Visual Object Recognition

Neurobiology 230 – Harvard / GSAS 78454

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Web site: http://tinyurl.com/vision-class
Dates: Mondays
Time: 4:00 – 6:00 PM
Location: Biolabs 1058
Object information can be decoded from small populations of ITC neurons in single trials

Hung et al. Science 2005
Response onset in ITC occurs before 100 ms after stimulus onset.

Neurons in ITC respond to very brief stimulus flashes.

**Table 1.** Statistics of Neurone Performance as a Function of Presentation Rate

<table>
<thead>
<tr>
<th>msec/image</th>
<th>Images/sec</th>
<th>Response onset</th>
<th>Response duration</th>
<th>Response-stimulus duration</th>
<th>Number of neurons</th>
<th>Percent neurons discriminating</th>
</tr>
</thead>
<tbody>
<tr>
<td>222</td>
<td>4.5</td>
<td>108</td>
<td>284</td>
<td>62</td>
<td>34</td>
<td>97</td>
</tr>
<tr>
<td>111</td>
<td>9</td>
<td>108</td>
<td>168</td>
<td>57</td>
<td>34</td>
<td>97</td>
</tr>
<tr>
<td>56</td>
<td>18</td>
<td>108</td>
<td>112</td>
<td>56</td>
<td>34</td>
<td>94</td>
</tr>
<tr>
<td>42</td>
<td>24</td>
<td>108</td>
<td>86</td>
<td>44</td>
<td>23</td>
<td>91</td>
</tr>
<tr>
<td>28</td>
<td>36</td>
<td>108</td>
<td>95</td>
<td>65</td>
<td>34</td>
<td>79</td>
</tr>
<tr>
<td>14</td>
<td>72</td>
<td>108</td>
<td>71</td>
<td>57</td>
<td>23</td>
<td>65</td>
</tr>
</tbody>
</table>

The images were presented as a continuous sequence, so that the number of images per second is the inverse of the duration of each image. The duration of the population response was defined as shown in Figure 4.

*Time of latency alignment and average detected discrimination onset.

*Percent neurons with significant ANOVA testing the effect of stimulus (1–8) on neuron response (p < .05).

Keysers et al. J. Cognitive Neuroscience 2001
Response latencies depend on the stimuli/questions

Sugase et al. Nature 1999
Clutter reduces the responses

Fig. 3 The neuronal firing rate of one cell when an effective stimulus was present parafoveally and an ineffective stimulus for that cell was present at the fovea. Fixation was always at the point shown by a dot in the centre of the upper right quadrant. Left, the neuron had a large firing rate when the effective stimulus was shown parafoveally. Middle, the neuron did not respond when the non-effective stimulus was present at the fovea. Right, the neuron had only a small firing rate to the parafoveal effective stimulus if a non-effective stimulus was present at the fovea. The means and standard errors of the firing rate are shown. The mean spontaneous rate of the cell was 10 spikes/s.

And yet the problem of clutter can be resolved at the population level

Left Occipito-Temporal Fusiform Gyrus [-42,-44,-24]

Agam et al. Current Biology 2010
Training can rapidly alter neuronal responses

Neuronal selectivity in ITC evolves over time

Neuronal activity in ITC can be modulated by tasks, attention and other cognitive states

Attention strongly modulates ITC responses (e.g. Desimone 1996)

ITC responses correlate with subjective perception (e.g. binocular rivalry; Sheinberg and Logothetis 1997)

ITC responses depend on the task demands (e.g. Sigala et al 2002)

The need to maintain information in memory is manifested in ITC during delayed match tasks (Chelazzi et al 1998)
Attentional modulation in ITC

Zhang et al. 2011
Neuronal responses in ITC are modulated by the task.

**Fig. 6.** Response of an individual neuron to the 2-stimulus array in the contralateral hemifield. A: responses time locked to the onset of the array. Vertical bar indicates average saccadic latency to the target. B: responses time locked to the onset of the saccade. Binwidth is 25 ms. Below the histograms in A and B are rasters from the good-target and poor-target trials. Each tick in the rasters represents an action potential from the neuron, and each row corresponds to a different trial.

**Fig. 7.** Population histograms showing the average response of 58 neurons to the 2-stimulus search array confined to the contralateral hemifield. A: responses time locked to array onset. Vertical bar indicates average latency of the saccade to the target. B: responses time locked to eye movement onset. Binwidth is 10 ms.
Neuronal responses in ITC persist during the delay period in DMTS tasks.

Selectivity and tolerance beyond ITC in humans

Microwire location:
right amygdala

Quian Quiroga et al 2005
Complex responses beyond metric properties

Microwire location: left entorhinal cortex

Kreiman et al 2000
What’s in the brain of a neuron?

• Reverse correlation
  - works well in 1D
  - typically requires linearity assumptions
  - also requires relatively large amounts of data
• Analysis of “natural stimuli” (e.g. movie clips) followed by quantitative models
• “Feature reduction”
  - typically requires subjective decisions
  - local minima
• Approaches based on computational models (more about this on class 6)
• Parametrized shape space(s)
Genetic algorithm to search for visual features

- Superior temporal sulcus

- Initial generation (random)

- Partial examples across 4 generations

- Top 10 stimuli (out of 500)

Genetic algorithm to search for visual features

Yamane et al Nature Neuroscience 2008

Supplementary Figure 2 | Successive stimulus generations for Fig. 1 neuron, Run 1. Average response to each stimulus is indicated by background color.

Supplementary Figure 3 | Successive stimulus generations for Fig. 1 neuron, Run 2. Average response to each stimulus is indicated by background color.
Further reading

**Original articles cited in class (see lecture notes for complete list)**