Harsh parenting relates to increased error-related brain activity in children

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Psychophysiology
Cognitive, Affective, & Behavioral Neuroscience
Anxiety disorders

- Among children and adolescents, anxiety disorders are the most frequently diagnosed form of psychopathology (Beesdo, Knappe, & Pine, 2009)

- Anxiety disorders often continue into adulthood and result in chronic impairment (Kessler et al., 2005; Pine, 2007)

- Identifying early neural markers of pathological trajectories may aid prevention and intervention efforts

- It may be possible to identify modifiable environmental factors that modulate these neural markers of risk
ERN.mov

Response

Averaging

Correct Response

Erroneous Response
Error-Related Negativity (ERN)

From Hajcak (2012). *Current Directions in Psychological Science.*
Error-Related Negativity (ERN)

- Is evident across a variety of stimulus and response modalities (Gehring, 1993)

- Generated in the anterior cingulate cortex (vanVeen & Carter, 2002)

- ERN amplitude 40 – 60% heritable (Anokhin et al., 2008)

- Trait-like (i.e., high test-retest)
  - 2 week ($r \sim .70$)
    - Olvet & Hajcak, 2009
  - 2 year ($r \sim .65$)
    - Weinberg & Hajcak, 2011
  - 2 year in kids (8-13; $r \sim .60$)
    - Meyer, Bress, & Hajcak (in press)

ERN and Individual differences

• Increased ERN amplitude has been consistently related to trait anxiety in adults:
  • Generalized Anxiety Disorder (Weinberg, Olvet, & Hajcak, 2010; Weinberg, Klein, & Hajcak, 2012; Xiao et al., 2011)
  • Obsessive-Compulsive Disorder (Gehring et al., 2000; Endrass et al., 2008, Hajcak et al., 2008; Stern et al, 2010; Xiao et al., 2011)
  • extreme worry (Hajcak, McDonald, & Simons, 2003)
  • behavioral inhibition (Amodio, Master, Yee, & Taylor, 2008)
  • high negative affect (Hajcak, McDonald, & Simons, 2004)
  • punishment sensitivity (Boksem, Tops, Wester, Meijman, & Lorist, 2006)
    • For meta-analysis, see: (Moser, Moran, Schroder, Donnellan, & Yeung, 2013)

• ERN has been suggested as a neural biomarker of anxiety (Weinberg, Riesel, & Hajcak, 2012)
The ERN and anxiety in children and adolescents

- An increased ERN has also been observed in:
  - A heterogeneous group of clinically anxious children (Ladouceur, Dahl, Birmaher, Axleson, & Ryan, 2006)
  - Children with obsessive-compulsive disorder (Carrasco et al., 2013; Hajcak, Franklin, Foa, & Simons, 2008; Hanna et al., 2012)
  - Six year old children with clinical anxiety (Meyer et al., 2013)
  - Adolescents with non-clinical anxiety (Meyer, Weinberg, Klein, & Hajcak, 2012)
How do individual differences in ERN come to be?

Anokhin, Golosheykin, & Heath (2008)
ERN and punishment

Operant conditioning paradigm: punishment schedule switches from continuous (first five errors) to intermittent (50% of errors)

Acquisition (8 blocks, 4 each condition)

punishment

control

Extinction (8 blocks, 4 each condition)

punishment

control

ERN and punishment

- ERN was increased when errors were punished, and this effect persisted into extinction period.

- Punishment-related modulation of the ERN was larger among more anxious individuals.

- Learning-related experiences may impact the ERN and the relationship between ERN and anxiety.

- Children’s exposure to critical or punitive parenting may impact the magnitude of their ERN.

Parenting and anxiety

- Parenting characterized by high control, low support, hostility, rejection, and authoritarianism have been associated with anxiety in offspring (Bogels & Brechman-Toussant, 2006; Brown & Whiteside, 2008; Erozkan, 2012; McLeod, Wood, & Weisz, 2007).

- Punitive parenting styles may similarly sensitize children to error commission, and thereby increase their ERN.

- The relationship between parenting and anxiety may be mediated by increases in ERN magnitude.
ERN and harsh parenting

- We examined the relationship between parenting styles and children’s ERN in a longitudinal study.

