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Figure S1

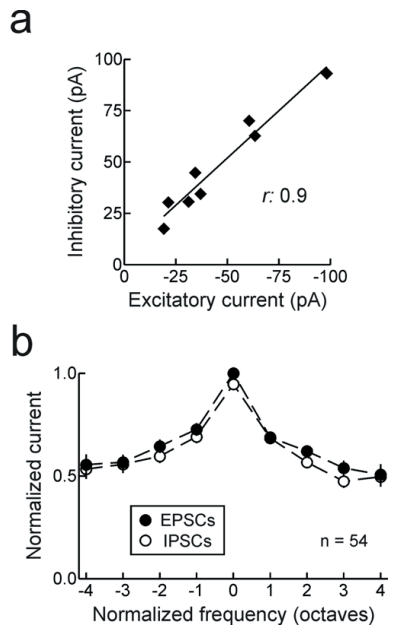

Figure S1: Amplitudes of tone-evoked EPSCs and IPSCs were correlated. a, Correlation of EPSC and IPSC amplitudes before NB pairing for the cell shown in Fig. 1c. Line indicates the linear regression (*r*: 0.92). **b**, Average normalized frequency tuning of excitation and inhibition for pre-NB pairing voltage-clamp recordings (*r*: 0.71±0.03; n=54). Synaptic currents were normalized to the amplitude of the largest EPSC and IPSC across frequencies. The center frequency (0 octaves) was set to the BF of excitation. Filled symbols, excitation; open symbols, inhibition. Error bars, s.e.m.

Figure S2: Changes to synaptic conductance and charge transfer after NB pairing were similar to changes in peak currents. a, Example frequency tuning curves based on measurements of synaptic conductance for the cell shown in Fig. 1c. Top, frequency tuning of excitation. Excitatory conductance at the paired frequency (2 kHz) increased from 0.9±0.2 nS to 1.6±0.1 nS (77.8%, p<0.006). Inset, synaptic conductance at the paired frequency before (gray) and after (black) NB pairing. Lines, mean tuning curves before (dashed) and 10 minutes after (solid) induction. Arrow, frequency of the paired tone. Bottom, frequency tuning of inhibition. Inhibitory conductance at the paired frequency (2 kHz) decreased from 1.4±0.3 nS to 0.6±0.2 nS (–57.1%, p<0.04). Filled symbols, excitation; open symbols, inhibition. **b**, Same experiment as **a**, but tuning curves are based on measurements of net charge transfer (current integrated over 10-70 msec after tone onset) for the cell shown in Fig. 1c. Top, excitatory charge transfer at the paired frequency increased from –1.7±0.5 nA*msec to –3.6±0.6 nA*msec (114.3%, p<0.02). Bottom, inhibitory charge transfer at the paired frequency decreased from 3.5±0.6 nA*msec to 1.5±0.7 nA*msec (–56.7%, p<0.04). Inset, synaptic current at the paired frequency before (gray) and after (black) NB pairing (same as shown in Fig. 1b). **c**, Summary of changes to excitatory (filled) and inhibitory (open) conductance for experiments from Fig. 1d (excitation: 78.7±24.4%, p<0.007; inhibition: –30.3±7.6%, p<0.002). Double asterisks, p<0.01. **d**, As in **c**, but summarizing changes to charge transfer (excitation: 97.1±21.9%, p<0.0006; inhibition: –42.4±8.3%, p<0.0002). Error bars, s.e.m.

