A wireless neural recording system with a precision motorized microdrive for freely behaving animals

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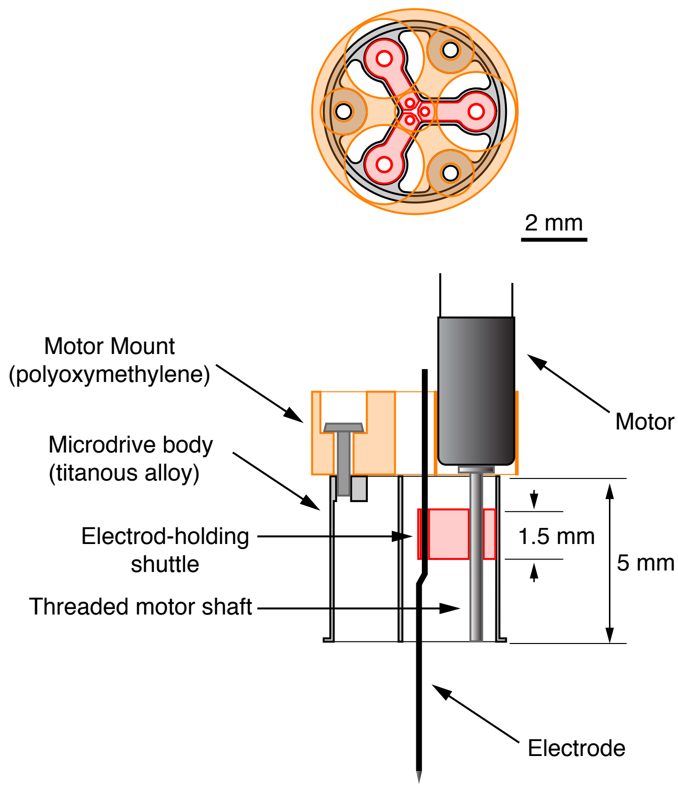
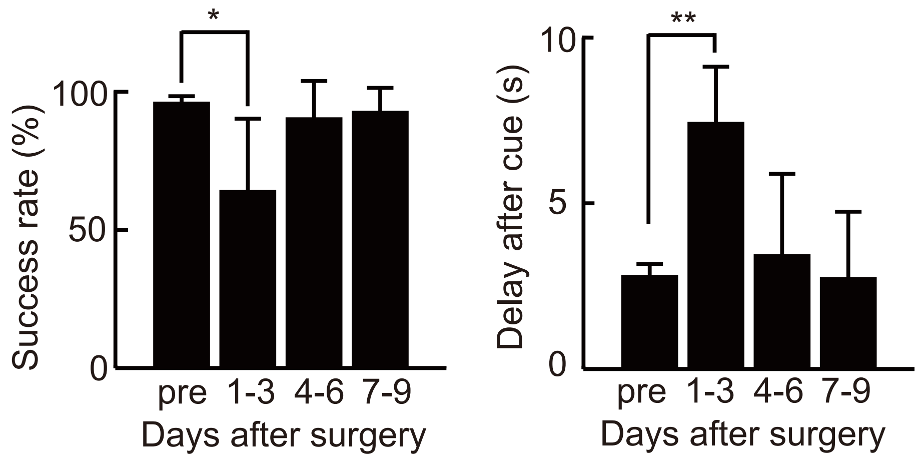
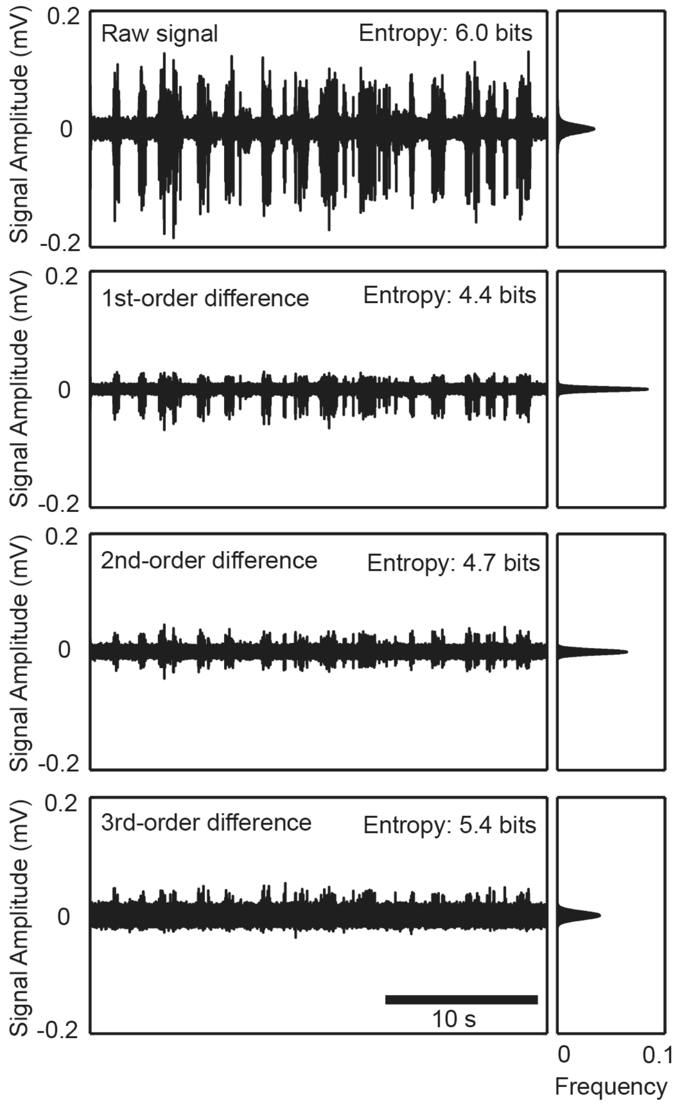


