Supporting Information

Multi-waveform fast-scan cyclic voltammetry mapping of adsorption/desorption kinetics of biogenic amines and their metabolites

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Biological experiments protocol

Adult male Sprague−Dawley rats weighing 250−350 g were used for the experiments in this studies (n = 3). NIH guidelines were followed for all animal care, and the Mayo Clinic Institutional Animal Care and Use Committee approved the experimental procedures. Rats were housed with a 12:12 hr light and dark cycle (lights on at 0600 hr) with ad libitum access to food and water. The rats were anesthetized with an injection of urethane (1.6 g/kg, i.p.) and stabilized in a commercially available stereotaxic frame (David Kopf Instruments, Tujunga, CA) for the surgery. Three burr holes (0.5-1.0 mm diameter) were made in the skull of each rat for the implantation of a carbon fiber microelectrode (CFM), a bipolar electrical stimulating electrode (Plastic One, MS303/2, Roanoke, VA, USA), and an Ag/AgCl reference electrode. The reference electrode was positioned superficially in cortical tissue contralateral to the CFM and stimulating electrode. Electrode coordinates were referenced by a rat brain atlas based on flat-skull position using bregma and dura as reference points with coordinates anteroposterior (AP), mediolateral (ML), and dorsoventral (DV)[1]. The CFM was placed in the right hemisphere in the striatum (AP +1.2 mm; ML +2.0 mm; DV -4.5 mm), and the stimulating electrode was inserted ipsilaterally just above the medial forebrain bundle (AP -4.6; ML +1.3; DV -8.0 to -9.0). A train of bipolar pulses (2 ms pulse width, 300 µA, 60 Hz) was delivered for 10 seconds. WINCS Harmoni was used in both FSCV recording and electrical stimulation[2].