Figure S2

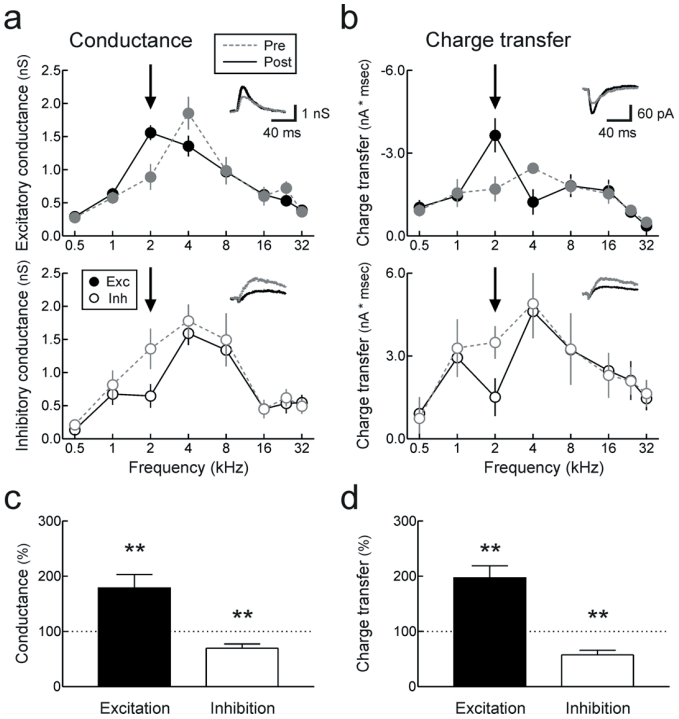

Figure S3

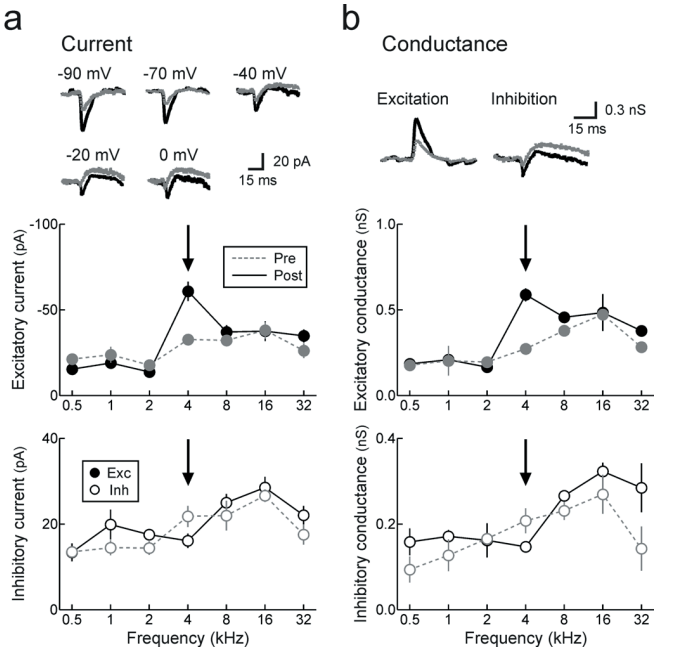

Figure S3: Changes to frequency tuning measured at multiple holding potentials. a, Example of frequency tuning measured in voltage-clamp at holding potentials of –90, –70, –40, –20, and 0 mV. Top, synaptic currents at the paired frequency (4 kHz) before (gray) and ~30 minutes after (black) NB pairing. Center, mean frequency tuning at –70 and –90 mV. Current at the paired frequency increased from –32.6±2.7 pA to –60.8±5.6 pA (86.5%, p<0.0009). Lines, mean tuning curves before (dashed) and 10 minutes after (solid) induction. Arrow, frequency of the paired tone. Bottom, mean frequency tuning at –20 and 0 mV. Current at the paired frequency decreased from 21.8±2.5 pA to 16.1±1.6 pA (–26.1%, p<0.06). **b**, Same experiment as **a**, but tuning curves are based on calculations of conductance. Top, synaptic conductance at the paired frequency before (gray) and after (black) NB pairing. Center, tuning curves of excitatory conductance. Conductance at the paired frequency increased from 0.27±0.01 nS to 0.59±0.04 nS (119%, $p<10^{-5}$). Bottom, tuning curves of inhibitory conductance. Conductance at the paired frequency decreased from 0.21±0.03 nS to 0.14±0.01 nS (–33.3%, p<0.02). Error bars, s.e.m.

