Optogenetic Activation of the Inferior Colliculus: Electrophysiological and Behavioral Effects in Rats

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INTRODUCTION

Our prior investigations showed that electric or chemical stimulation of the IC ameliorates haloperidol-induced catalepsy, a manifestation of Parkinsonism in animals. We hypothesized that this amelioration stems from a sensory-motor gating mechanism via Inferior Colliculus activation of the mesencephalic locomotor region (MLR). Aiming to investigate this hypothesis, we performed IC optogenetic stimulation and electrophysiological recordings of MLR neuronal activity in anesthetized rats. Additionally, we examined whether optogenetic manipulation of IC could improve motor deficits and affect emotional states in awake rats.

METHODS AND RESULTS

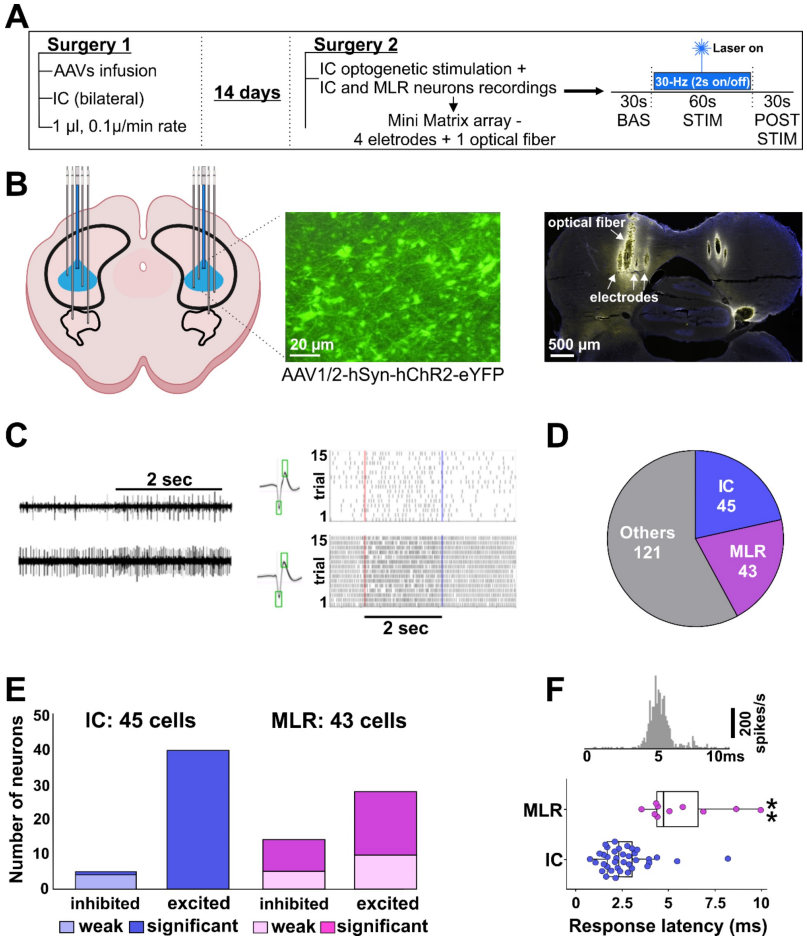

Fig. 1. (A) Experiment timeline and protocol summary; (B) Left - Illustrative representation of the IC and MLR neuronal activity recordings with 4 electrodes associated with IC optogenetic stimulation. Center - IC transfected neurons expressing the fluorescent marker after ChR2 AAVs injection. Right - Example of electrodes and optical fiber bilateral placements on IC; (C) Left - Example of two extracellular signals recorded simultaneously from two electrodes, Middle - averaged spike shapes detected from the adjacent raw signals. Right – Raster plots of spike activity during 15 repetitions of 2 sec with 30 Hz light stimulation (2 ms pulses); (D) Total number of recorded neurons; (E) Electrophysiological response of IC and MLR neurons during IC optogenetic stimulation; (F) Top - Example for a neuron's pulse response relative to pulse onset (at t= 0). Bottom – Response latency for IC and MLR neurons. * P < 0.005 after IC and MLR comparison.