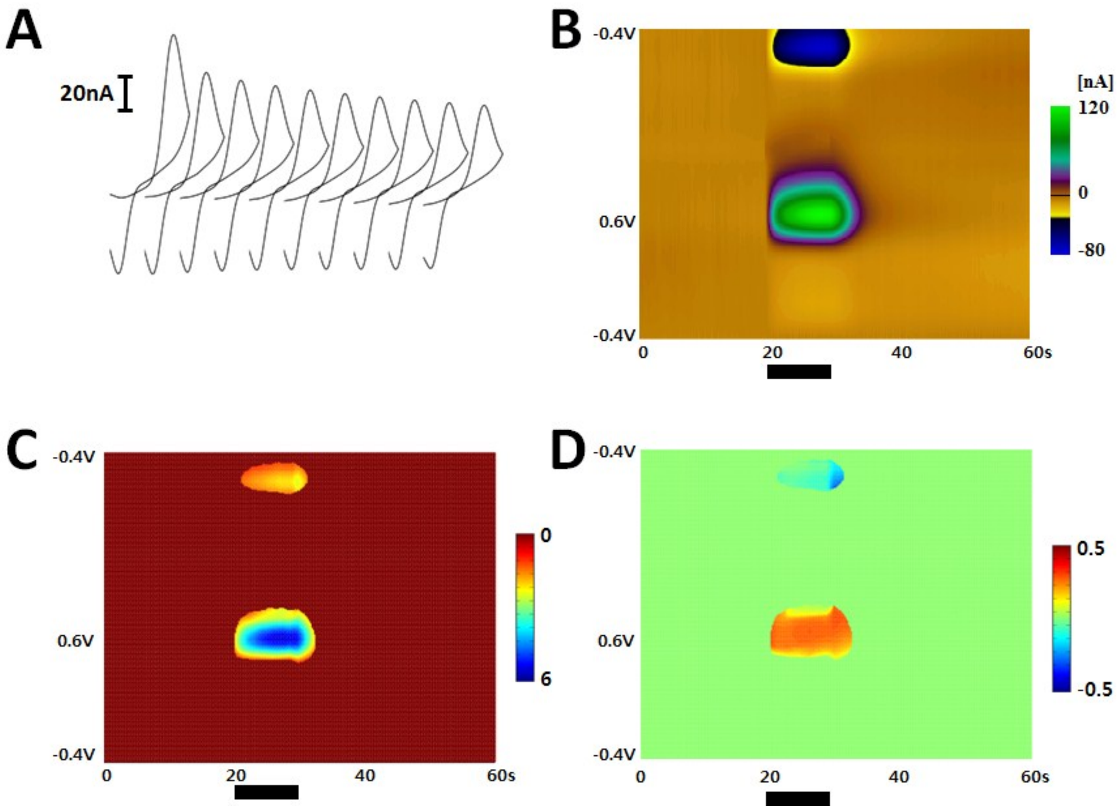

Figure S1. *In vivo* phasic dopamine (DA) response to M-FSCV. (A) The successive decade cyclic voltammogram. (B) Color plots of the first pulse from M-FSCV. Black bar indicates electrical stimulation at medial forebrain bundle to evoke phasic DA release in the striatum. (C) A map of the M-FSCV. (D) K map of the M-FSCV. (0.30 ± 0.06 SD, n=4).

