Analysing Cognitive Systems in Parkinson Disease Patients

Sara Mousavi

CS-594
Outline

• What is Parkinson's Disease
• Investigating cognitive systems of PD patients
  • Reinforcement learning
  • Decision making
  • Working memory
Parkinson disease (PD)

- Is a long-term degenerative disorder
  - Of the central nervous system
- Less cells that release dopamine (DA)
  - Substantia nigra
- Mainly affects the motor system
PD symptoms

• Physical problems
  • Shaking, rigidity and slowness of movements
• Mental/cognitive deficits
  • Thinking and behavioral problems
Reinforcement learning

- Taking action in an environment
  - Maximizing some reward
- Used in:
  - Game theory
  - Simulation-based theory
  - Multi-agent systems
Decision making

- A cognitive process resulting in selecting an action among several alternatives
Working memory

• Temporarily holds and manages information
• Keeps the information available for processing
  • Encoding, storing, and retrieving data
Basal ganglia pathway
Neural Network Model
Dopamine in PD patients

- Dopamine
  - Excites the GO & Inhibits the NoGo pathway
- Depleted level of dopamine in PD patients
  - Influences learning from +/- outcomes
  - Effects working memory
- STN disruption
  - Impulsivity in decision making
Training in RL experiment

- 30 PD patients and 19 healthy
- Choosing one in each pair
- Feedback is provided
- Learning could be more
  From + or - outputs
Testing in RL experiment

• Novel combination of the pairs
  • Involving an A
    • AC, AD, AE, AF
  • Involving a B
    • BC, BD, BE, BF
Result of DA on RL

- On med patients
  - Learn from positive
- Off med patients
  - Learn from negative
Deep brain stimulation of STN

- A surgical procedure to treat motor symptoms
- Improving motor symptoms in PD patients
Decision making experiment
High conflict win/win

A

Win/Win Conflict
First Test Phase

B

Win/Win Conflict
Second Test Phase

<table>
<thead>
<tr>
<th>Patient Condition</th>
<th>Reaction Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seniors Off Meds</td>
<td>1600</td>
</tr>
<tr>
<td>Seniors On Meds</td>
<td>1500</td>
</tr>
<tr>
<td>Seniors Off DBS</td>
<td>1400</td>
</tr>
<tr>
<td>Seniors On DBS</td>
<td>1300</td>
</tr>
<tr>
<td>Off Meds</td>
<td>1200</td>
</tr>
<tr>
<td>Off DBS</td>
<td>1100</td>
</tr>
<tr>
<td>On Meds</td>
<td>1000</td>
</tr>
<tr>
<td>On DBS</td>
<td>900</td>
</tr>
</tbody>
</table>

* Statistically significant difference.
Working memory experiment

Maintain context information

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>A</td>
<td>Perform well on AX</td>
</tr>
<tr>
<td></td>
<td>Bad on AY</td>
</tr>
<tr>
<td>B</td>
<td>Perform well on BX</td>
</tr>
</tbody>
</table>
Working memory results

<table>
<thead>
<tr>
<th></th>
<th>On medication</th>
<th>Off medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY- performance</td>
<td>decreased</td>
<td>increased</td>
</tr>
<tr>
<td>BX- performance</td>
<td>increased</td>
<td>decreased</td>
</tr>
</tbody>
</table>

• DA medications enhance WM updating, which is indexed by relatively better BX and worse AY performance
Summary

- Dopamine improves learning from positive but worsen learning from negative cases
- DBS causes impulsivity
- Dopamine improves the working memory updating
Thank you