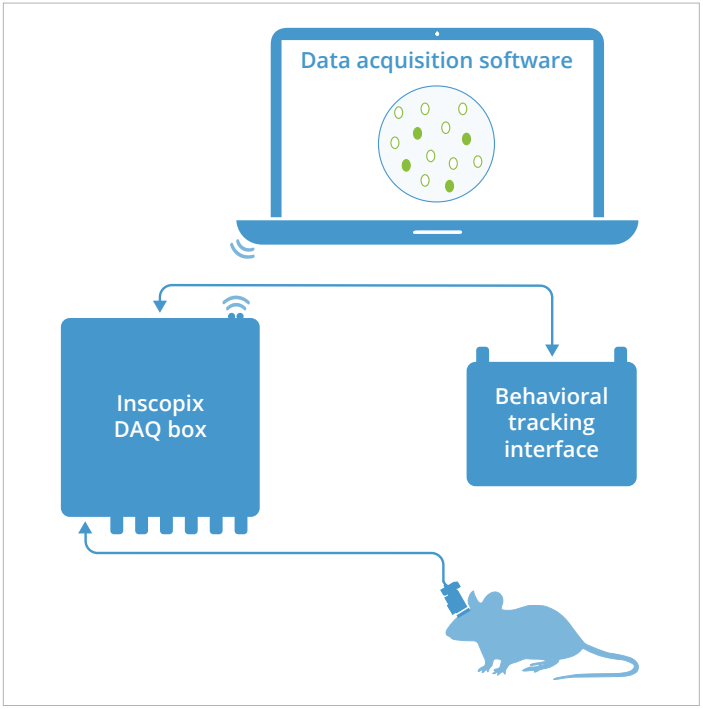
nVoke™

State-of-the-art for integrated calcium imaging & optogenetics

iNSCOPIX

Transform your neural circuit research

nVoke empowers you to causally link calcium dynamics in specific cell-types and neural circuits that mediate complex behavior in freely-moving mice. Our revolutionary miniature microscope combines optogenetic manipulation and wide-scale calcium imaging in a single, integrated system for gaining new insights into the neural circuitry of behavior.



The nVoke system simultaneously enables optogenetic modulation while capturing changes in brain cell fluorescence. Both synchronized acquisition of integrated imaging and optogenetics with behavioral tracking* is transmitted via the Inscopix DAQ box to a computer.

*Behavioral tracking apparatus not included with nVoke platform

> "The nVoke system gave us the unprecedented ability to simultaneously activate dopamine terminals while recording activity in anatomically-defined neurons in a freely-moving animal. nVoke was essentially plug-and-play - allowing us to collect data within days of receiving the system!
>
> **Kay Tye, MIT**

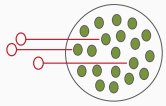
Key benefits

- A lightweight body (1.8g) enables naturalistic free behavior
- Software-controlled electronic focus for precise longitudinal imaging
- Acquire data remotely using a web-based interface; no dedicated computer needed
- New image sensor and re-designed data acquisition (DAQ) box facilitate external data
- Commutator support enables a wider range of freely behaving experiments

Multiple applications

nVoke integrates two LED light sources for simultaneous or sequential cellular-resolution imaging using GCaMP indicators and red-shifted opsins* for temporally precise control of cells within the same field of view in freely-behaving mice. Using common spectrally-matched indicator and opsin combinations* (see table), with nVoke, you can now test unique applications and causal relationships surrounding neural circuit calcium dynamics that are synchronous with behavior.

* The following opsin and indicator combinations were tested and validated in-house and shown to display minimal biological cross-talk with maximized signal-to-noise.

