Autism and the Social Brain
A Visual Tour

Charles Cartwright, M.D.
Director
YAI Autism Center
“Social cognition refers to the fundamental abilities to perceive, categorize, remember, analyze, reason with, and behave toward other conspecifics”

Pelphrey and Carter, 2008
INSIDE THE WORLD OF AUTISM

More than one million Americans may have it, and the number of new cases is exploding. What scientists have discovered. What families should know.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Structure</th>
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<tbody>
<tr>
<td>AMY</td>
<td>Amygdala</td>
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<tr>
<td>EBA</td>
<td>Extrastriate body area</td>
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<tr>
<td>STS</td>
<td>Superior temporal sulcus</td>
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<tr>
<td>TPJ</td>
<td>Temporal parietal junction</td>
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<tr>
<td>FFG</td>
<td>Fusiform gyrus</td>
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<tr>
<td>OFC</td>
<td>Orbital frontal gyrus</td>
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<tr>
<td>mPFC</td>
<td>Medial prefrontal cortex</td>
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<tr>
<td>IFG</td>
<td>Inferior frontal gyrus</td>
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</tbody>
</table>

Pelphrey and Carter 2008
Building Upon Structures and Function

Pelphrey and Carter 2008
Neuroimaging technologies

• Explosion of neuroimaging technology
  – Faster, more powerful magnets
  – Better resolution images showing thinner slices of brain
• Visualize the brain in action
• Explore relationship between brain structure, function, and human behavior.
• Help identify what changes unfold in brain disorders like autism
Neuroimaging in ASDs

• No reliable neuroimaging marker
• Imaging not recommended as part of routine work-up
• Neuroimaging research can provide clues to brain structure and function and to neurodevelopmental origins
Structural Brain Imaging

• MRI and CT
• Allows for examination of structure of the brain
• Identifies abnormalities in different areas of brain
• Helps understand patterns of brain development over time
MRI

• Magnetic Resonance Imaging
• Uses magnetic fields and radio waves to produce high-quality two- or three dimensional images of brain structures
• Large cylindrical magnet creates magnetic field around head; radio waves are sent through the magnetic field; sensors read the signals; computer constructs an image
Axial brain image
Sagittal brain image
Coronal brain image
Functional Brain Imaging

• fMRI and PET
• fMRI adapts MRI to measure functional changes in brain activity
• Amount of oxygen found in blood affects its magnetic properties
• fMRI detects regions with changes in levels of blood oxygenation due to activity-related changes in blood flow
Touch MRI
Magnetic Resonance Signals to Location of Function

Left Hand - Touch

Left hand touch
Understanding Autism

Why More Kids & Families Are Facing the Challenge of ‘Mindblindness’

By Geoffrey Cowley

Russell Rollins, 9
Face processing in autism

• Recognition of faces and interpretation of facial expressions are integral part of interpersonal interactions

• Typically developing children discriminate between familiar and unfamiliar faces by a very early age

• Failure to look at faces is one of earliest symptoms of autism; may be present within first year
The Fusiform Gyrus
What is the Fusiform Gyrus?

- Area of the temporal lobe
- Present in both right and left hemispheres
- Certain areas activated in:
  - Facial recognition
  - Color recognition
- Communicates with amygdala
- Specialized area for viewing faces- fusiform face area
- Intraoperative electrical stimulation disrupted facial recognition (Fried et al 1982)
fMRI experiment: face, object, pattern stimuli

Schultz et al, 2000
Patterns of brain activation

Face

Object

Typical Control Group

ASDs Group
What happened in your fusiform face area?

- If you saw the faces the FFA responded much more strongly

- If you saw the vase the FFA was not as highly activated
Fusiform Gyrus in Autism

• Abnormalities in the structure of the FG
• Hypoactivation of fusiform face area
• Indicates disruption of connectivity
  – Inability to generate higher level facial perception processes
Why 4 of 5 Autistic Children Are Male

Boys, Girls and Autism

What New Science Tells Us About How Our Brains Work

By Geoffrey Cowley
Amygdala
What is the amygdala?

• Located within medial temporal lobe
• Sends information to and receives information from multiple neurological structures
• Involved in the fear response
• Analyzes facial expressions to determine emotional states
Amygdala

- Emotion, arousal
- Critical structure for social-emotional functioning
- Works in concert with frontal lobes, cingulate gyrus, temporal cortex to add emotional tone
Fusiform Gyrus-Amygdala Connections

- The viewing of emotional faces increases interaction between the two

- Amygdala acts to increase neural activity of FG to increase awareness of emotional states
Superior Temporal Sulcus
What is the Superior Temporal Sulcus?