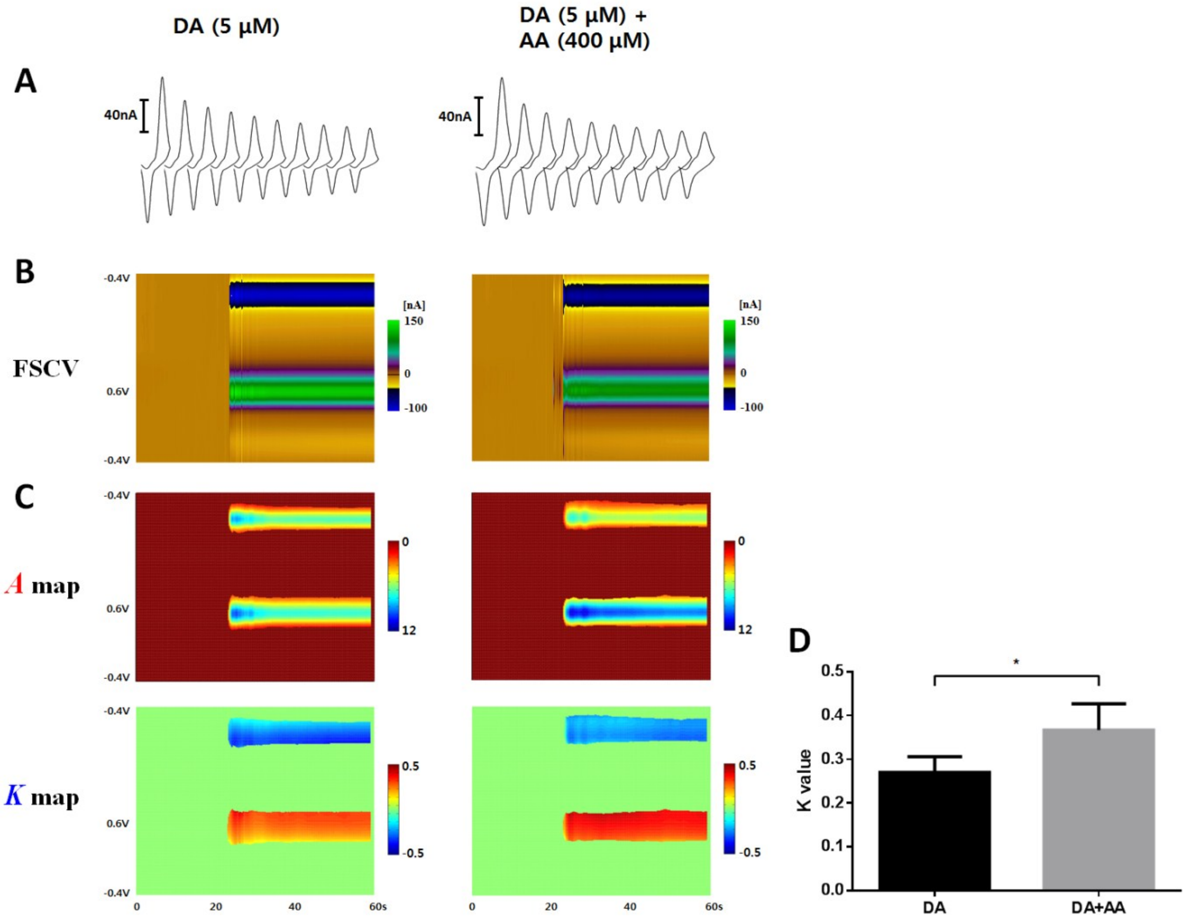

Figure S2. M-FSCV recordings of dopamine (DA) and DA/ascorbic acid (AA) mixture environment. AA is added to TRIS buffer in DA/AA experiment. (A) The successive decade cyclic voltammograms of DA and DA/AA. DA injected at 20 seconds. (B) Color plots of the first pulse from M-FSCV. (C) M-FSCV maps of successive decade cyclic voltammograms. (D) K value properties of DA and DA/AA. DA/AA showed significantly higher K value (n=3, CFM, paired *t* test, *p* value = 0.0285; values as the mean ± SD).

