Facing (some) facts:
Psychological and neural mechanisms of face processing

Marlene Behrmann
Department of Psychology
Carnegie Mellon University

Complex visual scene

Division of labour in cortical visual system

Anatomical segregation of streams

Ungerleider, Mishkin et al., 1982
<table>
<thead>
<tr>
<th>‘What’, ‘where’ and their coordination</th>
<th>Converging methodologies</th>
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<tbody>
<tr>
<td>• Operation of the ‘what’ system</td>
<td>• Neuropsychological studies</td>
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<tr>
<td>• Operation of the ‘where’ system</td>
<td>– brain damage on visual processing</td>
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<td>• The interface of ‘what’ and ‘where’</td>
<td>• Reaction time studies in normal subjects</td>
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<td></td>
<td>– test behavioral hypotheses</td>
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<td>• Computational/quantitative models</td>
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<td>– mechanistic account of computation</td>
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<td>• Neuroimaging (fMRI)</td>
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<td>– brain-behavior functional and structural relations</td>
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<td>• Single unit recording in behaving monkeys</td>
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<td>– ascertain neural substrate</td>
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<td>• Magnetoencephalography (MEG)</td>
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<td>– temporal dynamics of neural subsystem</td>
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<th>‘What’, ‘where’ and their coordination</th>
<th>Mechanisms for object recognition</th>
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<tr>
<td>• Operation of the ‘what’ system</td>
<td>Domain-specific regions</td>
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<td>• Operation of the ‘where’ system</td>
<td>– Fusiform Face Area (FFA)</td>
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<td>• The interface of ‘what’ and ‘where’</td>
<td>– Occipital Face Area (OFA)</td>
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<td>– Extrastriate Body Area (EBA)</td>
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<td>– Fusiform Body Area (FBA)</td>
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<td></td>
<td>– Parahippocampal Place Area (PPA)</td>
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<td>– Visual Word Form Area (VWFA)</td>
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</table>
Faces are ‘special’

- Dedicated mechanisms
  - Psychological
  - Neural

What is special about face processing?

- May be the most developed visual perceptual skill
- Have same local elements
- Convey a large amount of critical information: age, gender, identity, emotion, eye gaze, intention...
- Useful model to study the ventral visual system at its peak.

Faces not objects: Orientation effect
upright > inverted

Whole and configuration:
Faces > other objects
Specific N170 waveform for faces not objects

(Carmel, Bentin et al. 2002)

Single neuron recording studies in monkeys: Baylis et al.

(Claude, 1996; McCarthy et al., 1997; Epstein and Kanwisher, 1998; Kanwisher et al., 1997; Aguirre et al., 1998; Ishai et al., 1999; Halgren et al., 1999)

Segregated representation: face and building images

Fusiform Face area

Ventral view

(Tsao et al., 2003, 2006)

Face-selective activation in monkeys

Anterior

Posterior

Faces > Other objects

(Tsao et al., 2003, 2006)
Face versus non-face: human with lesions

- Prosopagnosia -
  -
  -
  - rely on other cues for recognition

Acquired prosopagnosia (AP)
Right inferotemporal - fusiform damage

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Face recognition

AP: average 17%

(Behrmann, Avidan et al., JOCN, 2005)
Congenital prosopagnosia (CP)

- Normal neurological status and intelligence
- Right handed
- Full field, normal low-level vision
  *(color, motion, orientation)*
- Identify by nonface cues
- These studies: n=7-9 (heterogeneity?)

Anecdotes

- I suffer from an embarrassing, curiously humbling neurological condition called prosopagnosia, which, translated, means I have a problem in face recognition. I used to think that it was due to some mental laziness, and I desperately tried to memorize the faces of people I met. Quite by chance, when talking to a friend, I found out that he suffered from the same problem. I could not believe it. Then I discovered that my own sister, Judy, knew similar embarrassment. Perhaps, others did also. I wrote to the well-known neurologist Dr. Oliver Sacks. Had he ever heard of such an unusual condition? Not only had he heard from it—he suffered from it himself. And his situation was far more extreme than mine. (Jane Goodall)
Familial component

- Autosomal dominant mode of inheritance
- 2% of population

Kennehnacht et al. (2007)
Schmidl et al. (2007)

