Visual perception across the lifespan

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The million £ question in visual neuroscience

What brain computations mediate human behaviour in complex environments?
Life-long Development
Ageing: behavioural changes

Hedden & Gabrieli, 2004
From MRI to fMRI

MRI: brain anatomy

fMRI: brain function
Three scenarios:

1. Similar activation patterns for young and old individuals but greater activation for young individuals.

2. Similar activation patterns for young and old individuals but greater activation for old individuals.

3. Different patterns of activation with new alternate areas recruited in old individuals to compensate for cell changes.

D'Esposito, 1999
Questions and Aims

What are the brain mechanisms that mediate decisions in complex environments across the lifespan?

We aim to identify biomarkers of cognitive ageing by combining: behavioural measurements with structural and functional imaging and advanced mathematical modelling.
How does the brain solve the puzzle of coherent visual perception?
What is the developmental timecourse of coherent visual perception?

Kovacs et al., 1999
Glass patterns

Signal 100%

Radial

Concentric

Signal 50%

Signal 0%

Smith et al., 2002
Development of coherent visual perception: functions that mature later decline faster

Young adults (19-35)

Older adults (65-86)
Development of coherent visual perception: functions that mature later decline faster

75% Threshold performance

Visual Acuity (Snellen)

Diopters

Concentric
Radial
Linear

Young group  Middle age group  Older adult group

Visual Acuity (Snellen)

1 (20/20)  0.7 (20/30)  0.2 (20/100)
Brain Imaging at 3T
Functional Localisation of visual areas in young adults

- Grill-Spector et al., 1998
- Kanwisher et al., 1996
- Kourtzi & Kanwisher, 2000
- Malach et al., 1995
Functional Localisation of visual areas in older adults

![Localisation of visual areas in left and right hemispheres]

- Intact Images
- Scrambled Images

- Grill-Spector et al., 1998
- Kanwisher et al., 1996
- Kourtzi & Kanwisher, 2000
- Malach et al., 1995
Design

Fix      Concentric       Radial           Linear            Random
+  

3 Tesla Phillips Achieva
TR 2000 ms
2.5 x 2.5 x 3 mm Voxels

Observer’s Task

Target detection

Young adults: hyperbolic pattern
Older adults: denser pattern
Mapping areas involved in the analysis of global patterns

Young adult group

Concentric  Radial  Linear  Random

p (RFX) <0.05
Mapping areas involved in the analysis of global patterns
Older adult group

Concentric  Radial  Linear  Random

p (RFX) < 0.05  t (11) 2.2
fMRI selectivity for global forms

75% Threshold performance

Concentric
Radial
Linear

Young group  Middle age group  Older adult group
Studying neural selectivity with fMRI

Multivariate

Condition A

Condition B

Accuracy map

Response to condition B

Response to condition A

Cox & Savoy 2003
Haynes & Rees, 2005
Kamitani & Tong, 2005
fMRI selectivity for global forms
Young adult group

Concentric vs. Radial vs. Linear

Classification Accuracy 0.43 0.52
fMRI selectivity for global forms
Older adult group

Concentric vs. Radial vs. Linear

Left Hemisphere
Right Hemisphere

Classification Accuracy 0.38
0.43
Summary

- Perceptual integration of global forms and decisions in cluttered scenes are mediated by perceptual processes that mature late and decline faster.

- fMRI shows decreased involvement of temporal areas but additional recruitment of early visual areas potentially modulated by fronto-parietal networks in older adults.
Future questions

• How do behavioural and functional changes in ageing relate to changes in the morphology and connectivity of brain structures?

• What is the neural dynamics of perceptual integration and decisions and how do they change with age?

• Does learning shape the brain functions and cognitive abilities that mediate decisions across the lifespan?
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