Crawling onset facilitates Spatial Cognition in Infants with Lumbar Spina Bifida

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- I do not have any commercial products or services to discuss

- I do not intend to discuss non-FDA approved uses of products/providers of services.

- I do not have anything to disclose nor have any financial relationships
Emergence of infant mobility is a catalyst for a range of psychological transitions (Campos et al 2000)

- Visual Perception
- Spatial Cognition
- Social Emotional
Infant Mobility and Spatial Cognition

• Mobile organisms require spatial intelligence (Giuliani et al 2014)
  • Relocating food, home, or terrain
  • Memory of position in space

• Mobility spurs visual exploration (Brandone, 2014, Gibson, 1989; Acredolo, 984)
  • Categorical orientation: color, size, shape, outlines
  • Infant mobility leads to increases in visual attention
  • Mobility facilitates differentiation in terrain (slopes, uneven surfaces)
Research: Infant Mobility and Spatial Cognition

• Typically Developing (TD): powered mobility and optic flow  
  (Uchiyama et al, 2008)

• TD infants: onset of crawling spurs optic flow sensitivity and spatial search  
  (Kermoian et al 1988)

• Sacral Spina Bifida (SB) and spatial search  
  • Onset of mobility increased finding hidden objects  

(SB)
Spina Bifida Visual Attentional Deficits (Taylor, 2010; Caspersen 2010; Dennis 2005; Dennis 2012)

Toddlers SB:18 months
- Difficulties disengaging from attended information
- Reduced visual shifting in objects moving in space

Longitudinal study: 6m to 3yrs
- Diminished capabilities in obtaining and disengaging attention
- Similar in age match controls: sustained attention
Infants with Spina Bifida & Spatial Performance Deficits
(Dennis, 2002, 2004;2005; Fletcher, 2005)

Cognitive Performance
Figure Ground
Contours
Memory for Designs

Associated with Neuroanatomical Anomalies
Distortion in Tectum (midbrain)
Hydrocephalus & Arnold Chiari II
An unexplored explanation for spatial deficits are late onset crawling and lack of ongoing exploratory and spatial experiences (Rendeli, 2002; Wiedenbauer, 2006; Lomax-Bream, 2007)

**Purpose:** Investigate spatial cognitive tasks in TD infants and infants with SB (late onset of crawling), examining performance in 3 spatial cognitive paradigms re and post mobility.
<table>
<thead>
<tr>
<th><strong>TD</strong> (n=30)</th>
<th><strong>SB</strong> (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age held constant design</td>
<td>Longitudinal Grouped into two data points (non-crawling, crawling)</td>
</tr>
<tr>
<td>Cross-sectional Crawling compared to Pre-crawling</td>
<td></td>
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<tr>
<td>Comparison of two groups 8-9 TD infants</td>
<td>Comparison of crawling to one prior to onset of crawling (Campos et al, 2009)</td>
</tr>
<tr>
<td>Purpose: Assess validity</td>
<td>Purpose: to evaluate effects of late onset of crawling</td>
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</tbody>
</table>
Three spatial cognitive tasks

<table>
<thead>
<tr>
<th>Perception</th>
<th>Properties</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving Room</td>
<td>Form Extraction</td>
<td>Joint Visual Attention</td>
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</tbody>
</table>
Moving Room

Two Conditions: Whole room and Sidewall
Peripheral optic flow (side wall): increases postural sway onset of crawling

Postural Sway
Center of pressure changes
   Force plate
   4 pressure gauges

Wall potentiometer
   Measures direction and speed
Form Extraction

Series of familiarization trials with two side by side similar forms

Subsequent trials: distinctions in orientation, size, and color

**Measurement:** Test Trials
Percentage of looking time at Novel Object (10 sec)

Onset of mobility: increased looking at novel shape compared to familiar
Joint Visual Attention
## Demographics: TD

<table>
<thead>
<tr>
<th></th>
<th>Crawling Infants (n=15)</th>
<th>Non-crawling Infants (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (months)</strong></td>
<td>8.54 ± .32</td>
<td>8.39 ± .28</td>
</tr>
<tr>
<td><strong>Age onset of crawling (months)</strong></td>
<td>7.1 ± 0.39</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Number of weeks Crawling</strong></td>
<td>6.04 ± 2.1</td>
<td>n/a</td>
</tr>
</tbody>
</table>
TD JVA

Looking Percentage

Non-Crawling     Crawling

TD Infants
Form Extraction (n=28)

- NOVEL
- FAMILIAR

TD Moving Room
((n=30))

Cross Correlation

Noncrawling     Crawling

* p<0.001
## Demographics SB Infants

<table>
<thead>
<tr>
<th></th>
<th>SB02</th>
<th>SB03</th>
<th>SB05</th>
<th>SB06</th>
<th>SB07</th>
<th>SB08</th>
<th>SB10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesion Level</strong></td>
<td>L1</td>
<td>L4</td>
<td>L4</td>
<td>L4</td>
<td>L5</td>
<td>L5</td>
<td>L5</td>
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<tr>
<td><strong>Hydrocephalus VP shunt</strong></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Arnold Chiari II</strong></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Age at study onset (months)</strong></td>
<td>14</td>
<td>15</td>
<td>8.5</td>
<td>13</td>
<td>7.5</td>
<td>7.5</td>
<td>9.5</td>
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<tr>
<td><strong>Belly crawling</strong></td>
<td>22</td>
<td>24</td>
<td>20</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>NA</td>
</tr>
<tr>
<td>M=18.6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hands/Knees</strong></td>
<td>23</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>16</td>
<td>NA</td>
<td>12</td>
</tr>
<tr>
<td>M=17.0 months</td>
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</tbody>
</table>
SB Sidewall Forward Moving Room

Cross Correlation

NON-CRAWLING  CRAWLING

No sign differences  
t(6)=-0.92, p=0.20
Main effect of crawling: F(1,27) = 11.99; P = .002
Main interaction: F(1,27) = 4.52; P = .04

Correct
Experimenter

Looking Responses Percentage

0.5

0.45
0.36
0.163
0.29

0.1

0.0

Pre Crawl
Crawling
SB Form Extraction

Interaction F(1,20)=8.31; P=0.09

Noncrawling
Crawling

Looking Percentage

- Novel
- Familiar

0.36
0.55
0.28
0.26

SB SPINA BIFIDA WORLD CONGRESS
LIMITATIONS

Small sample size
Lack of standardized visits for SB Infants
Environmental Influences
Account for age differences at onset of mobility
What are the mechanisms driving spatial cognitive changes?

Crawling Facilitates

Mobility

Attention

Environment Experiences Exploration

Spatial Cognition Skills
Implications

Late onset of crawling in infants with SB disrupts spatial cognitive development

Combination of brain structure plus loss of environmental exploration

Crawling onset spurs spatial cognition performance

Provide the opportunity for early mobility in infants with motor disability (Wiart, 2002)
Acknowledgements

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Audun Dahl PhD
References