# The Effects of Alcohol, Opiates, Cannabis, and Benzodiazepines on Grid Cell Firing

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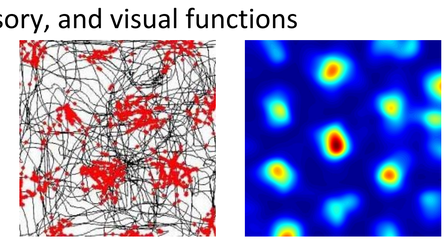
## Introduction

**Grid Cells**

- Neurons that fire in a regular geometric pattern; form the brain's navigation system
- Present in all cortical areas such as motor, sensory, and visual functions



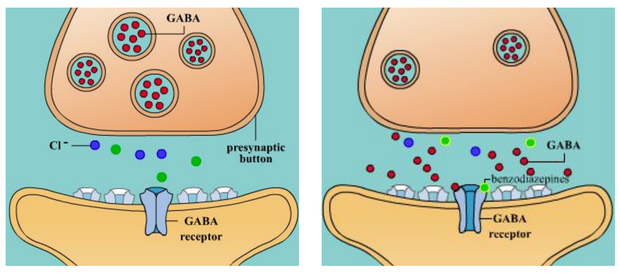
**GABA**

- Gamma-aminobutyric acid (GABA)
- The chief inhibitory neurotransmitter
- Reduces neuronal excitability

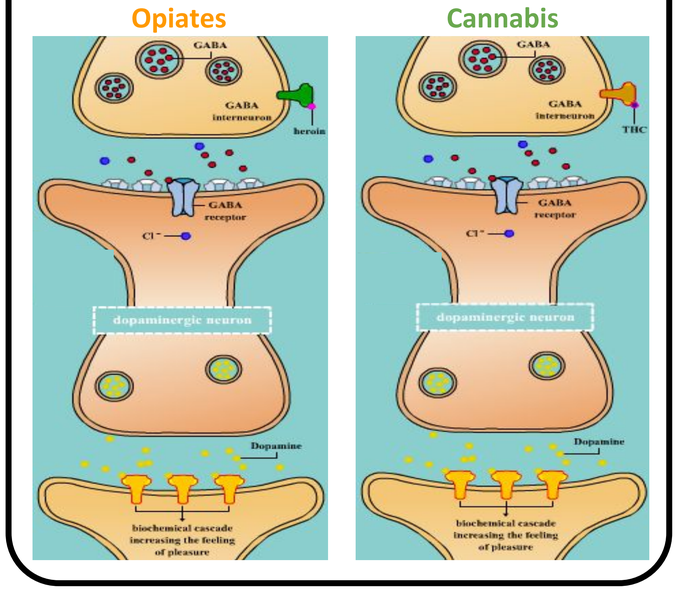
**AMPA**

- α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA)
- Agonist for the AMPA receptor
- Mimics the effects of the glutamate
- AMPA receptor current suppresses firing

**Alcohol** **Benzodiazepines**




**Opiates** **Cannabis**




## Methods

- HybridModelNew in Matlab
- Baseline GABA conductance = 0.14e-4 mS
- Baseline AMPA conductance = 0.215e-4 mS

**Conductances**

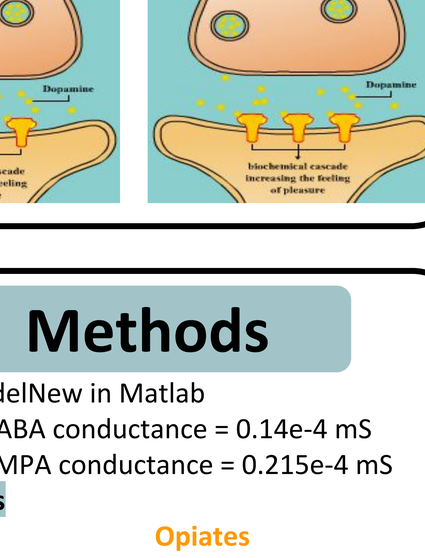
**Alcohol**
1. GABA = 0.15e-4 mS
1. AMPA = 0.205e-4 mS
2. GABA = 0.16e-4 mS
2. AMPA = 0.195e-4 mS