- Fold located in the temporal lobe
- Visually analyzes biological motion to interpret and predict the intentions of others
- Vital for ‘detection of life’
- Essential for understanding of eye-gaze
- Responds strongly to eye and mouth movements
Eye Gaze Research

Which part of the face is the person looking at?
Visual Fixation Patterns

Viewer with autism – green
Typical viewer – yellow

Klin et al, 2002
Table 2. Percentage of Viewing Time Spent Focused on Mouth, Eyes, Body, and Object Regions*

<table>
<thead>
<tr>
<th>Region</th>
<th>Autism Group (n = 15)</th>
<th>Control Group (n = 15)</th>
<th>t Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>41.2 (15.0)</td>
<td>21.2 (12.1)</td>
<td>4.026</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Eyes</td>
<td>24.6 (8.1)</td>
<td>65.4 (12.8)</td>
<td>-10.455</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Body</td>
<td>24.6 (12.4)</td>
<td>9.7 (5.7)</td>
<td>4.226</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Object</td>
<td>9.6 (6.5)</td>
<td>3.7 (2.4)</td>
<td>3.286</td>
<td>&lt;.003</td>
</tr>
</tbody>
</table>

*Data are given as mean (SD).
Eye-Gaze Processing in Autism

- Individuals with ASD can detect gaze direction.
- However, difficulty in inferring mental states from gaze analysis.
Superior Temporal Sulcus in Autism

- Lack of engagement and activation with mPFC
- Does not differentiate between biological and non-biological motion
Pelphrey et al. 2003
Processing of Emotional Expressions in Autism

• Abnormal modulation of activation from static vs. dynamic emotion in:
  – Amygdala
  – FFG
  – STS

• Amygdala reduced capacity to process visual information and create a sense of emotional meaning
Pelphrey et al. 2007

Amygdala

Fusiform Gyrus

Superior Temporal Sulcus

% Signal Change

Dynamic Emotion

Static Emotion

Autism

Neurotypical

% Signal Change

Autism

Neurotypical

% Signal Change

Autism

Neurotypical

% Signal Change

Autism

Neurotypical

Pelphrey et al. 2007
INSIDE THE WORLD OF AUTISM

More than one million Americans may have it, and the number of new cases is exploding. What scientists have discovered. What families should know.

Tommy Barrett, 11, of San Jose, California, has Asperger syndrome.
Mirror Neuron Systems and the Superior Temporal Sulcus

Iacobono and Dapretto 2006
Mirror Neurons

- Located in the frontoparietal area
- Active when:
  - Performing goal directed actions
  - Observing goal directed actions
- Regions containing MNS connected to STS
- Involved in the development of the ability to imitate
- Critically important structure in enabling individuals to experience and express empathy
Importance of Imitation

• Learning

• Social interaction

• Understanding other’s actions and the feelings that go along with the actions

• Empathy
Medial Prefrontal Cortex
Medial Prefrontal Cortex

- Frontal lobe
- Information from multiple subcortical and cortical structures
- Responsible for reasoning, reflection, and emotional inferences
- STS and mPFC connection
Theory of Mind

• Ability to explain and predict behavior of others by recognizing their:
  – Thoughts
  – Feelings
  – Goals

• Different levels of ToM
  – Inferring personal mental state
  – Inferring other’s mental state
  – Analyzing socially relevant cues

• Information integrated from visual senses regarding:
  – Eye-gaze
  – Facial recognition
  – Emotional status of face
Oxytocin and Autism

• Social peptide
• Better known as Pitocin
• The trust hormone
• New role in the treatment of ASDs
• Access to the CNS
  – Nasal spray
fMRI study of Oxytocin’s Effect on Amygdala Response to Fear

Kirsch et al
2005
‘Face’ training

• Use of computer games
• Pre- and post-training fMRI
• Assess whether patterns of FG activation can be modified by training and whether changes are associated with improvements in social skills
artist with autism, age 14
Building Upon Structures and Function

Pelphrey and Carter 2008
Conclusions

- Social brain is the interaction and connection of multiple neurological structures integrating information to enable social and emotional functioning
- Structures have many connections to and from other structures
- Significant differences shown in individuals with autism
- Further research will further increase understanding of the social brain
Thank you