SUPPLEMENTAL INFORMATION

A wireless transmission neural interface system for unconstrained non-human primates

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SUPPLEMENTARY FIGURES

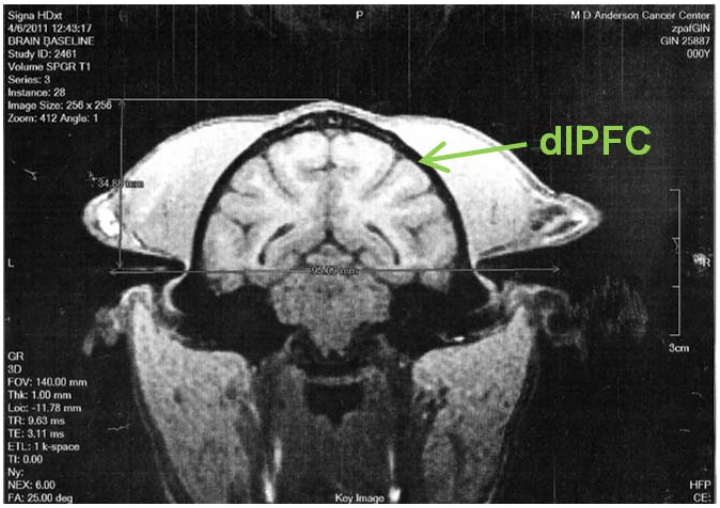

Figure S.1. Example of the outlining white matter on one T1 coronal section. The coronal image from one monkey was obtained using MRI technique. The image highlights the dlPFC area, according to MRI and stereotaxic specifications(Paxinos et al., 2000, Saleem and Logothetis, 2007), where the 96-channels Utah array was implanted. The field of view (*FOV*) is 140.00 mm defined as the size of the two dimensional spatial encoding area of the image. The slice had a thickness (*Thk*) of 1.00 mm. A short repetition time (*TR*=9.63 ms) and short echo time (*TE*=3.11 ms) sequence was defined for the T1-weighted. The sample averaging (*NEX*) and turbo factor (or Echo Train Length (*ETL*)) related to scan time and image quality was defined as 1 k-space and 6.00 respectively. The fractional anisotropy (*FA*) was 25.00 deg and the inversion time (*TI*) was zero. The plane localizer (*PL*) was defined as -11.78 mm.

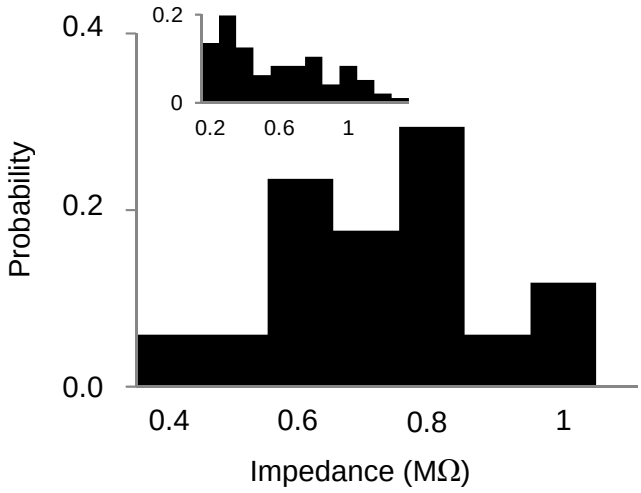

Figure S.2. Probability distribution of electrode impedance values for one sample session recorded after 6 months following the dlPFC implant. *Main plot*: distribution of impedances for the 34 electrodes that showed reliable single and multi-unit spiking activity. This figure indicates that a high impedance (>0.6 MΩ) was observed in 35% of electrodes (mean impedance 0.73±0.17 MΩ) even after several months of implant. *Inset*: impedance distribution for the entire array (96 electrodes) measured in the same session.