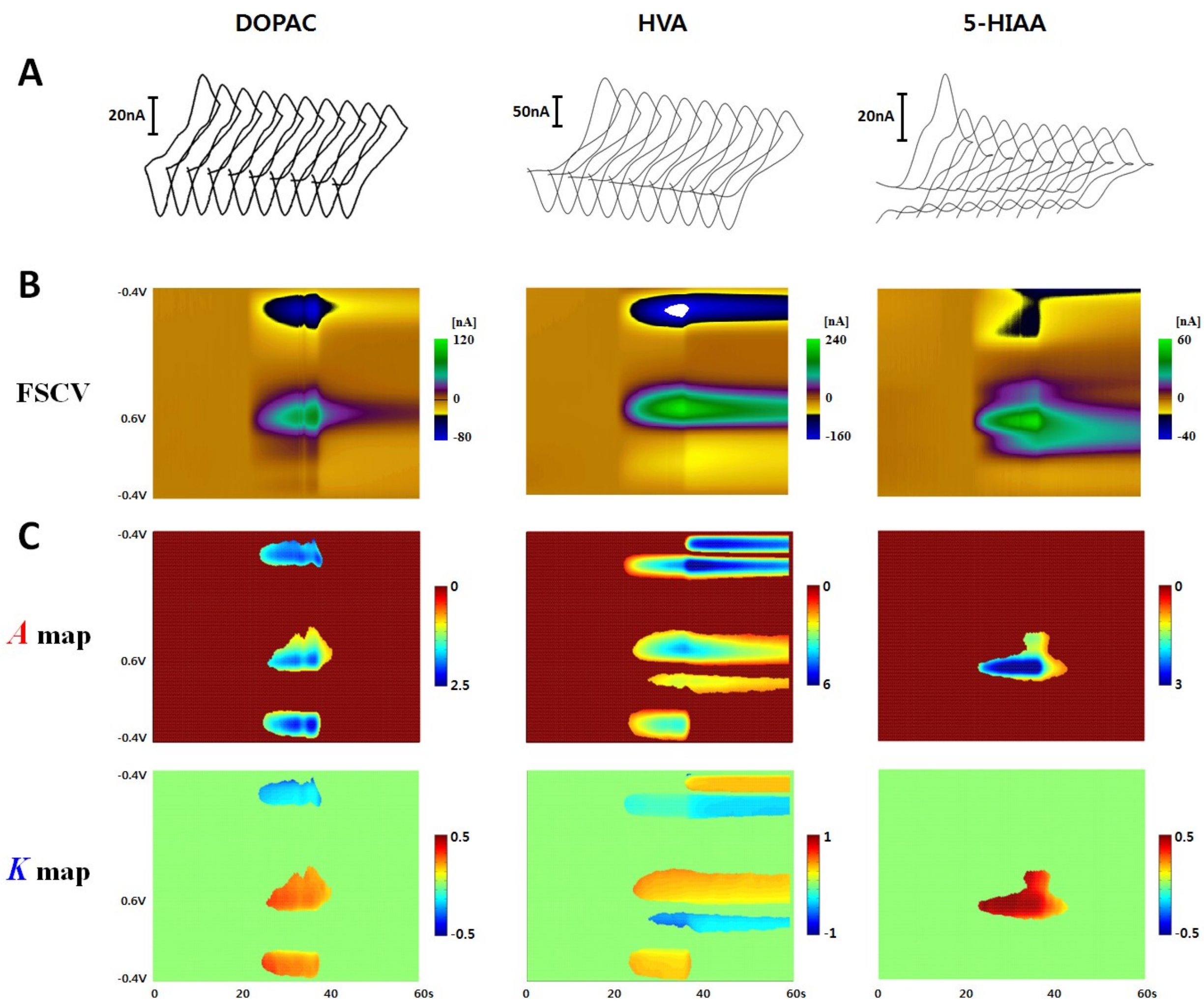

Figure S3. M-FSCV recordings of dihydroxyphenylacetic acid (DOPAC) (100µM), homovanillic acid (HVA) (100µM), 5-hydroxyindoleacetic acid (5-HIAA) (60µM). DOPAC and HVA showed no significant difference within the decade cyclic voltammograms under 600µM. (A) The successive decade cyclic voltammograms of different analytes. Analytes injected at 20 seconds. (B) Color plots of the first pulse from M-FSCV. (C) M-FSCV maps of successive decade cyclic voltammograms from analytes. K values from each of the analytes were 0.28 ± 0.01, 0.34 ± 0.01, and 0.43 ± 0.05 respectively (n=3, SD).

Derivation steps

$$A = \frac{k_1[DA]}{k_{-1}} \qquad B = \frac{k_2[DOQ]}{k_{-2}}$$

$$\Gamma_{DA} = A(e^{(k_{-1}\tau)} - 1)e^{-(k_{-1}\tau)} + \Gamma_{DA}^{o} e^{-(k_{-1}\tau)}$$

$$\Gamma_{DOQ} = B(e^{(k_{-2}t_s)} - 1)e^{-(k_{-2}t_s)} + \Gamma_{DOQ}^{o} e^{-(k_{-2}t_s)}$$

$$\Gamma_{DA}^{1} = A(e^{(k_{-1}\tau_l)} - 1)e^{-(k_{-1}\tau_l)} + \Gamma_{DA}^{o} e^{-(k_{-1}\tau_l)}$$

Substitute Γ_{DOQ}^{0} with F_1

$$\Gamma_{DOQ}^{1} = B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s} + F_1 e^{-(k_{-2}t_s)}$$

$$\begin{aligned}
\Gamma_{DA}^{2} &= A(e^{k_{-1}\tau_s} - 1)e^{-k_{-1}\tau_s} + [B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s} + F_1 e^{-k_{-2}t_s}]e^{-k_{-1}\tau_s} \\
&= A(e^{k_{-1}\tau_s} - 1)e^{-k_{-1}\tau_s} + [B(e^{k_{-2}t_s} - 1) + F_1]e^{-(k_{-1}\tau_s + k_{-2}t_s)} \\
&= \left\{ \begin{aligned} &[A(e^{k_{-1}\tau_s} - 1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s} - 1)]e^{-(k_{-1}\tau_s + k_{-2}t_s)} \\ &+ F_1 e^{-(k_{-1}\tau_s + k_{-2}t_s)} \end{aligned} \right\}
\end{aligned}$$

$$\begin{aligned}
\Gamma_{DOQ}^{2} &= B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s} + \left\{ A(e^{k_{-1}\tau_s} - 1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s} - 1)]e^{-(k_{-1}\tau_s + k_{-2}t_s)} + F_1 e^{-(k_{-1}\tau_s + k_{-2}t_s)} \right\} e^{-k_{-2}t_s} \\
&= B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s} + \left\{ \begin{aligned} &[A(e^{k_{-1}\tau_s} - 1) + B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s}]e^{-(k_{-1}\tau_s + k_{-2}t_s)} \\ &+ F_1 e^{-k_{-2}t_s} e^{-(k_{-1}\tau_s + k_{-2}t_s)} \end{aligned} \right\}
\end{aligned}$$

$$\begin{aligned}
\Gamma_{DA}^{3} &= A(e^{k_{-1}\tau_s} - 1)e^{-k_{-1}\tau_s} + \left\{ B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s} + [A(e^{k_{-1}\tau_s} - 1) + B(e^{k_{-2}t_s} - 1)e^{-k_{-2}t_s}]e^{-(k_{-1}\tau_s + k_{-2}t_s)} + F_1 e^{-k_{-2}t_s} e^{-(k_{-1}\tau_s + k_{-2}t_s)} \right\} e^{-k_{-1}\tau_s} \\
&= \left\{ \begin{aligned} &[A(e^{k_{-1}\tau_s} - 1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s} - 1)]e^{-(k_{-1}\tau_s + k_{-2}t_s)} \\ &+ [A(e^{k_{-1}\tau_s} - 1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s} - 1)]e^{-2(k_{-1}\tau_s + k_{-2}t_s)} \\ &+ F_1 e^{-2(k_{-1}\tau_s + k_{-2}t_s)} \end{aligned} \right\}
\end{aligned}$$

