Encoding of information about actions and outcomes by medial thalamus in the rat

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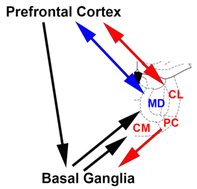
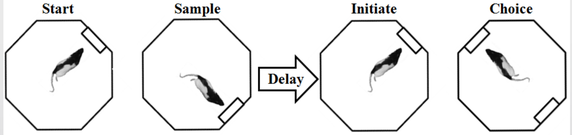
BACKGROUND

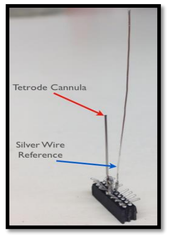
- Central thalamus (CT) plays a critical role in pathways mediating communication with prefrontal cortex (PFC).
- These pathways are important for executive function and goal directed behavior and are implicated in thought disorders, such as schizophrenia and amnesia.
- Damage to the medial dorsal nucleus (MD), and adjacent nuclei, of thalamus results in delay-dependent impairment on memory tasks including delayed non-matching to position task (DNMTP).
- Cellular activity was recorded, characterized, and compared to previous data collected from PFC.



METHODS



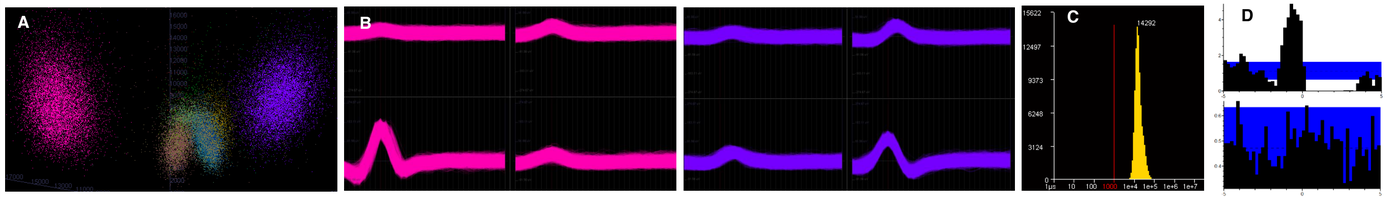
- Rats trained to 70% criterion on a novel DNMTP task. Start position varies randomly among all four levers for each trial, allowing for comparison of allocentric and egocentric response patterns.
- A two lever task was later implemented to identify reinforced versus non-reinforced levers on any given trial.
- Rats implanted with drivable 4-tetrode array to record multiple sites in CT as the implant was lowered after each daily session.



- Neural activity was recorded using Neuralynx™ DigitalLynx SX. Standard spike sorting and cluster cutting software (SpikeSort3D™; KlustaKwik™) was used to identify and isolate single cells.

RESULTS

Data Analysis

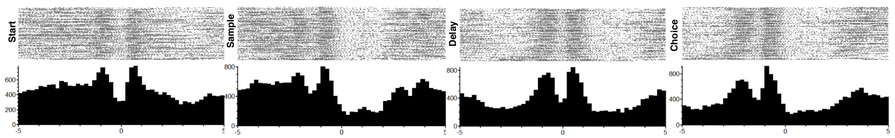


- Cellular activity included in analysis must:
  - ❖ Form a distinct cluster in the 3-D plot (Figure A)
  - ❖ Have a signal to noise ratio of at least 1.5:1 (Figure B)
  - ❖ Have an inter-spike interval above 1000 μs. (Figure C)
- Data were analyzed as perievent rasters and histograms using NeuroExplorer™ based on events specific to the DNMTP task.
- Histograms (99% confidence interval) for each possible cell to confirm behavioral correlates (Figure D).

Response Properties Similar to Those Found in PFC

Action

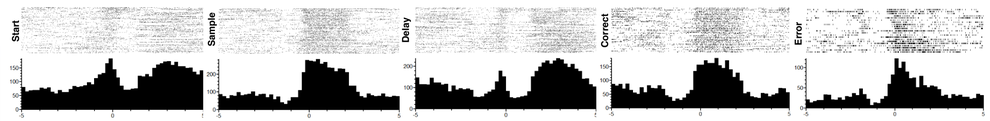
Movement 1



Increased 1-3 s before lever press, abrupt decrease prior to lever press; Longer period of decreased activity during reinforcement

Reinforcement Anticipation

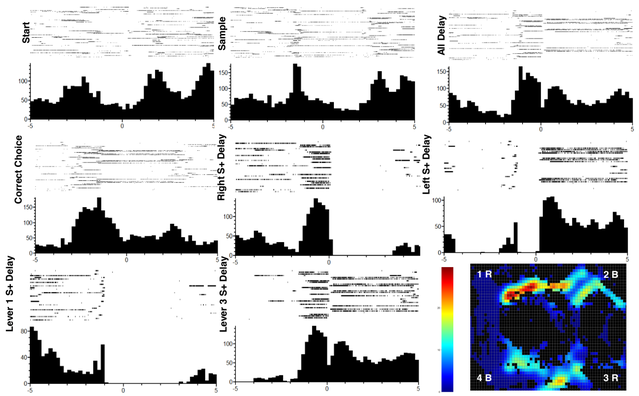
Outcome



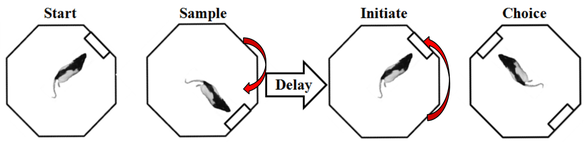
Increase in activity 1 s before lever press that drops abruptly for base levers but sustains during reinforcement

Response Properties Not Found in PFC

Split Delay



Right travel (Lev 1 to 2) after sample; Left travel (Lev 2 to 1) before choice

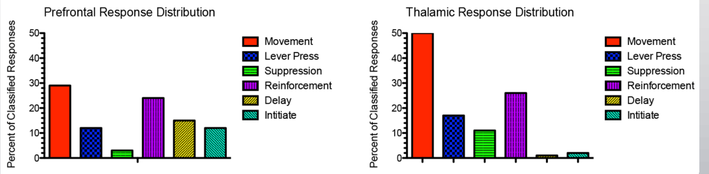


Increased activity from sample to delay or from delay to choice depending on direction of travel.

Also exists as left travel (Lev 4 to 3) after sample; Right travel (Lev 3 to 4) before choice.

CONCLUSIONS

- 1,122 cells were recorded from 5 rats, 268 of which were behaviorally correlated (24%); 173 (65%) of these correlates where fit the categories previously defined in PFC (Onos, et al., 2013).
- Distribution of response types differs between thalamic regions.
  - Medial MD – reinforcement and suppression
  - Paralaminar MD – movement
  - Intralaminar (IL) – movement, reinforcement, suppression
  - Central medial (CM) – lever press, reinforcement



- Most thalamic responses resemble medial PFC response types.
  - More movement and suppression responses.
  - Fewer delay, initiation, and lever press responses.
  - Similar proportion of reinforcement-related responses.
- Response types not found in medial PFC were identified in paralaminar and IL recordings.
- From previous research in our lab and the field, the connections between thalamic nuclei and prefrontal regions are clear. Our research shows that not only are cells in both areas carrying similar information but that thalamic nuclei are also carrying information distinct from prefrontal cortex.

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