Visual and Proprioceptive Workspaces

Planning of motor movements involves the integration of multiple sensory inputs such as visual and proprioceptive (body posture) feedback.

- Visual and proprioceptive feedback have separable effects on neural firing (Stavisky 2018)
- Visual feedback (visual information to plan movement) and proprioceptive feedback (limb position) may be received from different possible workspaces, or physical regions in space
- How is the neural representation of movement impacted when visual and proprioceptive feedback are received from different workspaces?

Radial 8 Target Task

2 Possible Workspaces

- Performed by rhesus monkey with Utah array implanted in M1
- Task performed with visual cue and arm movement synchronized to the same (V1P1 or V2P2) or different workspaces (V1P2 or V2P1)
- Neural firing data analyzed during reach period when monkey moves arm from center to one of eight target directions

Creating a Naïve Bayes Classifier

1. Create a Naïve Bayes Classifier to decode neural firing rates under different (visual and proprioceptive) workspace conditions
2. Accuracy of decoder under different conditions indicates which type of input (visual and/or proprioceptive) is most important to decoder
3. Reveals which type of information may have a greater impact on the neural representation of movement

Separation by visual workspace does not impact accuracy

Visual Target Decoder

- Input: Neural firing rates
- Output Class: Estimated target angle from Radial 8 Target Task

<table>
<thead>
<tr>
<th>Accuracy Differentiating Targets</th>
<th>Visual Workspace 1 (N=720)</th>
<th>Visual Workspace 2 (N=728)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chance:</td>
<td>56.8%</td>
<td>55.6%</td>
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</table>

Separation by proprioceptive workspace improves accuracy

Proprioceptive Target Decoder

- Input: Neural firing rates
- Output Class: Estimated target angle from Radial 8 Target Task

<table>
<thead>
<tr>
<th>Accuracy Differentiating Targets</th>
<th>Proprioceptive Workspace 1 (N=720)</th>
<th>Proprioceptive Workspace 2 (N=728)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chance:</td>
<td>78.6%</td>
<td>77.9%</td>
</tr>
</tbody>
</table>

Visual workspace confused more than proprioceptive workspace

Workspace Decoder

- Input: Neural firing rates
- Output Class: Estimated workspaces

<table>
<thead>
<tr>
<th>Accuracy Differentiating Workspaces</th>
<th>Chance: 25%</th>
<th>Chance: 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Workspaces (n=1448)</td>
<td>47.6%</td>
<td>84.9%</td>
</tr>
<tr>
<td>Proprioceptive Workspaces (n=1448)</td>
<td>84.9%</td>
<td></td>
</tr>
<tr>
<td>Visual Workspaces (n=1448)</td>
<td>55.6%</td>
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</tbody>
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Discussion

- Proprioceptive feedback has a dominant effect on the neural representation of movements
  - Target decoder accuracy drops when proprioceptive space is assumed to be the same
  - Workspace decoder confuses visual workspaces more than proprioceptive workspaces
  - Transfer of learned motor movements to different environments may be restricted by proprioceptive workspace
  - Performance of brain-machine interfaces (BMI) which seek to reanimate limbs may be impacted by subsequent proprioceptive feedback if movement performed in different workspaces

References


Funding

- Undergraduate Program for Neural Computation