Eye Movements and High Level Saliency Effects in Natural Scenes

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How fast is the underlying processing?

Many studies using go/nogo tasks

- Minimal processing time is remarkably stable
- Differential ERP activity at 150 ms
- Is this the time taken for the feedforward sweep?

Recent work with a choice saccade task

- Behavioural responses much faster
- Large variations depending on the type of stimulus
- Difficult to control using task dependent modulation

Interpretation

- A form of hardwired saliency effect?
Rapid Animal Categorisation Tasks

Manual Go/Nogo

Mean RT ~ 400 ms

Reaction Time (ms)

Correct

Errors

20 ms

800-1600 ms
Rapid Animal Categorisation Tasks

Saccadic choice with 20 ms Flash

Mean RT = 228 ms
(Kirchner & Thorpe, VR, 2006)

Mean RT ~ 400 ms

Correct

Errors

Mean RT = 228 ms
(Kirchner & Thorpe, VR, 2006)

Saccadic choice with 20 ms Flash

800-1600 ms

200 ms

20 ms

Reaction Time (ms)
Rapid Animal Categorisation Tasks

Saccadic Choice Presentation 400 ms

Mean RT = 228 ms
(Kirchner & Thorpe, VR, 2006)

Mean RT = 180 ms

Mean RT ~ 400 ms

Reaction Time (ms)

Correct

Errors

Reaction Time (ms)

Mean RT = 228 ms
(Kirchner & Thorpe, VR, 2006)
Ultra Rapid Scene Processing

The Saccadic Choice task with long presentations produces remarkably short reaction times.

Question
What would happen with simpler visual stimuli?
What about Simple Stimuli?

<table>
<thead>
<tr>
<th>Colour</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Easy</strong></td>
<td><strong>Hard</strong></td>
</tr>
<tr>
<td>177 ms</td>
<td>199 ms</td>
</tr>
<tr>
<td>94.2%</td>
<td>64.9%</td>
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</table>

<table>
<thead>
<tr>
<th>Shape</th>
<th>Motion Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fairly Easy</strong></td>
<td><strong>Hard</strong></td>
</tr>
<tr>
<td>187 ms</td>
<td>214 ms</td>
</tr>
<tr>
<td>75.9%</td>
<td>68.9%</td>
</tr>
</tbody>
</table>
A Paradox

The speed and ease of the saccadic choice task does not fit with simplistic hierarchical explanations.

Question

What other stimuli are good for performing the task?
Ultra-Rapid Detection of Human Faces

- 800-1600 ms
- 200 ms
- 400 ms
Results for 8 subjects

Accuracy = 89.3%
Mean RT = 140.7 ms

Minimum RT Around 100 ms
Fast trials for one subject

- All trials with RTs of \( \leq 122 \) ms
- Correct on 22/24 (91.6%)
Comparison with Simple Saccade

Mean RT = 134.8 ms
Mean RT = 140.7 ms

10 ms!
What Pathways are Involved?

Ventral Stream

A Short Cut?

Subcortical Route?

Go Right

Go Left

40-70 ms
50-60 ms
70-90 ms
60-80 ms
50-70 ms
25-60 ms

40-60 ms
45-65 ms
40-60 ms

Hannula, Simons & Cohen (2005)
Difference with Manual Tasks

Can the task be reversed?

Yes – in the case of Manual Go/Nogo tasks

What about the saccadic choice task?
Transport versus Human

Accuracy = 89.3%
Mean RT = 140.7 ms

Accuracy = 69.0%
Mean RT = 169 ms
Why are faces so easy?

A Cortical Region Consisting Entirely of Face-Selective Cells

Doris Y. Tsao,1,2,*† Winnich A. Freimund,1,2† Roger B. H. Tootell,3,4,5 Margaret S. Livingstone6

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Differences in Onset Latency of Macaque Inferotemporal Neural Responses to Primate and Non-Primate Faces

Roozbeh Kiani,1 Hossein Esteky,1,2 and Keiji Tanaka3
A Hypothesis

Fast and accurate performance on the saccade task requires neuronal mechanisms that respond earlier and more on one side of the brain than the other.

This would not occur when two equivalent stimuli are paired:
- Vertical vs oblique
- Upwards vs Downwards motion

There may be a "built-in" prioritizing of particular types of stimuli such as faces.

This may not be controllable by top-down biasing.
A multi-level Saliency Map?

Could LIP be a convergence area for saliency signals from all levels of the visual system?
Conclusions

Fast saccade responses
• From as little as 100 ms after stimulus onset
• Only for certain types of key stimuli
• Very hard for "simple" stimuli
• Difficult to control

OK for eye movements, but not for "real" decisions

Could this reflect the existence of high-level saliency effects?

These fast saccades could provide a direct window on populations of selective neurons in higher order visual areas
Thanks!

Holle Kirchner

Sébastien Crouzet