**Opiates**
1. GABA = 0.13e-4 mS
1. AMPA = 0.205e-4 mS
2. GABA = 0.12e-4 mS
2. AMPA = 0.195e-4 mS

**Cannabis**
1. GABA = 0.135e-4 mS
1. AMPA = 0.21e-4 mS
2. GABA = 0.13e-4 mS
2. AMPA = 0.205e-4 mS

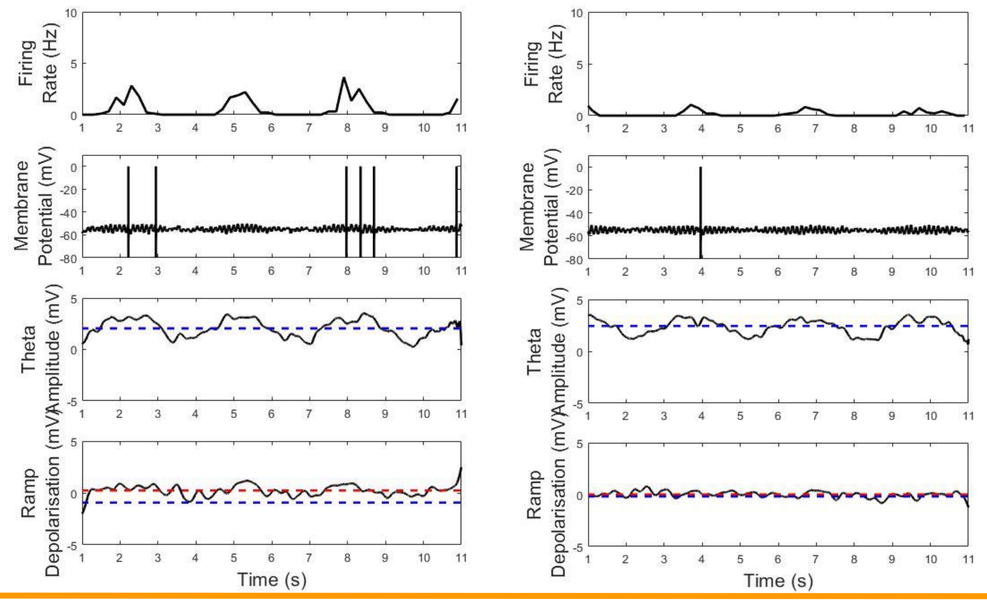
**Benzodiazepines**
1. GABA = 0.15e-4 mS
2. GABA = 0.16e-4 mS

