation of unit activity in SP against CP. (iii) Cross-correlation of unit activity in SP against CP from group data (66 spindle bursts from 5 P0 to P1pups). (B) Simultaneous recording of a gamma oscillation in cortical plate (upper trace) and MUA in subplate (lower trace) of a P1 rat. (ii) Simultaneous recording of gammaoscillationMUA in cortical plate (iia) and MUA in subplate (iib) of a P1 rat (same data in (i)). (iic) Cross-correlation of unit activity in SP against CP. (iii) Cross-correlation of unit activity in SP against CP from group data from group data (79 gamma oscillations from 6 P1 to P2pups).

Supplementary Figure 7. Pharmacological profile of spindle bursts (A) and gamma oscillations(B) in the P0-P2 rat S1 *in vivo*. Control data were obtained before drug application on the cortical surface (for details see *Materials and Methods*). Recordings in ACSF without drug or in ACSF containing APV, carbenoxolone (CBX) or lidocaine (LIDO) were obtained 3 min after the beginning of ACSF or drug application. Data were normalized to the occurrence of oscillatory events during 3 minbefore cortical ACSF or drug application. Data are expressed as box plots and asterisks mark significant differences in comparison to the ACSF group (** for $p<0.01$, *** for $p<0.001$, Mann-Whitney-Wilcoxon test). Numbers in parentheses give number of newborn rats studied.

Supplementary Movie 1. Long lasting recording of coordinated network activity in S1 cortex of a P3 rat. Continuous field potential recording (original trace and 5-80 Hz filtered, upper blue traces) accompanied by MUA (middle black trace) and corresponding color-coded wavelet spectrum. Note presence of distinct oscillatory activity patterns, which differ in duration, frequency distribution and amplitude.

Supplementary Movie 2. Simultaneous field potential (blue traces) and MUA (black traces) recordings from a P1 rat with 4x4 electrode array (inter-electrode distance of 200 µm). Note presence of column-like synchronized spindle burst at multiple recording sites.

Supplementary Movie 3. Simultaneous field potential (blue traces) and MUA (black traces) recordings from a P3 rat showing locally synchronized gamma oscillations in the upper cortical layers.

Supplementary Movie 4. Simultaneous field potential (blue traces) and MUA (black traces) recordings from a P6 rat showing propagating and widely synchronized long oscillations at all recording sites.

Supplementary Table 1. Properties of spindle bursts, gamma oscillations and long oscillations recorded in non-anesthetized and urethane-anesthetized newborn rats. Note that urethane has a significant effect only on the amplitude of the gamma oscillations, whereas all other patterns and properties are similar in both experimental conditions.

	Duration (sec)			Amplitude (µV)			Frequency (Hz)			Occurrence (min^{-1})		
	Non-anesthetized	Urethane-anesthetized	Sign.	Non-anesthetized	Urethane-anesthetized	Sign.	Non-anesthetized	Urethane-anesthetized	Sign.	Non-anesthetized	Urethane-anesthetized	Sign.
Spindle bursts (n=10 pups, n=40 pups)	1.22 ± 0.48	1.07 ± 0.57	n.s.	361.96 ± 385.47	280.4 ± 203.83	n.s.	9.33 ± 1.83	9.72 ± 2.22	n.s.	4.85 ± 1.71	5.97 ± 3.65	n.s.
Gamma oscillations (n=9 pups, n=14 pups)	0.16 ± 0.06	0.15 ± 0.04	n.s.	177.1 ± 86.52	95.97 ± 55.02	*	36.78 ± 2.28	37.74 ± 2.33	n.s.	2.44 ± 1.45	4.15 ± 4.35	n.s.
Long oscillations (n=8 pups, n=12 pups)	52.28 ± 10.47	61.31 ± 17.12	n.s.	587.81 ± 419.56	360.15 ± 195.95	n.s.	12.15 ± 6.16	9.51 ± 2.63	n.s.	0.05 ± 0.03	0.04 ± 0.02	n.s.