Normative Changes in Frontoamygdala Circuitry Supporting Emotion Regulation

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No disclosures to report
Emergence and Peak in Mental Disorders

- ADHD, Conduct disorder
- Anxiety disorders
- Mood disorders
- Schizophrenia
- Substance Abuse
- Any Mental Illness

Newman et al., 1996
Kessler et al., 2005
O’Connell et al., 2009
Lee et al., 2014
Brain Development:
major changes in limbic areas relative to prefrontal areas

QuickTime™ and a Sorenson Video 3 decompressor are needed to see this picture.

PBS graphic based on Galvan et al., 2006, Hare et al., 2008
Emotion Regulation in Healthy Adults

Amaral et al., 1992
Banks et al., 2007
Ghashghaei et al., 2007
Kim & Whalen, 2009
Normative Amygdala Functional Development

- When and how do the amygdala and PFC connect?
- How relate to normative separation anxiety?

- 45 healthy participants (4-22 years old)

Gee et al., 2013, J Neuroscience
Amygdala Reactivity to Fear Faces Declines with Age

p = 0.002, corrected

Negative correlation with age

Gee et al., 2013, J Neuroscience
Developmental Valence Switch in Frontoamygdala Connectivity

Gee et al., 2013, J Neuroscience

Age group (years)

Frontoamygdala Functional Connectivity

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-9 yrs</td>
<td>12</td>
</tr>
<tr>
<td>10-13 yrs</td>
<td>12</td>
</tr>
<tr>
<td>14-17 yrs</td>
<td>12</td>
</tr>
<tr>
<td>18-22 yrs</td>
<td>9</td>
</tr>
</tbody>
</table>

Gee et al., 2013, J Neuroscience
Rodents: Amygdala-originating inputs to the mPFC earlier than mPFC-originating inputs to the amygdala

(Cressman et al., 2010; Bouwmeester, Wolterink, Van Ree, 2002; Bouwmeester, Smits, Van Ree, 2002)

Hypothesis in humans:
Valence Switch and Separation Anxiety

**p<.001
*p<.05

Gee et al., 2013, J Neuroscience
Typical Development: Conclusions

- Developmental valence switch mediates change in anxiety
- Qualitative frontoamygdala differences in childhood
Social Regulation in Childhood

• Parent has widespread regulatory influences
  – Physiological, thermal, nutritional

• Parental buffering against stress reactivity
  – Non-human animals: alters glucocorticoid receptor gene expression, reduced amygdala reactivity
  – Humans: reduced cortisol levels

McCoy & Masters, 1985
Hofer, 1994
Gunnar & Donzella, 2002
Weaver et al., 2004
Morieceau & Sullivan, 2006
Parental Role in Emotion Regulation

- 53 healthy participants (4-17 years old)
- Behavioral: emotional go/no-go task
  - In physical presence of mother or stranger
- fMRI: viewed faces - mother, stranger
  - Press to happy faces (not neutral), regardless of identity

Gee et al., 2014, Psych Science
Improved Regulatory Behavior in Parent’s Presence

Gee et al., 2014, Psych Science
Reduced Amygdala Reactivity in Parent’s Presence

Gee et al., 2014, Psych Science
Mature Frontoamygdala Connectivity in Parent’s Presence

Parental Modulation

Amygdala-mPFC Functional Connectivity

X = -4

Children

Adolescents

Stranger Stimulus
Mother Stimulus

Gee et al., 2014, Psych Science
Individual Differences in Frontoamygdala Modulation and Behavior

Gee et al., 2014, Psych Science

![Bar chart showing false alarm rate with and without parental modulation.](image)
Controlling for age

Individual Differences in Frontoamygdala Modulation and Behavior

*Controlling for age

Gee et al., 2014, Psych Science
Parental Modulation: Conclusions

• Caregiver as regulatory mechanism
• Childhood as potential sensitive period
Conclusions

• Normative developmental changes
  – Amygdala functionally reactive by early childhood
  – Frontoamygdala connectivity immature in childhood, switch to negative connectivity around transition to adolescence
  – Mediates age-related changes in separation anxiety

• Role of caregiver
  – Parent buffers via reduced amygdala reactivity and mature pattern of frontoamygdala connectivity
  – Parental modulation of circuitry associated with individual differences in separation anxiety, attachment
  – Childhood as potential sensitive period for environmental shaping
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