- **The first assessment:**
  - Parents and children (approximately 3 years old) completed behavioral tasks that were coded by trained observers to assess hostile and supportive parenting style.
  - Parents also completed the Parenting Styles and Dimensions Questionnaire (PDSQ)

- **The second assessment (3 years later):**
  - Children were approximately 6 years old
  - ERPs were recorded while children performed a Go/No-Go task
Participants

- 326 children with adequate EEG data
  Of these:
  - 295 had completed the teaching task battery at age 3
  - 280 had self-report data regarding parenting style from age 3

- Of these 280 children (144 female)
  - Age at first assessment: M = 3.52, SD = .27
  - Age at second assessment: M = 6.11, SD = .42

- 95% Caucasian, 1.7% Asian, 8.5% Hispanic, 1.7% African American, 5.4% other
Observed parental hostility and support

- 93% were mothers
- Modified version of the Teaching Task battery (Egeland et al., 1995)
- 6 standardized tasks (e.g. block-building, book-reading) designed to elicit behaviors from parents and children
- Coders rated on a 5-point scale
- **Hostility** = parent’s expression of anger, frustration, and/or criticism towards her child, $M = 1.19$, $SD = .33$, Range: $1.0 - 3.67$
- **Support** = parent’s provision of emotional support and expression of positive regard, $M = 4.48$, $SD = .56$, Range: $2.17 - 5.00$
Self-reported parenting style

- At the first assessment, the primary parent completed the PSDQ (Robinson, Mandleco, Olsen, & Hart, 2001)
  - 37 items
  - Scale from 1 (never) to 5 (always)

- Measures three parenting styles:
  - Authoritative (high control, high warmth)
  - Authoritarian (high control, low warmth)
  - Permissive (low control, high warmth)
Diagnostic interviewing

• Time 2 (Age 6)
• Preschool Age Psychiatric Assessment (PAPA; Egger, Ascher, & Angold, 1999)

• Anxiety disorders included: specific phobia, separation anxiety disorder, social phobia, generalized anxiety disorder, obsessive-compulsive disorder, and agoraphobia.
Go/No-Go task & ERN

• Time 2 (Age 6)
  • Children respond to upward-pointing triangles
  • Children withheld responses to tilted triangles

• ERN: average activity 0-100 ms at Fz on error trials
• CRN: average activity 0-100 ms at Fz on correct trials
• ΔERN: ERN minus CRN
Statistical analyses

• Pearson correlations ($r$) to examine associations between parenting and ERN

• A simultaneous regression analysis to examine the specificity of the relationships between self-reported and observed parenting with ERN

• A nonparametric bootstrapping method (MacKinnon, Lockwood, & Williams, 2004) to conduct mediational analysis
## Correlations

<table>
<thead>
<tr>
<th></th>
<th>ΔERN</th>
<th>ERN</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. ΔERN</strong></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-4.93</td>
<td>8.30</td>
</tr>
<tr>
<td><strong>2. ERN</strong></td>
<td>.85**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.68</td>
<td>8.04</td>
</tr>
<tr>
<td><strong>3. PSDQ Factor 1: Authoritative</strong></td>
<td>-.05</td>
<td>-.03</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>61.44</td>
<td>6.68</td>
</tr>
<tr>
<td><strong>4. PSDQ Factor 2: Authoritarian</strong></td>
<td>-.10†</td>
<td>-.12*</td>
<td>-.23**</td>
<td>-</td>
<td></td>
<td></td>
<td>20.08</td>
<td>4.67</td>
</tr>
<tr>
<td><strong>5. PSDQ Factor 3: Permissive</strong></td>
<td>-.03</td>
<td>-.05</td>
<td>-.10†</td>
<td>.42**</td>
<td>-</td>
<td></td>
<td>10.76</td>
<td>3.26</td>
</tr>
<tr>
<td><strong>6. Observed Hostility</strong></td>
<td>-.13*</td>
<td>-.14*</td>
<td>-.03</td>
<td>.21**</td>
<td>.27**</td>
<td>-</td>
<td>1.19</td>
<td>.33</td>
</tr>
<tr>
<td><strong>7. Observed Support</strong></td>
<td>.06</td>
<td>.10</td>
<td>.05</td>
<td>-.21**</td>
<td>-.23**</td>
<td>-.65**</td>
<td>4.48</td>
<td>.56</td>
</tr>
</tbody>
</table>

