A Turn-Key Fast Scan System for Detection of In Vivo Dopamine Release

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Introduction

• Continuous Fast Scan Cyclic Voltammetry (FSCV) is a technique wherein biogenic amine signatures are detected by rapidly cycling the voltage on an implanted carbon fiber electrode and recording the amperometric change resulting from specific oxidation and reduction events (Figure 1).
• Previous systems have documented FSCV recording for detection of dopamine1, noradrenaline2, and serotonin3 using both tethered4 and wireless5–8 recording devices.
• We have developed a complete turn-key system comprising a 34 μm recording electrode, hardware and software to continuously record FSCV data from freely moving animals.

Methods

• Young (age 3-4 months) Sprague Dawley rats and young (age 2-3 months) C57B6/J mice were surgically implanted with a carbon fiber electrode (Figure 2) placed in the striatum region. A single Ag/AgCl reference electrode was implanted in the contralateral cortex.
• All animals were housed under a 12 hour light 12 hour dark cycle persisting throughout the experiment with food and water available ad lib. All surgical procedures were previously approved by the University of Kansas ACUC.
• All rats were fitted with a plastic recording enclosure designed to fit on the head of the animal and protect the electronics, carbon fiber electrode and reference electrode (Figure 3a). Mice were connected to a lightweight tether and swivel following implantation.
• After a one week recovery period, the carbon fiber electrode and reference were connected to Pinnacle’s 8501 wireless FSCV system (rats, Figure 3b) or Pinnacle’s 8504 tethered FSCV system (mice). To enhance biogenic amine release in some animals, an amphetamine bolus was administered (4 mg/kg). Dopamine was detected using continuous FSCV wherein the voltage was rapidly cycled on the carbon fiber electrode between -0.4 V and +1.1 V at a rate of 400 V/s. The resulting oxidation and reduction peaks were recorded using the PAL 8500 software suite.
• Continuous FSCV traces were successfully collected over periods up to 90 minutes in length.
• Rats tolerated the wireless head enclosure well and exhibited normal behavior (feeding, rearing and exploration) during testing periods.
• Using this system, dopamine signature traces were detected during spontaneously released transient pulses in the striatum of an anesthetized rat (Figure 4).
• Application of a 400 μA stimulus to the substantia nigra region resulted in clearly distinguishable dopamine peaks in the striatal region of an anesthetized rat (Figure 5).
• FSCV traces of dopaminergic release in the striatum of a freely moving rat followingamphetamine injection (4 mg/kg) were clearly detectable (Figure 6).
• Dopamine release in the striatum of a mouse was also detected following amphetamine injection (Figure 7).
• Simultaneous video tracking of behavior demonstrated correspondence between dopamine release and stereotypy behaviors.

Results

Figure 1: 3-D visualization of FSCV data demonstrating oxidation and reduction peaks resulting from a 0.4 μA in vivo dopamine injection.

Figure 2: 30 μm Carbon fiber electrode prior to implantation.

Figure 3: (a) Wireless FSCV plastic enclosure on the head of a rat. (b) Inside of enclosure showing electronics package and wiring for the E851 wireless FSCV system.

Figure 4: FSCV traces showing spontaneous dopamine release recorded in the striatum of an anesthetized rat. CFS (1000 Hz FSCV sensor #02AB) implanted in the striatum (coordinates AP +2.5, M.L. 0.0, D.V. 8.6).

Figure 5: FSCV traces showing stimulation bursts recorded in the striatum of an anesthetized rat using the wireless FSCV system. CFS (1000 Hz FSCV sensor #02AB) implanted in the striatum (coordinates AP +2.5, M.L. 0.0, D.V. 8.6; stimulus parameters used: 3 msec biphasic pulse in 10 msec burst, 5 second duration @ 20 Hz, amplitude 400 μV).

Figure 6: FSCV traces showing spontaneous dopamine release recorded in a freely moving rat. CFS (7002 FSCV sensor #04AB) implanted in the striatum of a freely moving Sprague Dawley rat under the influence of 4 mg/kg of amphetamine (p. administration).

Figure 7: FSCV traces showing dopamine release in the striatum of a mouse following amphetamine injection (4 mg/kg) recorded with a protonated sensor. CFS (7004 FSCV sensor #04AB) implanted in the striatum (coordinates AP +3.5, M.L. 0.5, D.V. -2.0). (a) Data collected using tethered FSCV system on a freely moving Sprague Dawley rat under the influence of 4 mg/kg of amphetamine (p. administration). Peak collection: peak height (0.4 μA DA = 201 nA; Oxidation wave). Max in vivo peak height = 43.1 nA; Measured DA concentration = 0.064 μM. Analysis time period = 180 sweeps (72 seconds).

Conclusions

• The system is capable of long-term continuous monitoring of dopamine in both the wireless and tethered configurations.

References


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