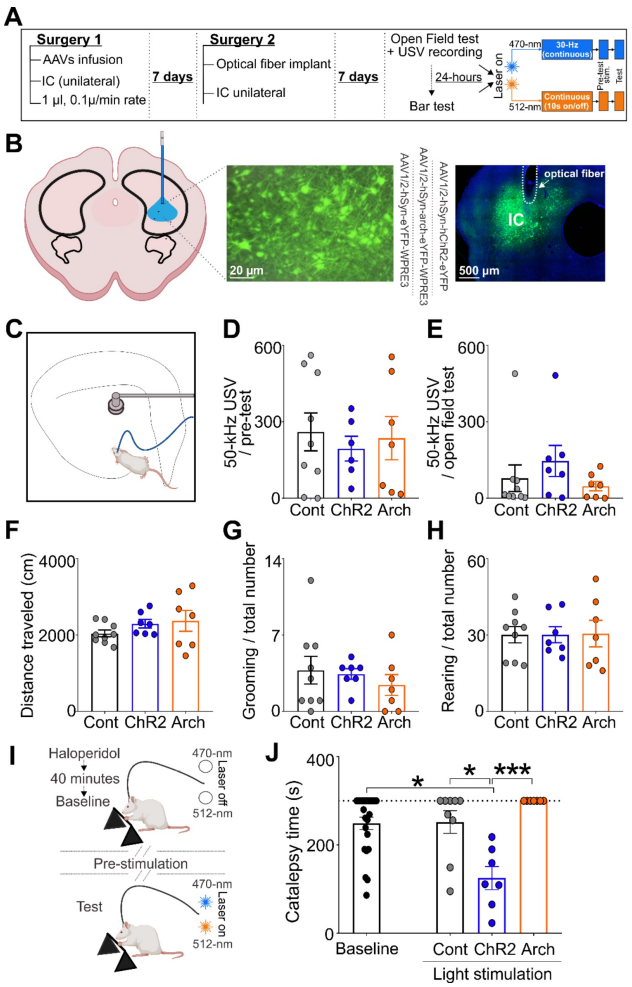

Fig. 2. (A) Experiment timeline and experimental protocol summary; (B) Left - Illustrative representation of the optogenetic manipulation in the IC transfected neurons expressing the fluorescent marker and optical fiber placement on IC; (C) Open field test showing rats receiving light stimulation (light 470 or 512-nm light stimulation) via a patch cable connected to the implanted optical fiber. (D and E) Total number of 50-kHz USVs recorded; (F) Total locomotion (cm) traveled during the open field test; (G) Total number of grooming and (H) rearing behavior; (I and J) Bar test and catalepsy time during the bar test. Data are expressed as mean ± SEM. * P < 0.05 and *** P < 0.001 compared to the ChR2 group.

CONCLUSION

- Electrophysiological data revealed an excitatory response in MLR neurons following IC optogenetic stimulation, with a longer onset latency in MLR neurons suggesting synaptic modulation from IC to MLR.
- Behavioral results showed that IC optogenetic stimulation improved haloperidol-induced motor deficits without affecting emotional state or basal locomotor activity.
- Our study suggest that in order for paradoxical kinesia to occur, the brain activates alternative pathways that bypass the defective basal ganglia in PD patients. We hypothesized that alternative pathways activated to ensure this motor improvement might, at least in part, involve projections from the IC to the MLR, both of which are situated outside the basal ganglia.

REFERENCE

- Pochapski, J.A., Franke, J., Kruse, W. et al. Optogenetic stimulation of inferior colliculus neurons elicits mesencephalic locomotor region activity and reverses haloperidol-induced catalepsy in rats. Sci Rep 15, 12649 (2025). https://doi.org/10.1038/s41598-025-96995-4

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