Diffusion Tensor Imaging

Image Processing & Analysis

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Objectives

• Data Processing
  – Quantitative quality control
  – Alignment of DTI to anatomical MRI for co-analysis
  – Computations of parametric DTI maps
    • Text

• Data Analysis
  – Measure DTI alterations in PD
  – Identify DTI changes over time
  – Explore novel analysis strategies
    • Tractography
    • Analysis of Networks
    • Machine Learning
## Processing Status

<table>
<thead>
<tr>
<th>Time point</th>
<th>HC</th>
<th>PD</th>
<th>SWE DD</th>
<th>Prodromal</th>
<th>Processed/Received</th>
<th>Uploaded</th>
<th>Total Excluded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>76</td>
<td>168</td>
<td>41</td>
<td>30</td>
<td>297/316</td>
<td>276</td>
<td>20</td>
</tr>
<tr>
<td>12m</td>
<td>67</td>
<td>150</td>
<td>23</td>
<td>0</td>
<td>233/240</td>
<td>222</td>
<td>12</td>
</tr>
<tr>
<td>24m</td>
<td>10</td>
<td>106</td>
<td>13</td>
<td>0</td>
<td>123/129</td>
<td>121</td>
<td>4</td>
</tr>
<tr>
<td>48m</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0/3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>153</td>
<td>427</td>
<td>77</td>
<td>30</td>
<td>653/688</td>
<td>619</td>
<td>36</td>
</tr>
</tbody>
</table>
Baseline Paper (under rev)

- "outlier issue"

- Split PD into TD & nonTD
Tractography (published)

Diffusion tensor imaging of the nigrostriatal fibers in Parkinson's disease.

Zhang Y, Wu IW, Buckley S, Coffey CS, Foster E, Mendick S, Seibyl J, Schuff N.


PMID: 25920732
Longitudinal DTI

Substantia Nigra: 3% / year higher rates of FA reduction in PD vs HC
Midbrain and Thalamus: 2% / year higher rates of FA reduction in PD vs HC
## Correlations between DTI and DAT rates

<table>
<thead>
<tr>
<th>Region of Interest</th>
<th>Hemisphere*</th>
<th>Statistic</th>
<th>UPDRS-total&lt;sup&gt;a&lt;/sup&gt;</th>
<th>UPDRS-III&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Putaminal DAT&lt;sup&gt;b&lt;/sup&gt; (min side)</th>
<th>Putaminal DAT&lt;sup&gt;b&lt;/sup&gt; (ave side)</th>
<th>MOCA total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substantia Nigra</td>
<td>Contra</td>
<td>Coefficient</td>
<td>-0.09</td>
<td>-0.09</td>
<td><strong>0.27</strong></td>
<td>0.15</td>
<td><strong>0.02</strong></td>
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<tr>
<td></td>
<td></td>
<td>p-value</td>
<td>0.4</td>
<td>0.3</td>
<td><em>0.005</em></td>
<td>0.1</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Ipsi</td>
<td>Coefficient</td>
<td>-0.03</td>
<td>-0.04</td>
<td>0.10</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
<td>0.8</td>
<td>0.7</td>
<td>0.3</td>
<td>0.8</td>
<td>0.3</td>
</tr>
<tr>
<td>MidBrain</td>
<td>Contra</td>
<td>Coefficient</td>
<td>-0.08</td>
<td>-0.08</td>
<td>0.12</td>
<td>0.10</td>
<td><strong>0.09</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
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<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Ipsi</td>
<td>Coefficient</td>
<td>-0.01</td>
<td>-0.02</td>
<td>0.07</td>
<td>0.08</td>
<td><strong>0.17</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
<td>0.9</td>
<td>0.8</td>
<td>0.5</td>
<td>0.4</td>
<td><strong>0.07</strong></td>
</tr>
<tr>
<td>Thalamus</td>
<td>Contra</td>
<td>Coefficient</td>
<td>-0.07</td>
<td>-0.07</td>
<td><strong>0.26</strong></td>
<td><strong>0.006</strong></td>
<td><strong>0.10</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
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<td>0.5</td>
<td><strong>0.006</strong></td>
<td>0.05</td>
<td><strong>0.3</strong></td>
</tr>
<tr>
<td></td>
<td>Ipsi</td>
<td>Coefficient</td>
<td>-0.04</td>
<td>-0.05</td>
<td>0.08</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* No significant differences between ipsilateral and contralateral hemisphere in association with clinical progression

<sup>a</sup> 18 missing values; <sup>b</sup> 14 missing values; <sup>c</sup> 6 missing values
Longitudinal Structural MRI using Machine Learning
Regions Of Brain Atrophy in PD vs. HC

Rates of subcortical atrophy are associated with rates of CSF a-Beta and MoCA changes.
Preliminary results of DTI in SWEDD

SWEDD has lower FA than HC

SWEDD has lower FA than PD

P_{FDR} < 0.01
Preliminary results of DTI in SWEDD

**SWEDD (n=32)**
- FA~ Part3 ($p = 0.7$)
- FA~ TD ($p = 0.02$)
- FA~ PIGD ($p = 0.8$)
- FA~ AR ($p = 0.5$)

**PD (n=151)**
- FA~ Part3 ($p = 0.002$)
- FA~ TD ($p = 0.2$)
- FA~ PIGD ($p = 0.4$)
- FA~ AR ($p = 0.008$)
Planned Analyses/Pubs

- Cross-sectional SWEDD
- Longitudinal DTI
- Machine Learning/Data-driven regional analysis
  - DTI
  - Structural MRI
- Individual prediction of PD progression from MRI
- Brain Network Analyses