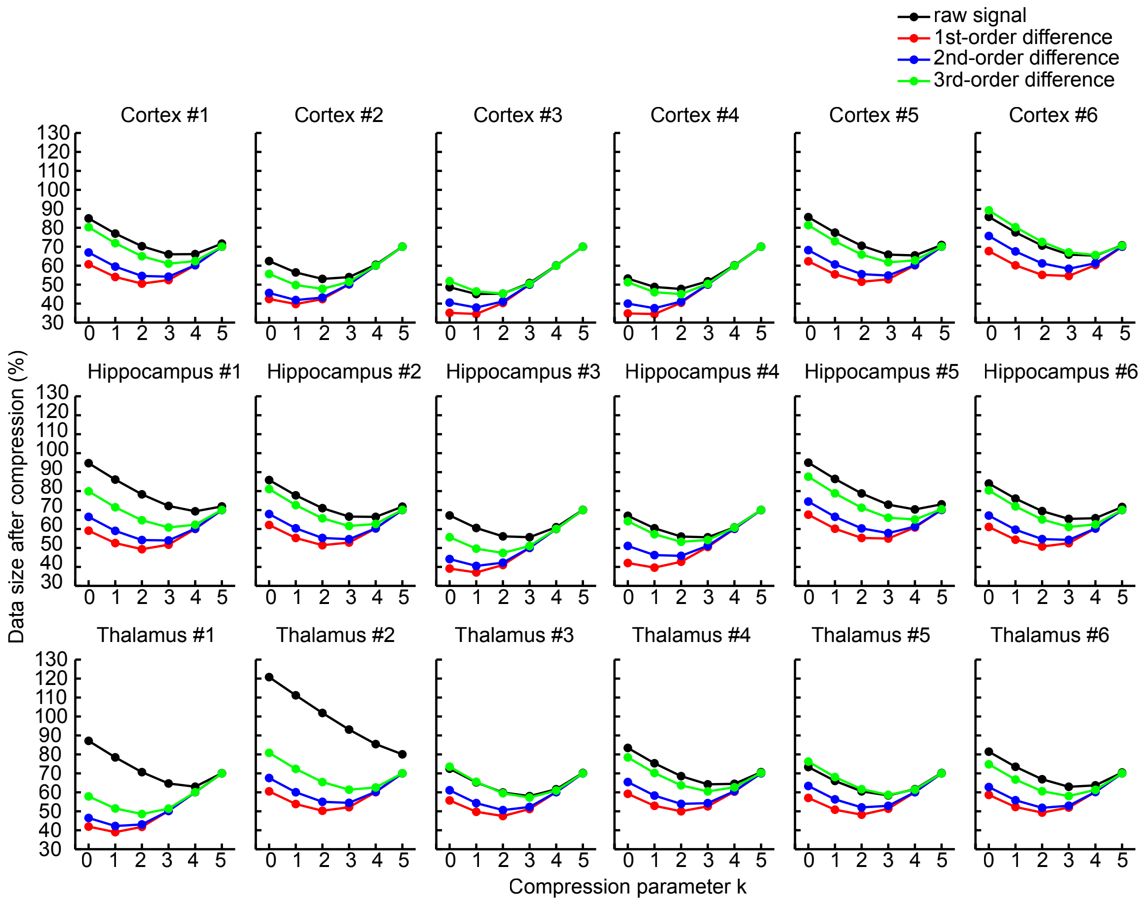
Supplementary Figure S1 | Schematic drawing of a motorized microdrive. Each electrode-holding shuttle (red) can travel along a threaded motor shaft (pitch 125 µm) in a “Y-shaped” space within a microdrive body. A motor mount is screwed onto the microdrive body.