Autism

<table>
<thead>
<tr>
<th>Autism type</th>
<th>Education level</th>
<th>VIQ</th>
<th>PIQ</th>
<th>FSIQ</th>
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</thead>
<tbody>
<tr>
<td>AP (n=3)</td>
<td>12</td>
<td>86</td>
<td>75</td>
<td>82</td>
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<tr>
<td>CP (n=8)</td>
<td>15</td>
<td>85</td>
<td>77</td>
<td>76</td>
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<tr>
<td>Autism (n=14)</td>
<td>15</td>
<td>86</td>
<td>78</td>
<td>83</td>
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<td>1</td>
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14 individuals (12 male); IQ 108; full fields, normal low-level vision

Face recognition

AP (n=3): average 17%
CP (n=8): average 38%
Autism (n=14): very few

(Behrmann, Avidan et al., JOCN, 2005; Behrmann et al., Neuropsychologia, 2006)

Face discrimination

<table>
<thead>
<tr>
<th>Condition</th>
<th>Controls</th>
<th>AP</th>
<th>CP</th>
<th>Autism</th>
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<tr>
<td>RT (msec)</td>
<td>1200</td>
<td>1200</td>
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Different Gender
Different Individual
A. Psychological investigations

1. Neuropsychological data
   - Impaired at face processing (AP, CP, autism)
   - Impaired at non-face processing too?

2. Why faces disproportionately impaired?

B. Neural investigations

1. Role of fusiform face area

2. Distributed interactivity with other regions
Faces are ‘special’?

A. Psychological investigations
   1. Neuropsychological data
      • Impaired at face processing (AP, CP, autism)
      • Impaired at non-face processing too
   2. Why faces disproportionately impaired

B. Neural investigations
   1. Role of fusiform face area
   2. Distributed interactivity with other regions

Perceptually homogenous exemplars

- Local components insufficient
- Ability to extract configural information
  - Holistic
  - Second order statistics
  - Interrelations between features/parts

Impairment in configural processing?

a. Spatial frequency stimuli

b. Gabor stimuli for contour detection (from Kovács et al.)
Deriving configural relations: 
global from local elements

- hierarchical letters of two types:
  - consistent: global and local have
    same identity
  - inconsistent: global and local have
    different identities

- two tasks
  - identify letters at (I) global or at (II) local level
  - use two keys on button box to respond

Normal subjects show global advantage

Accuracy: 96.3%

Local advantage and local-global interference

Local bias correlates significantly with face processing difficulties $r = .61, p<.03$
Faces are ‘special’?

A. Psychological investigations
1. Neuropsychological data
   • Impaired at face processing (AP, CP, autism)
   • Impaired at non-face processing too
2. Why faces disproportionately impaired
   • Failure to derive configural relations necessary to support more fine-grained processing

B. Neural investigations
1. Role of the fusiform face
2. Distributed interactivity with other regions

FFA as specialized module

• Origin of FFA?
  – Innate?

• Necessary?
  – Yes, because damage impairs recognition

• Sufficient?
FFA as specialized module

- Origin of FFA
  - Experience- and/or maturation dependent?

- Necessary?
  - Yes, because damage impairs recognition

- Sufficient?
Acquired prosopagnosia (AP)
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Autism

Functional MRI: CP

- Prediction: reduced/no activation in FFA

Congenital Prosopagnosia:
Normal category selectivity
Activation maps: individuals

Abnormal behavior in scanner

N-back
Press button for consecutive repeats

Normal magnitude and site of activation

Not just statistically weak
Faces are ‘special’?

A. Psychological investigations
   1. Neuropsychological data
      - Impaired at face processing (AP, CP, autism)
      - Impaired at non-face processing too
   2. Why faces disproportionately impaired
      - Failure to derive configural relations

B. Neural investigations
   1. Role of the fusiform gyrus
      - FFA not sufficient for normal face processing
   2. Distributed interactivity with other regions

FFA as specialized module

- Origin of FFA
  - Experience- and/or maturation dependent?

- Necessary?
  - Yes, because damage impairs recognition

- Sufficient?
  - Activation insufficient to support normal face processing