† = p < .09, * = p < .05, ** = p < .01
## Simultaneous regression

### Variables entered

<table>
<thead>
<tr>
<th></th>
<th>$b$</th>
<th>Std. error</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at ERN assessment</td>
<td>-1.50</td>
<td>1.23</td>
<td>-1.22</td>
</tr>
<tr>
<td>PSDQ Factor 1: Authoritative</td>
<td>-.11</td>
<td>.08</td>
<td>-1.44</td>
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<tr>
<td>PSDQ Factor 2: Authoritarian</td>
<td>-.22</td>
<td>.12</td>
<td><strong>-1.79</strong>*</td>
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<tr>
<td>PSDQ Factor 3: Permissive</td>
<td>.19</td>
<td>.18</td>
<td>1.07</td>
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<tr>
<td>Observed Hostility</td>
<td>-3.92</td>
<td>2.00</td>
<td><strong>-1.96</strong>*</td>
</tr>
<tr>
<td>Observed Support</td>
<td>-.78</td>
<td>1.18</td>
<td>-.66</td>
</tr>
</tbody>
</table>

Overall model: total $R^2$ = .04

$\Delta R^2 = N = 280$

$\dagger = p < .09$, $* = p < .05$, $** = p < .01$
Results: Parenting and anxiety

<table>
<thead>
<tr>
<th></th>
<th>Anxiety Diagnosis (N = 43)</th>
<th>No Anxiety Diagnosis (N = 260)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ΔERN</td>
<td>-7.74 (8.74) µV*</td>
<td>-4.49 (8.25) µV*</td>
</tr>
<tr>
<td>2. ERN</td>
<td>-2.07 (7.93)µV</td>
<td>-.46 (8.13)µV</td>
</tr>
<tr>
<td>3. PSDQ Factor 1: Authoritative</td>
<td>62.44 (6.39)</td>
<td>61.30 (6.72)</td>
</tr>
<tr>
<td>4. PSDQ Factor 2: Authoritarian</td>
<td>22.20 (5.25)*</td>
<td>19.78 (4.52)*</td>
</tr>
<tr>
<td>5. PSDQ Factor 3: Permissive</td>
<td>12.03 (3.94)†</td>
<td>10.57 (3.12)†</td>
</tr>
<tr>
<td>6. Observed Hostility</td>
<td>1.23 (.29)</td>
<td>1.18 (.33)</td>
</tr>
<tr>
<td>7. Observed Support</td>
<td>4.42 (.62)</td>
<td>4.49 (.55)</td>
</tr>
</tbody>
</table>
Mediation analysis

• Results indicated that the mediation model was predictive of variance in childhood anxiety, at a trend level, $R^2 = .024$, $F = 2.87$, $p = .06$

• Harsh parenting significantly predicted the magnitude of the $\Delta$ERN, $\beta = -0.14$, $t(279) = -2.23$, $p < .05$

• The $\Delta$ERN in turn significantly predicted childhood anxiety disorders, $\beta = .51$, $t (279) = 2.37$, $p < .05$

• While, harsh parenting was not directly predictive of childhood anxiety disorders, $\beta = -.03$ $t(279) = -.16$, $p = .88$, there was a significant indirect effect of harsh parenting, mediated through the $\Delta$ERN, on childhood anxiety disorders, $\beta = -.08$ (95% confidence interval [CI]: -.19 to -.02).
Discussion

• Observed parental hostility, as well as self-reported authoritarian parenting style, both prospectively predicted an increase in ERN in children 3 years later.
  • Both measures uniquely predicted ERN (authoritarianism at a trend level)

• Observational and self-reported measures of harsh parenting were only minimally correlated ($r = .21$).
  • Consistent with previous work (Bogels & Brechman-Toussaint, 2006; Greco & Morris, 2002)

• Relationships with ERN were specific to harsh parenting.

• ERN magnitude mediated the relationship between harsh parenting and child anxiety disorder status at age 6

• Harsh parenting may relate to subsequent risk for anxiety insofar as it shapes children’s neural response to errors.
Discussion

• Previous human and animal works suggests that parenting may substantially impact brain development and stress reactivity (Belsky & de Hann, 2011; Francis, Diorio, Liu, & Meany, 1999).

• It is possible that parenting may program biological responses to threatening stimuli to allow organisms to thrive under the unique demands of their environment (Francis et al., 1999)

• Harsh parenting may “program” errors as threatening and thereby increase children’s neural response to them

• The extent to which parenting specifically impacts the ERN relative to other measures of threat sensitivity should be explored in future work
Discussion

• Mediation analysis suggest a pathway whereby parents confer risk of clinical anxiety to their children through the impact of harsh parenting on children’s error processing.
  • Need additional longitudinal data to properly test mediation

• Parenting interventions decrease anxiety in children (Rapee, Kennedy, Ingram, Edwards, & Sweeny, 2010)

• Future work should explore whether the ERN is a mechanism through which parenting interventions work to decrease anxiety in children
  • Is the ERN a *modifiable* biomarker of risk?
Thanks!!

- Alex Meyer
- Dan Klein
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