Real-time spatial tracking in humans

Translating animal research methods into the study of cognitive change

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MILD COGNITIVE IMPAIRMENT

Challenging the definition

› MCI:
  - Cognitive impairment beyond expected for age
  - No functional impairment
  - No dementia

› Mild deficits in instrumental activities of daily living (IADL) are common in individuals with amnestic and non-amnestic MCI. (Teng et al., 2010, Brown et al. 2011)
  - Appointments
  - Family occasions
  - Medications
  - Finances

› MCI patients perform with comparable accuracy to healthy controls, but take significantly longer to complete IADL tasks. (Wadley et al. 2008)

› A discrepancy score between self-reported and informant reported deficits significantly predict development of AD. (Tabert et al. 2002)
Animal models and navigation tasks

› **Morris Water Maze task**
  - spatial learning and memory

› **Open Field test** (forced exploration)
  - general activity and anxiety
Aims

› Determine whether there are any detectable differences between spatial patterns of activity between healthy elderly and those with MCI

› Whether indoor spatial technologies prove to be a feasible method for detection of functional impairment with regards to cost-effectiveness and participant comfort
Navizon™ indoor triangulation system

› Provides the location of active Wi-Fi devices inside the building
› Participants wear a Wi-Fi transmitting device (wristband or compact tag)
› Hardware nodes deployed in the area triangulate the position of the device
› A cloud-based server computes the location
THE SPATIAL MAPPING PROJECT

Navizon™ indoor triangulation system dashboard

› Load the floor plan of the building onto the dashboard using Google Earth

› Manually place the nodes corresponding to the real physical location within the building

› Enter the MAC address of the device which is being tracked
THE SPATIAL MAPPING PROJECT

The participants – inclusion criteria

› Individuals aged >60 years
› Living independently
› No notable mobility or vision impairment
› Single floor house or apartment
› WiFi internet connection
› Healthy or MCI (Petersen criteria)
THE SPATIAL MAPPING PROJECT

- Participants:
  - 4 healthy controls,
  - 4 MCIs (varying subtypes)

- 56 days of tracking

- Total hours of data (at home): 996.2 hr

- Total data points included in the analysis: 963,902 (~1 mil)
Spatial maps of 24 hours of activity

<table>
<thead>
<tr>
<th>Healthy controls</th>
<th>MCI</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
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</tbody>
</table>
Preliminary results

### Total distance travelled in 24 hours (at home)

<table>
<thead>
<tr>
<th>Distance travelled (km)</th>
<th>Control</th>
<th>MCI</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (km/day)</td>
<td>1.22 (0.56)</td>
<td>1.91 (1.34)</td>
<td>0.67</td>
</tr>
</tbody>
</table>
Preliminary results

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mean (hr/day)</td>
<td>4.12 (2.62)</td>
<td>2.44 (2.04)</td>
<td>0.72</td>
</tr>
</tbody>
</table>

**Total time spent outside of the house in 24 hours**
### Preliminary results

**Average distance travelled per hour at home**

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Control</th>
<th>MCI</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean km/hr</td>
<td>0.08 (0.08)</td>
<td>0.07 (0.09)</td>
<td>0.09 (0.06)</td>
<td>-0.2</td>
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</tbody>
</table>
Preliminary results

**% of time spent in motion per day**

<table>
<thead>
<tr>
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<th>Control</th>
<th>MCI</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.89% (2.5)</td>
<td>8.09% (5.6)</td>
<td>0.51</td>
</tr>
</tbody>
</table>

**% of time spent static per day**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>93.9% (2.6)</td>
<td>91.9% (5.6)</td>
<td>0.46</td>
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</table>
Preliminary findings summary

› MCI individuals tend to be more home-bound, therefore cover more distance at home

› MCI individuals are overall more active while at home then the controls shown by the proportion of daily time spent in motion

› No difference between controls and MCIs in the average distance travelled while at home, per hour
What’s next?

› Technical
  - Spatial filter raw data to improve map fidelity
  - Validate spatial accuracy using fine-tuned localization instruments

› Analysis
  - The amount of daily time spent in each room of the house
  - Frequency of room entries and exits
  - Average speed
  - Machine learning to distinguish complex patterns

› Comparison with traditional assessments of cognition and function
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