Figure S4

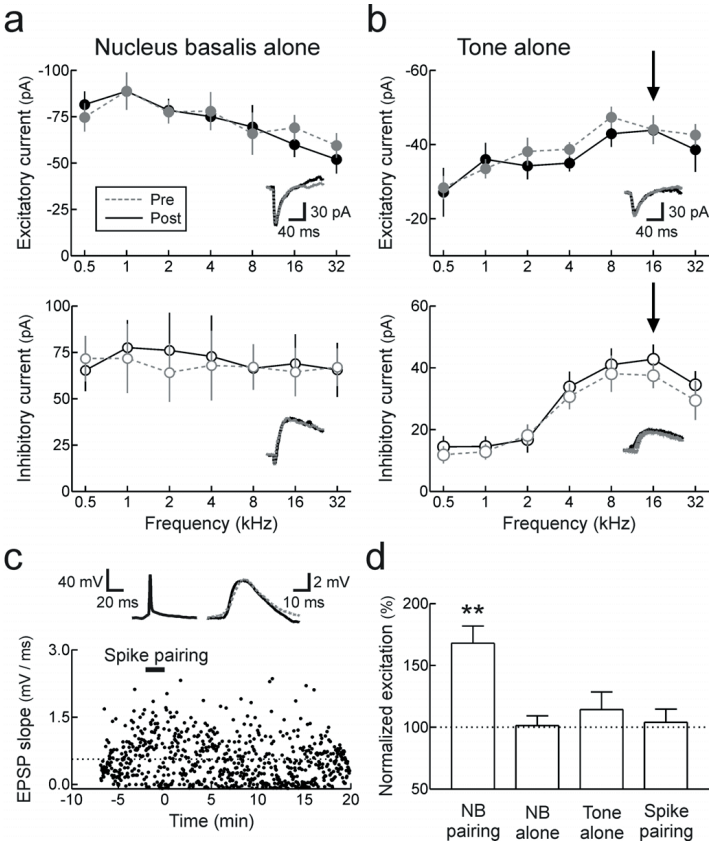

Figure S4: Unpaired stimulation did not induce modifications of synaptic frequency tuning. a, Example frequency tuning curves in which the NB was stimulated in the absence of sensory stimulation. Top, excitatory tuning both before (dashed line) and after (solid line) NB stimulation (change in responses: −2.0±3.2%, p>0.6). Inset, EPSCs evoked by 16 kHz tones before (gray) and after (black) NB stimulation. Bottom, inhibitory tuning (change in responses: 4.2±3.4%, p>0.2). **b**, Example frequency tuning curves in which 16 kHz tones were repetitively presented in the absence of NB stimulation. Top, excitatory tuning both before and after repetitive 16 kHz stimulation (change in responses at 16 kHz: −0.3%, p>0.9). Inset, EPSCs evoked by 16 kHz tones before (gray) and after (black) tonal stimulation. Bottom, inhibitory tuning (change in responses at 16 kHz: 14.3%, p>0.3). **c**, Example current-clamp recording in which 8 kHz tones were repetitively paired with postsynaptic spikes. The cell was slightly depolarized during the pairing procedure to ensure that tones reliably evoked well-timed spikes: postsynaptic spike peak followed EPSP onset by 10.8±0.34 ms (s.d.). The spike pairing procedure did not potentiate synaptic strength (EPSP slope before pairing: 0.56±0.04 mV/ms, EPSP slope 5-10 minutes after pairing: 0.49±0.04 mV/ms, change of −12.2%). Dashed line, mean EPSP slope of paired tone before pairing. Left inset, representative tone-evoked EPSP and spike during pairing. Right inset, average tone-evoked EPSPs before (gray) and 5-10 minutes after (black) spike pairing. **d**, Summary of changes to excitation by paired and unpaired NB/sensory stimulation (NB pairing data from Fig. 1d: increase of 68.0±13.9%, n=15, p<0.0002; unpaired NB stimulation across all frequencies: 1.4±7.9%, n=6, p>0.8; unpaired sensory stimulation: 14.3±14.2%, n=7, p>0.3; spike pairing: 4.0±10.7%, n=7, p>0.7). Double asterisks, p<0.01. Error bars, s.e.m.