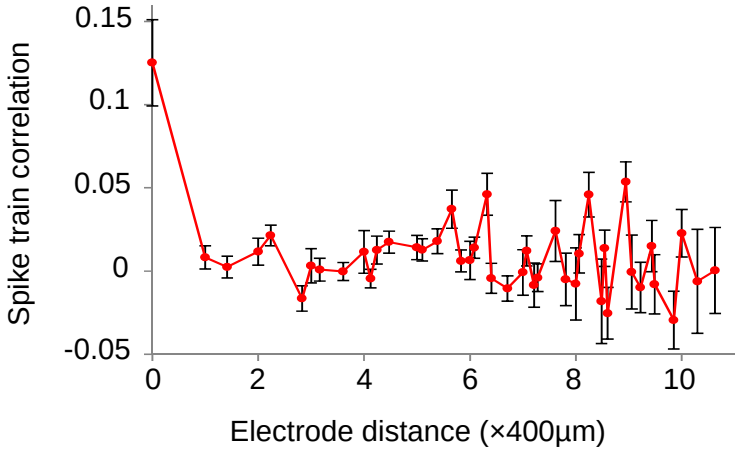

Figure S.3. Average spike train correlation as a function of distance. Spike trains were first converted to continuous signals by convolving them with a Gaussian kernel of 300 ms width. Pearson correlation between the continuous signals from two neurons was computed to quantify similarity in their spiking activity. The spike train correlation shows a sharp decay for cell pairs recorded from the same electrode compared to other distances. The average value did not change significantly with distance (>400 μm) and remained near zero, whereas the variability increased with distance (see **Supplemental Figure S.4**).

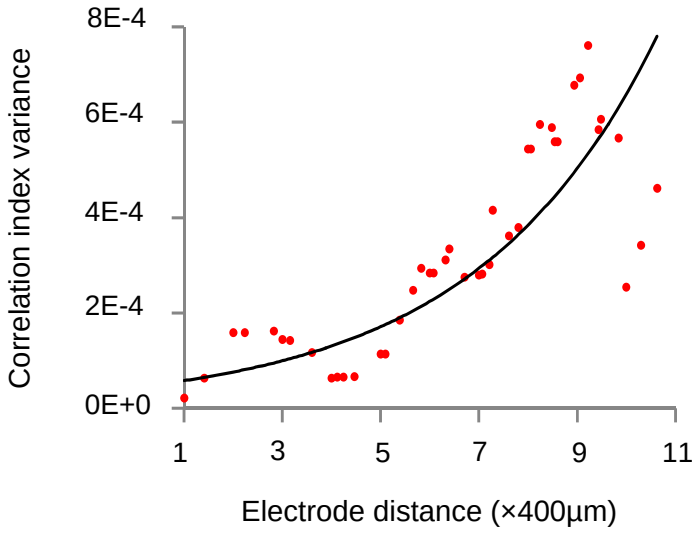

Figure S.4. Variance of the spike train correlations as a function of distance between electrodes. The variance at a distance is computed using correlation values in a [±1] electrode pitch window centered at that distance. The variability in correlation value increased with the distance between electrodes. The black trace represents the exponential fit.

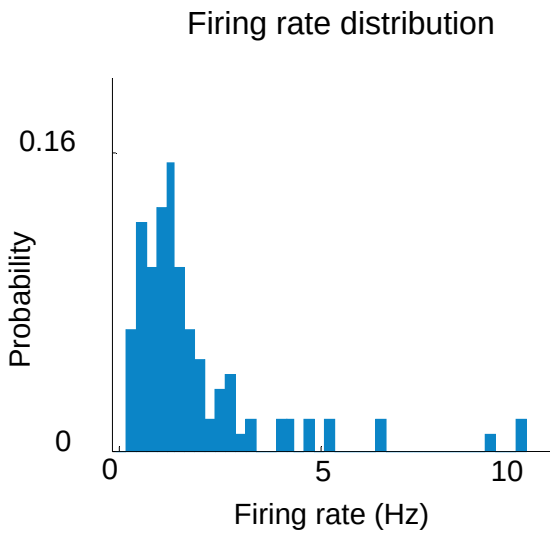

Figure S.5. Probability distribution of averaged firing rates of dlPFC neurons during free moving.