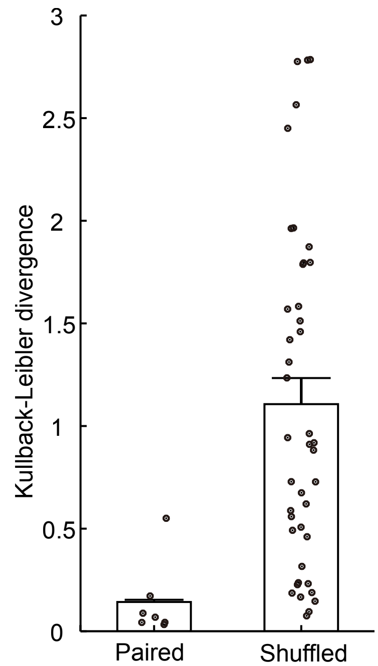
Supplementary Figure S2 | Effect of the wireless recording system on the operant task performance. Rats were water-deprived for 16-18 hr and placed in the operant chamber for a session consisting of 100 trials per day. In each session, rats were trained to press a lever after the presentation of a tone cue (1-kHz) to obtain a drop of sucrose-containing water as a reward. Rats learned to press the lever within 20 s after the cue presentation to be scored as "success". When the success rate reached over 90% for more than 3 consecutive sessions (pre-surgery sessions), the microdrive and WIF were implanted. The success rates decreased and the responses to the cues were delayed for 3 days after surgery. However, the performance recovered to the pre-surgery level thereafter (n = 5; t-test with pre-surgery). *$P < 0.1$, **$P < 0.05$; error bars, s.d.



Supplementary Figure S3 | Amplitude probability distributions of a sampled neuronal signal and its first-, second-, and third-order differences. Activity of the cortical neuron was recorded in an anesthetized rat with a 20 kHz sampling rate and a 10-bit resolution. Top: sampled neuronal signal (left) and its amplitude probability distribution (right). Second to Fourth Row: the first-, second-, and third-order differences of the same sampled data, respectively. Note that the data size of the theoretical limits in lossless compression (entropy) was the smallest when taking the first-order difference, and the data size could theoretically be reduced to 44% of the original (4.4 bit / 10 bit).



Supplementary Figure S4 | The effects of the first-, second-, or third-order difference operation and parameter k on the compression efficiency of the variable-length encoding. Neural recording data of the cortex, hippocampus, and thalamus in anesthetized rats (60 s, n = 6 neurons each) were used. Notice that, for all of the recoded data, taking the first-order difference resulted in the smallest data size.



Supplementary Figure S5 | Similarity in clustering pattern of detected spikes and background noise between wired and wireless recording systems. To evaluate the patterns of spike clusters between wired and wireless systems, all peaks including background noise were extracted as shown in Figure 3. V_{PP} and W_H of all peaks were converted to z scores and their distributions were smoothed with a 2-dimensional Gaussian filter ($\sigma = 0.3$). Kullback-Leibler (K-L) divergence of the peak distribution between the two systems were calculated using the simultaneously recorded data ("paired") and using the data at different sessions ("shuffled"). The "paired" group showed a significantly smaller divergence ($P = 0.0156$; n=7; Wilcoxon signed rank test), indicating that the clustering patterns of detected spikes and background noise using the wireless recording system are similar to those simultaneously recorded using the wired system.

Supplementary Video

Supplementary Movie S1 | Activity of a single neuron was wirelessly recorded in the thalamic parafascicular nucleus (PF) of a freely behaving rat. The frequency (Hz) and traces indicate the firing rate and the action potentials detected per second, respectively.