$$\Gamma_{DOQ}^{3} = B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s} + \left\{\begin{array}{l} [A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]e^{-(k_{-1}\tau_s+k_{-2}t_s)} \\ +[A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]e^{-2(k_{-1}\tau_s+k_{-2}t_s)} \\ +F_1e^{-2(k_{-1}\tau_s+k_{-2}t_s)} \end{array}\right\}e^{-k_{-2}t_s}$$

$$= B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s} + \left\{\begin{array}{l} [A(e^{k_{-1}\tau_s}-1) + B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s}]e^{-(k_{-1}\tau_s+k_{-2}t_s)} \\ +[A(e^{k_{-1}\tau_s}-1) + B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s}]e^{-2(k_{-1}\tau_s+k_{-2}t_s)} \\ +F_1e^{-k_{-2}t_s}e^{-2(k_{-1}\tau_s+k_{-2}t_s)} \end{array}\right\}$$

$$\Gamma_{DA}^{m} = [A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]\cdot\sum_{n=1}^{m-1}e^{-n(k_{-1}\tau_s+k_{-2}t_s)} + F_1e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \qquad m \geq 2$$

$$\Gamma_{DOQ}^{m} = B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s} + [A(e^{k_{-1}\tau_s}-1) + B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s}]\cdot\sum_{n=1}^{m-1}e^{-n(k_{-1}\tau_s+k_{-2}t_s)} + F_1e^{-k_{-2}t_s}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)}$$

$$\begin{aligned}\Gamma_{DA}^{m+1}-\Gamma_{DA}^{m} &= [A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]\cdot e^{-m(k_{-1}\tau_s+k_{-2}t_s)} + F_1e^{-m(k_{-1}\tau_s+k_{-2}t_s)} - F_1e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \\ &= [A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]\cdot e^{(k_{-1}\tau_s+k_{-2}t_s)}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} + [F_1e^{-(k_{-1}\tau_s+k_{-2}t_s)} - F_1]e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \\ &= \left\{A(e^{k_{-1}\tau_s}-1)e^{k_{-2}t_s} + B(e^{k_{-2}t_s}-1)]\cdot e^{(k_{-1}\tau_s+k_{-2}t_s)} + [F_1e^{-(k_{-1}\tau_s+k_{-2}t_s)} - F_1]\right\}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \\ &= W_{DA}^{o}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)}\end{aligned}$$

$$\begin{aligned}\Gamma_{DOQ}^{m+1}-\Gamma_{DOQ}^{m} &= [A(e^{k_{-1}\tau_s}-1) + B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s}]\cdot e^{-m(k_{-1}\tau_s+k_{-2}t_s)} + F_1e^{-k_{-2}t_s}e^{-m(k_{-1}\tau_s+k_{-2}t_s)} - F_1e^{-k_{-2}t_s}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \\ &= \left\{A(e^{k_{-1}\tau_s}-1) + B(e^{k_{-2}t_s}-1)e^{-k_{-2}t_s}]e^{-(k_{-1}\tau_s+k_{-2}t_s)} + [F_1e^{-k_{-2}t_s}e^{-(k_{-1}\tau_s+k_{-2}t_s)} - F_1e^{-k_{-2}t_s}]\right\}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)} \\ &= W_{DOQ}^{o}e^{-(m-1)(k_{-1}\tau_s+k_{-2}t_s)}\end{aligned}$$

(1) Paxinos, G.; Watson, C. *San Diego, CA: Academic* **1986**.

(2) Lee, K. H.; Lujan, J. L.; Trevathan, J. K.; Ross, E. K.; Bartoletta, J. J.; Park, H. O.; Paek, S. B.; Nicolai, E. N.; Lee, J. H.; Min, H. K.; Kimble, C. J.; Blaha, C. D.; Bennet, K. E. *Sci Rep* **2017**, *7*, 46675.