Encoding and enhancement of the motivation to consume alcohol by the central nucleus of the amygdala

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Introduction

The central amygdala has been implicated in the promotion of alcohol intake following the induction of physical dependence on alcohol that can occur in human populations after prolonged abuse of alcohol, or in rodent models by the use of forced alcohol vapor exposure. These models primarily posit that the central amygdala becomes involved to promote alcohol consumption only following dependence through processes associated with the generation of a prolonged negative affective state that is alleviated by alcohol consumption.

It has remained unclear, however, how the central amygdala is involved in the initial motivation to consume alcohol prior to the onset of physical dependence. If the central amygdala contributes to alcohol consumption produced by appetitive motivational processes, then it is possible that prolonged alcohol consumption can co-opt these appetitive mechanisms during the transition to compulsive alcohol consumption and alcohol abuse.

The central amygdala is an ideal site for such hypothesized alcohol-induced plasticity as it receives direct input from brainstem, thalamic and cortical gustatory regions and projects back to both affective processing structures like the bed nucleus of the stria terminalis and brainstem taste centers like the parabrachial nucleus and nucleus of the solitary tract.

We investigated the involvement of the central amygdala in the control of alcohol consumption by making use of *in vivo* electrophysiology and optogenetics to tease apart mechanisms by which the central amygdala promotes the motivation to consume alcohol despite the availability of more preferred options.

Methods

For *in vivo* electrophysiology experiments male Long Evans rats (n=5) were allowed to drink 15% ethanol in the homecage for 4 weeks on an every other day intermittent access schedule. They were then implanted with 16-wire drivable bundles of tungsten electrodes above the central amygdala. During recording sessions rats could freely enter a port where a cumulative presence of 2 seconds would trigger a delivery of 10% ethanol.

For optogenetic experiments male Long-Evans rats (n=14) first received infusions of 0.5 µL AAV5-hsyn-ChR2-eYFP or AAV5-hsyn-GFP into the central amygdala and then subsequent implantation of an optic implant above the central amygdala. Rats were then allowed to drink 15% ethanol on an every other day intermittent access schedule for 5 weeks. They were then extensively handled and accustomed to tethering needed for the optogenetic stimulation. During testing rats had access to two bottles for 30 minutes in a modified homecage. Licks were recorded from each bottle using a custom, low-cost lickometer and one bottle triggered stimulation on the first lick made each second.

Do you want the code and instructions for the lickometer?

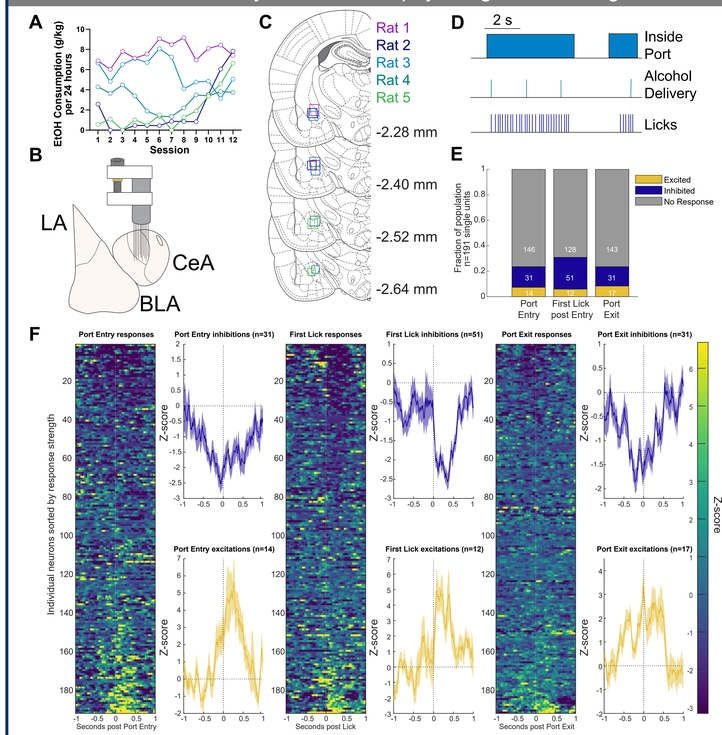
A reprint of this poster?

How-to guide, arduino code, and MATLAB analysis code for lickometer generated data all available at :
github.com/kmfras/lickometer

