Introduction
Research in animal and human populations has demonstrated that early postnatal experiences have a profound impact on later cognitive and brain development (e.g., Greenough et al., 1987). For example, studies examining attention development in adolescents and adults born very preterm (<32 weeks gestation) have suggested that the neural circuitry supporting inhibitory control may be particularly vulnerable to variations in early experience associated with preterm birth (Lawrence et al., 2009).

Interest has recently increased in monitoring neurodevelopmental outcomes of children born moderate to late preterm (32-36 weeks gestation). Although this population typically demonstrates good neonatal outcomes, it is unclear how 4-8 months of premature ex-utero experience may alter later brain and cognitive development.

The purpose of this project was to investigate whether moderate to late preterm birth impacts the development of inhibitory control and sustained attention at four years of age.

Question
Does moderate to late preterm birth impact the development of inhibitory control and/or sustained attention in preschool-aged children?

Participants

<table>
<thead>
<tr>
<th>Age at Test</th>
<th>Full- Term Children (n=44)</th>
<th>Preterm Children (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M = 56.9 months</td>
<td>M = 56.4 months</td>
<td></td>
</tr>
<tr>
<td>Range: 53 - 59 months</td>
<td>Range: 54 - 59 months</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Full- Term Children (n=44)</th>
<th>Preterm Children (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 f, 22 m</td>
<td>23 f, 9 m</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gestational Age</th>
<th>Full- Term Children (n=44)</th>
<th>Preterm Children (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M = 39.7 weeks</td>
<td>M = 34.33 weeks</td>
<td></td>
</tr>
<tr>
<td>Range: 38.0 - 42.2 weeks</td>
<td>Range: 32.0 - 35.9 weeks</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Birth Weight</th>
<th>Full- Term Children (n=44)</th>
<th>Preterm Children (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M = 3580 grams</td>
<td>M = 2323 grams</td>
<td></td>
</tr>
<tr>
<td>Range: 2605 - 4761 grams</td>
<td>Range: 1340 - 2885 grams</td>
<td></td>
</tr>
</tbody>
</table>

Demographics: Children were predominantly Caucasian (87%), and lived in two-parent families (91%). Median household income for the sample was between $76,000-$100,000. All children were screened for significant prenatal or birth complications, developmental or neurological disorders, and vision or hearing impairments.

Excluded Participants: Four children (3 full-term) failed to complete the inhibitory control or sustained attention task blocks and were excluded from analyses. One full-term child was excluded from the sustained attention task as a statistical outlier.

Methods

**Combined Go/No-Go – Continuous Performance Task**

**Task** Instructions: *To play I-Spy, press the space bar every time you see the [target stimulus]. But don’t be tricked! Don’t press the space bar for the [non-target stimulus].*

**Practice** Children completed an initial training block of 8 trials with 50% target probability.

**Stimuli** Possible Stimulus Combinations: [target stimulus: non-target stimulus]

**Experimental Design**

- **Go/No-Go Blocks**: 2 Targets: 5 Non-Targets (GO/NO-GO trials)
- **Sustained Attention Task**: [non-target stimulus]

**Outcome Measures**

- **Adjusted Go Accuracy**: measured by accuracy on [target stimulus: non-target stimulus] trials
- **Adjusted Non-Target Accuracy**: measured by accuracy on [target stimulus: non-target stimulus] trials

**CPT Blocks**

- **Block (Targets: Non-Targets)**
- **CPT**, 1 Target: 5 Non-Targets (2400 ms)
- **CPT**, 1 Target: 5 Non-Targets (1200 ms)

**Outcome Measures**

- **Adjusted Go Accuracy**: measured by accuracy on [target stimulus: non-target stimulus] trials
- **Adjusted Non-Target Accuracy**: measured by accuracy on [target stimulus: non-target stimulus] trials

**CPT Target Reaction Time**

- **Target Reaction Time**: in milliseconds

- **Non-Target Reaction Time**: in milliseconds

**Sustained Attention Results**

- **With** the within group, faster average reaction times for target stimuli were correlated with greater gestational age on both the Go/No-Go and CPT tasks.

**Reaction Time Results**

- **Within** the preterm group, faster average reaction times for target stimuli were correlated with greater gestational age on both the Go/No-Go and CPT tasks.

**Inhibitory Control Results**

- **Preterm** children made more NoGo errors than full-term children only in the difficult 5:1 condition.

**Discussion**

In comparison to full-term children, preschoolers born moderate to late preterm committed more inhibitory control errors during the most difficult condition of a Go/No-Go task. Group differences in inhibitory control were:

- Significant after controlling for individual differences in IQ.
- Detected in a high SES, high IQ sample, suggesting that the effects may be greater for children in less enriched environmental contexts.
- Possibly the result of atypical development rather than delayed maturation, given that adolescents born very preterm show disrupted inhibitory control (Lawrence et al., 2009).

Full-term and preterm children performed equivalently on measures of sustained attention, indicating that only specific aspects of cognitive development are disrupted in children born moderate to late preterm.

Future studies should investigate if moderate to late preterm children exhibit reductions in overall processing speed, given the association between reaction time and gestational age.

**Conclusion**

Inhibitory control may be particularly vulnerable to variations in early life experience associated with moderate to late preterm birth.

**Acknowledgments**

This research was supported by seed research (to J.E. Brumbaugh) and travel awards from the University of Minnesota Center for Neuroscience Development (Brumbaugh) and the University of Minnesota Graduate School for the study (to Jane E. Brumbaugh). Additional support was provided by the NICHD/NEIC Acquisition of New Investigator Research Experience (5T32HD007522-06) to Jane E. Brumbaugh (from the NICHD) and to University of Minnesota Graduate Fellowship Award (5T32HD007522-06) to Amanda S. Hodel. The authors thank the families of the participants and the support of the Minnesota Women’s Health and Development Center, Department of Education.