Figure S5: NB pairing increased spike output. a, Example of changes to spike rate after NB pairing. Top, ten example sweeps in current-clamp showing tone-evoked spikes at the paired frequency (16 kHz). The BF of this cell was 4 kHz. Before NB pairing, single spikes were evoked in 19/40 repetitions (4/10 repetitions shown), and bursts of two or more spikes were evoked in 0/40 repetitions (0/10 shown). After pairing, single spikes were evoked in 7/40 repetitions (2/10 repetitions shown), and bursts were evoked in 28/40 repetitions (7/10 repetitions shown). Bottom, peristimulus time histogram (PSTH) for this cell. The spike counts were smoothed with a running 10-point boxcar average. Dashed line, before pairing; solid line, after pairing. **b**, Time course of changes to excitability after NB pairing. Top, spiking evoked by the paired frequency was enhanced after NB pairing (change in overall spike rate: 83.7±27.4%, p<0.01, n=8). Bottom, Ri was unchanged after NB pairing (p>0.4). Horizontal bar, duration of NB pairing. **c**, Summary of changes in PSTHs after NB pairing (paired frequency: 65.8±25.0%, unpaired frequencies: −10.1±6.7%, n=8, p<0.01). Double asterisks, p<0.01. **d**, Summary of changes in spike burst probability after NB pairing (burst probability before NB pairing: 4.2±2.2%, 10 minutes after NB pairing: 36.2±9.4%, p<0.01). Error bars, s.e.m.

Figure S5

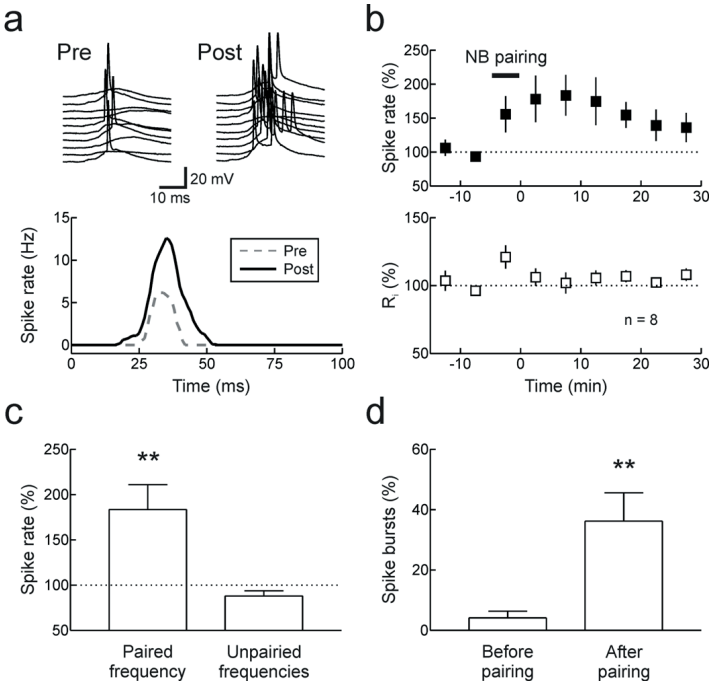

Figure S6: NB pairing shifted BFs of excitation and inhibition. Time course of excitatory and inhibitory BF shifts (n=5-17 at each time point). Shift in BF is in octaves away from the original BF in the direction of the paired frequency. Sixty minutes after NB pairing, the BF of excitation was shifted towards the paired frequency, but the BF of inhibition was unchanged (BF shift of excitation: 1.4±0.4 octaves, BF shift of inhibition: 0.4±0.2 octaves, n=7, p<0.02). Two hours after pairing, BFs of excitation and inhibition were both shifted in the direction of the paired frequency (BF shift of excitation: 1.7±0.6 octaves, BF shift of inhibition: 1.5±0.4 octaves, n=8, p>0.7). Time is relative to the end of NB pairing. Error bars, s.e.m.

Figure S6