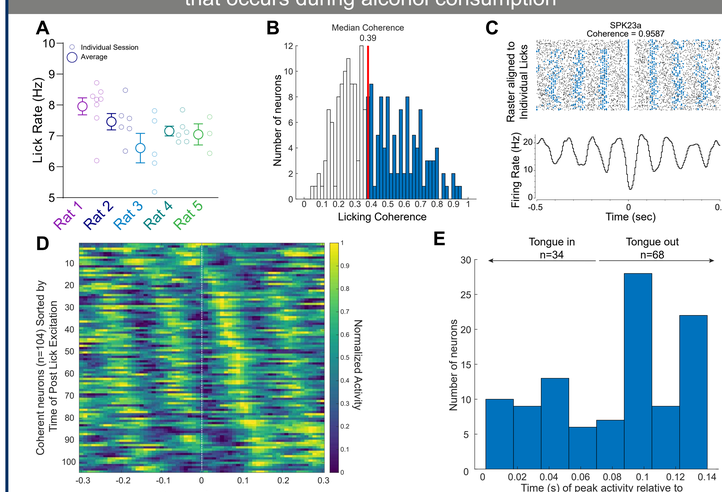
SCAN ME

Results

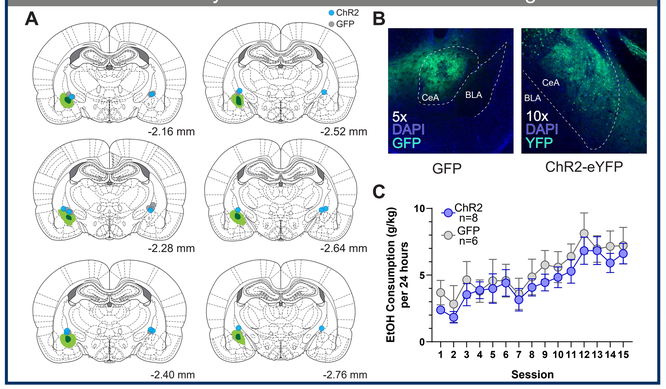
Correlates of alcohol consumption in the central amygdala revealed by *in vivo* electrophysiological recordings



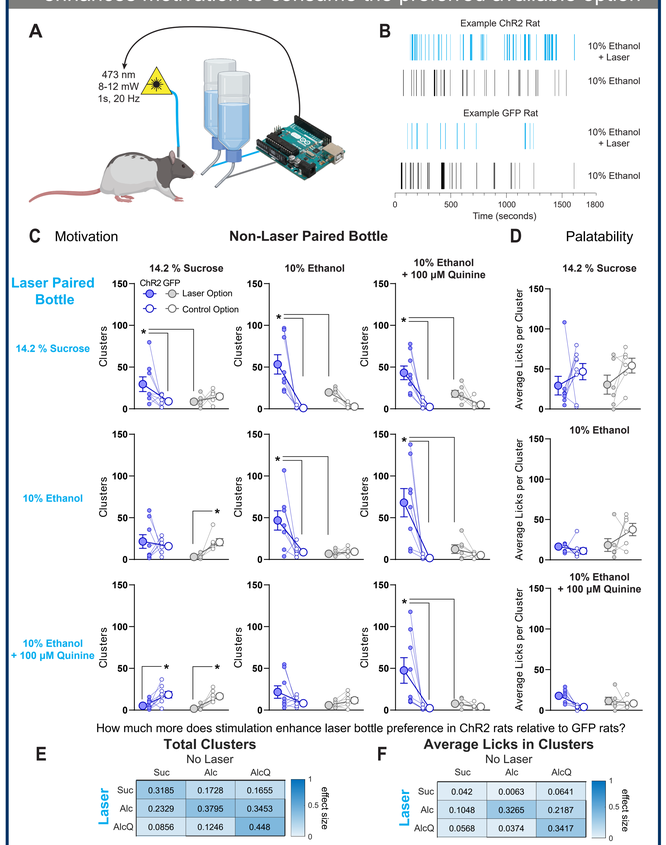
Central amygdala neurons are entrained to the frequency of licking that occurs during alcohol consumption



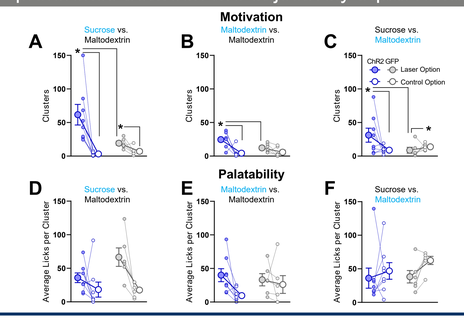
Optogenetic control of the central amygdala in rats with a history of alcohol intake in the homecage



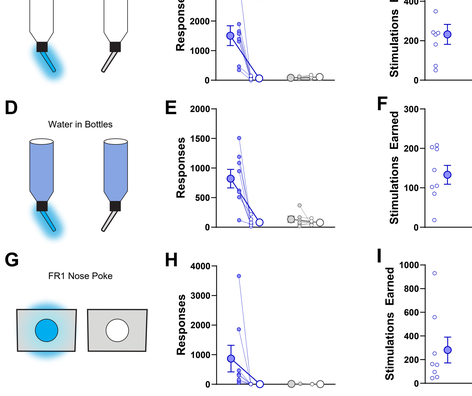
Closed-loop optogenetic stimulation of the central amygdala enhances motivation to consume the preferred available option



Optogenetic stimulation of the central amygdala alters preference between two objectively equal rewards



Optogenetic self-stimulation of the central amygdala is modest in rats with a history of alcohol consumption



Summary

- Central amygdala neurons are modulated by the consumption of alcohol, both movements related to the pursuit of alcohol and the tongue movements required to consume alcohol.
- Neurons within the central amygdala are tuned to the licking cycle and exhibit rhythmic firing during alcohol consumption
- Closed-loop optogenetic excitation of the central amygdala promoted consumption of the laser-paired option when the other option was equivalent. Stimulation was able to increase alcohol consumption when sucrose was available and enhance motivation to consume adulterated bitter alcohol.
- We observed modest self-stimulation of the central amygdala, perhaps owing to alcohol-induced plasticity resulting from voluntary alcohol consumption.

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