Connectivity mapping	Ca^{2+} imaging + opto-excitation*	Ca^{2+} imaging + opto-inhibition*
Two populations[1] 	✓ **VALIDATED** GCaMP6 + ChrimsonR	✓ **VALIDATED** GCaMP6 + NpHR3.0 / Jaws
Two populations[2] 	**UNDER VALIDATION**	✓ **VALIDATED** GCaMP6 + NpHR3.0 / Jaws
Same cells[2] 	**UNDER VALIDATION**	✓ **VALIDATED** GCaMP6 + NpHR3.0 / Jaws

Calcium indicator (GCaMP6) Opsin (ChrimsonR, NpHR3.0, Jaws)

*Sequential & simultaneous [1]Terminal optogenetics [2]Somal optogenetics

Hardware specifications

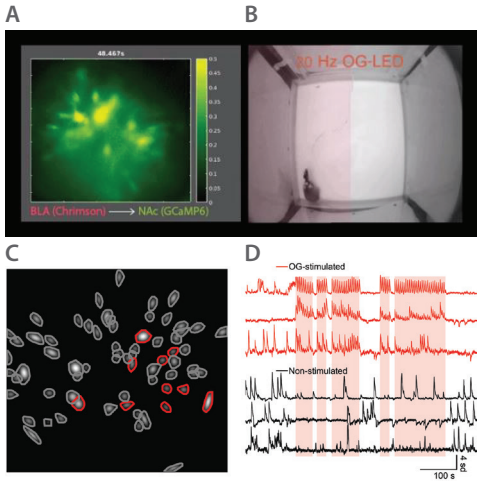
Description	Specification
Modality	Simultaneous optogenetic modulation and imaging
Integrated LED on microscope	Yes
Objective lens NA	0.5
Field of view	650 µm x 900 µm
Working distance	0 - 300 µm
Frame rate	5 - 60 FPS
Sensor format	1280 x 800 pixels
Electronic focusing range	300 µm
Electronic focusing axial step	<0.5 µm
Dimensions	8.8 mm x 15 mm x 22 mm
Weight	1.8 g
Data cable	2.5 m
Connectivity	Ethernet, WiFi
Storage	2TB SSD, SD card slot
GPIOs	4 analog capable GPIOs, 1 SYNCH output, 1 TRIG input, 5 USB 3.0
Optogenetics spectral characteristics	
OG excitation	620 ± 30 nm
OG irradiance (Excitatory protocol)	0 - 35* mW/mm^2
OG irradiance (Inhibitory protocol)	0 - 10** mW/mm^2
OG irradiance resolution	0.1 mW/mm^2
OG pulse repetition rate	1 - 100 Hz
OG pulse duty cycle (for excitatory protocols)	Minimum pulse (low or high) duration: ≥ 0.2 ms. Pulse rise and fall time is 0.5 ms. Maximum pulse duration (given 1 kHz sampling rate): 16 minutes
OG duration of illumination (for inhibitory protocols)	Shortest OG pulse: ~1.2 ms (0.5 ms rise time + 0.2 ms minimum pulse duration + 0.5 ms fall time). OG pulse durations up to steady-state illumination are supported.

Imaging spectral characteristics	
Fluorophore excitation	455 ± 8 nm
Fluorophore excitation irradiance	0 - 2** mW/mm^2
Fluorophore excitation irradiance resolution	0.1 mW/mm^2
Fluorophore emission	515 ± 25 nm
Infrared (IR) block	Microscope blocks IR from other sources

*At objective front surface, 25% duty cycle at max irradiance
**At objective front surface

nVoke research: reward circuit functional connectivity mapping

Inscopix scientists explore the causal relationship underlying reward circuit function, behavior, and network dynamics.



A) nVoke stimulation of terminal projections from the basolateral amygdala (BLA) to nucleus accumbens (NAc) with simultaneous imaging of local NAc neurons. **B)** BLA activation increases Ca^{2+} responses in NAc neurons and is rewarding in mice exposed to place preference. **C)** ROIs identified (red, OG-stimulated; gray non-stimulated) using Inscopix Data Processing Software. **D)** Traces from stimulated (red) and non-stimulated (black) cells. Orange bars indicate when the mouse was within OG-LED stimulation zone.

nVoke publication from our community

Fast-spiking interneurons supply feedforward control of bursting, calcium, and plasticity for efficient learning

Owen, S., et al., Cell, February 2018

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