**Baseline Graph**

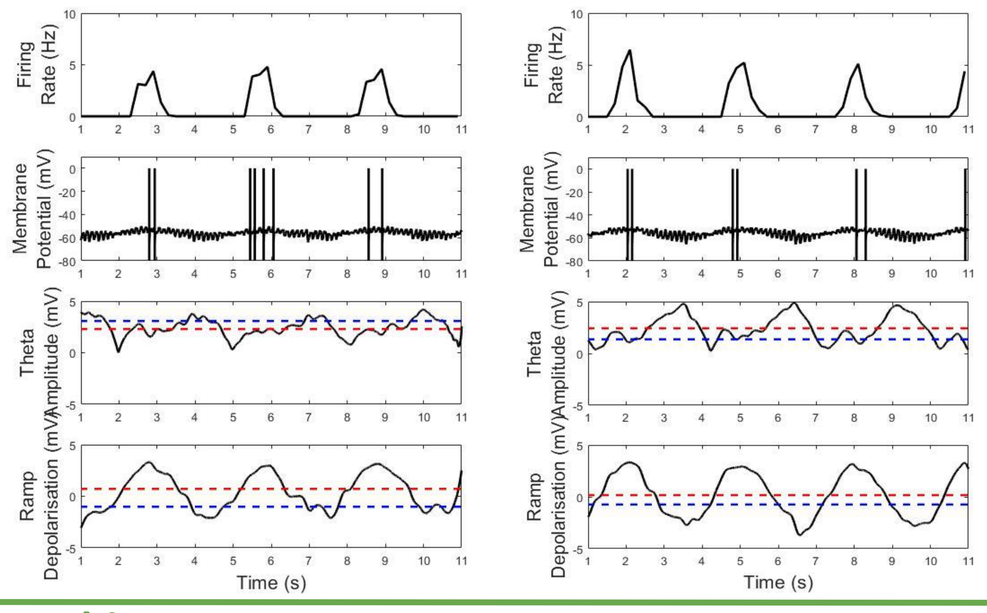



## Results

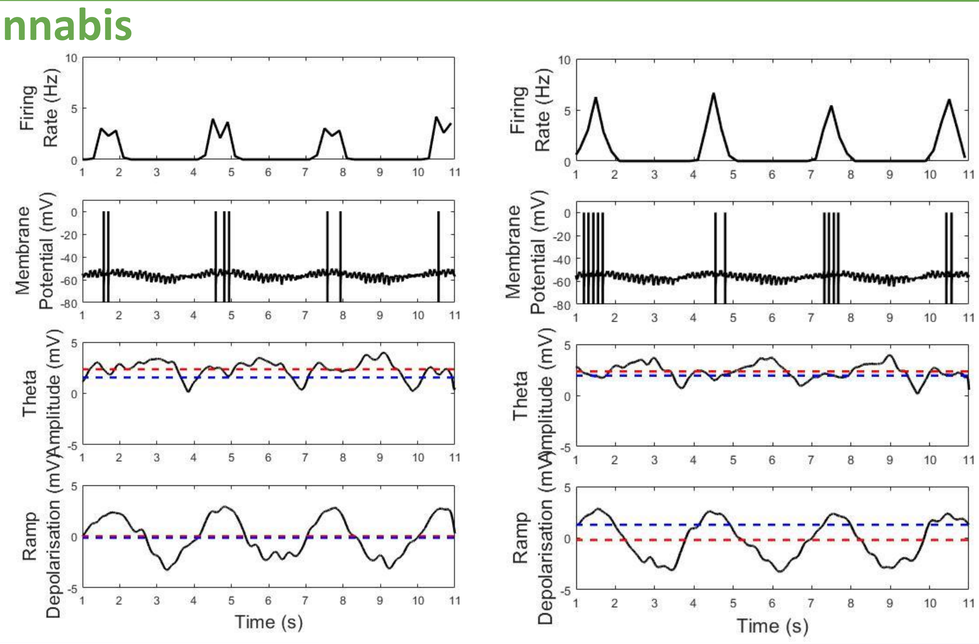
### Alcohol



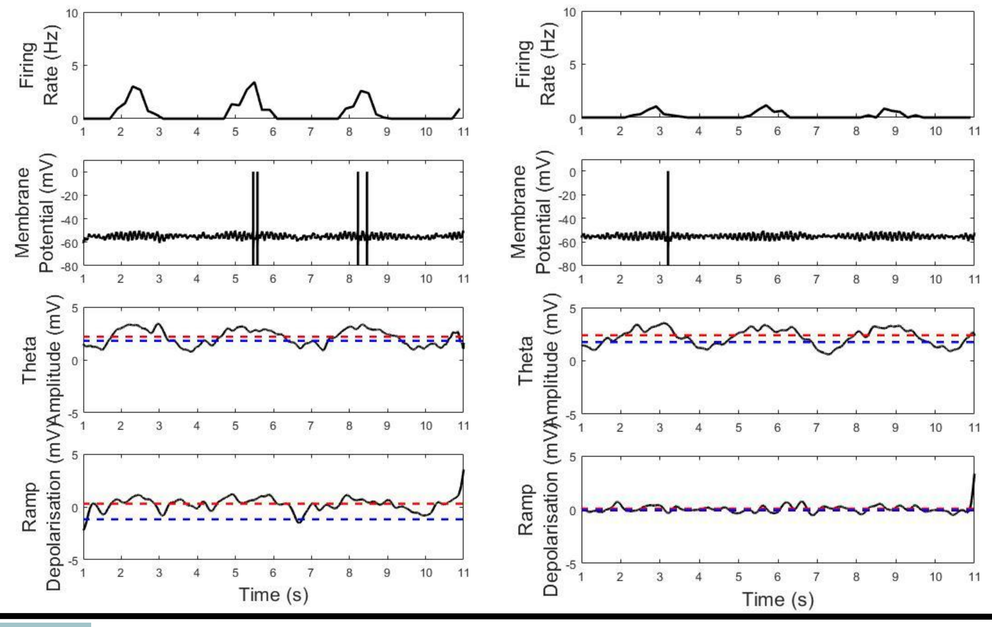

### Opiates




### Cannabis




### Benzodiazepines




**Subplots**

- **Firing Rate**: average number of action potentials per unit time
- **Membrane Potential**: difference in electric potential between interior and exterior of a cell
- **Theta Amplitude**: combines with ramp depolarization to make the grid cell fire
- **Ramp Depolarizatio**n: combines with theta amplitude to make the grid cell fire; has a stronger correlation to firing rate in comparison to theta amplitude

## Discussion/ Conclusions

**Alcohol**

- Lower amplitude of firing rate spikes
- Fewer membrane potential spikes
- Higher theta amplitude
- Smaller range in ramp depolarization
- Affected **firing rate** to the greatest extent

**Opiates**

- Higher frequency of firing rate spikes
- More membrane potential spikes
- Larger range of theta amplitude
- Greater ramp depolarization
- Affected **theta amplitude** to greatest extent

**Cannabis**

- Higher frequency of firing rate spikes
- More membrane potential spikes
- Higher range of theta amplitude
- Greater ramp depolarization
- Affected **membrane potential** to greatest extent

**Benzodiazepines**

- Lower amplitude of firing rate spikes
- Fewer membrane potential spikes
- Higher range of theta amplitude
- Lower range of ramp depolarization
- Affected **ramp depolarization** to the greatest extent

**Conclusions**

- Increase in firing rate increases connections in the brain, improving memory and allowing better learning of new skills
- Alcohol decreases firing rate and causes alcohol consumers to **lose connections** in their brain and have their **memory impaired**
- Changes in firing rate depend on a human's perception of spatial location, and a decrease represents being in an unknown environment
- Grid cells form the brain's navigation system and a decrease in firing rate of grid cells may make a person **question their location in an environment**
- Theta amplitude and ramp depolarization change grid cell firing by affecting firing rate
- Opiates and cannabis increase theta amplitude and ramp depolarization, therefore decreasing firing rate and decreasing memory capacity
- Changes in membrane potential enable communication with other cells or **initiate changes inside the cell**
- Benzodiazepines decrease membrane potential, resulting in less communication between cells and **impairment of common functions** and memory

## References

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