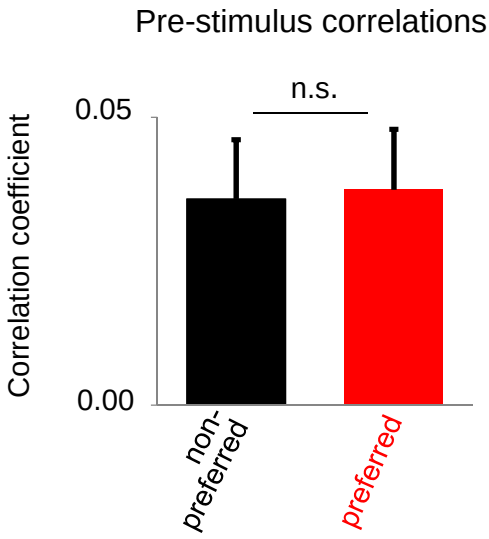

Figure S.6. Mean correlation coefficient measured before stimulus presentation (see also **Fig. 7C**). The mean correlation coefficients for non-preferred and preferred rewards were not statistically different (P=0.86; Wilcoxon rank sum test).

SUPPLEMENTARY TABLES

Transmitter model name	Blackrock Cereplex Radio
Power requirements	Two 3V CR123A batteries on the transmitter and +5V on the receiver
Resolution	12-bit
Sampling frequency	20 kSps
Input frequency range	0.00003-0.0075 MHz
Input impedance range	0.005 MΩ-0.001 MΩ
Transmit frequency	Ch 149 – 5745 MHz, Ch 153 – 5765 MHz, Ch 157 – 5785 MHz, Ch 161 – 5805 MHz, Ch 165 – 5825 MHz
Wireless standard	IEEE 802.11n
Radio power	15 dBm
Transmission range	32 ft
Water ingress protection	Ordinary equipment; not fluid resistant, IP20
Operating environment	10˚C to 40˚C, 5 to 95% R.H. (non-condensing)
Storage environment	-10˚C to 50˚C, 5 to 100% R.H. (non-condensing)

Table T.1. Technical specifications of the Blackrock Cereplex radio transmitter.

Reference	Type	Test model	Noise(μVr.m.s)	Bit (res)	S/s (kSps)	No. of Ch.	Data (Mbps)	Power (mW)	Size (mm)	Radio frequency
Chae et al.(Chae et al., 2009)	ASIC	Bench	4.9	9	2	128	90	6	8.8x7.2xNR	--- UWB
Harrison et al.(Harrison et al., 2009)	ASIC	Bench	5.0	10	15	100	0.35	10	5.4x7.0xNR	902/928 MHz FSK
Rizk et al.(Rizk et al., 2007)	ED	Rat	NR	12	31	96	1	100	50x40x15	916.5 MHz ASK
Szuts et al. (Szuts et al., 2011)	ED	Rat	<4	---	20	64	12	345	50x40x30[i]	2380 MHz FSK
Rizk et al. (Rizk et al., 2009)	ED	Sheep	7	12	31	96	NR	2000	50x40x15	916.5 MHz ASK
Borton et al. (Borton et al., 2013)	ID	NHP	8.6	12	20	100	24	90.6	56x42x11	3200/3800 MHz FSK
Schwarzet al. (Schwarz et al., 2014)	ED	NHP	NR	12	31	128 (each cube)	2	264	NR	2400 MHz FSK
This work	**ED**	**NHP**	**3.93**	**12**	**20**	**96**	**24**	**4000**	**56x42x44**	**5700-5800 MHz FSK**

Table T.2. Selection of current neural data recording and amplification systems. ASIC: amplifier application-specific integrated circuit; ED: external device; ID: implanted device; NHP: non-human primate; NR stands for not reported; ASK: Amplitude-shift keying. FSK: Frequency-shift keying. UWB: ultra-wideband. [i]back board (transmitter) from a three-part system (microdrive, head board, and back board). R.m.s. stands for root-mean-squared.