Spatial Working Memory: The Effects of Attention and Distractors for Children born Preterm and Fullterm

Anne R. Schutte
Department of Psychology, UNL
Outline

- Development of spatial working memory (SWM) in Early Childhood
- Dynamic Field Theory
- Spatial attention and spatial memory
  - Adults
  - Children
- Predictions of model
- Current study
  - Experiments 1 and 2
Development of SWM in Early Childhood

A developmental shift in “geometric” biases (Huttenlocher et al., 1994)
Spatial Memory Video Game
Dynamic Field Theory (DFT)

- Dynamic systems theory of Spatial Working Memory (SWM)
- Neural network model (e.g., Schutte, Spencer & Schöner, 2003; Schutte & Spencer, 2009; Schutte & Spencer, in press)
Dynamic Field Theory

(a) reference input, target input, PF_{obj}, Inhib_{obj}, 
activation, time (ms), location

(b) reference input, target input, PF_{obj}, Inhib_{obj}, 
activation, time (ms), location
Reference input (midline)

- Location
- Activation

- From perceptual field
- From inhibitory field
Dynamic Field Theory
Spatial Precision Hypothesis
activation

location
Geometric biases over development

Schutte & Spencer, in press
Schutte & Spencer, in press
Spatial Attention and Spatial Working Memory (SWM)

Spatial attention influences maintenance in SWM in adults (e.g., Awh and Jonides)

– Proposed selective spatial attention is a “rehearsal mechanism” for SWM
– When spatial attention is manipulated during the delay adults show larger errors

Adults are biased toward attention location (Johnson et al., 2008)
Preschoolers: no correlation between attention performance and SWM performance (Vicari et al., 2004)
Purpose of the Study

- To examine how spatial attention influences SWM in children from 3 to 6 years of age.
- Examine in model and children
- Model: no mechanism for differentiating target and distractors
  - Added color-space field (Johnson & Spencer, 2010)
DFT: Color-Space Field
Dynamic Field Theory

Perceptual Field
- target
- distractor

Inhibitory Field

Spatial Working Memory (SWM) Field

- time

Color:
- yellow
- blue

Target and distractor locations:
- location

Feedback from SWM field
<table>
<thead>
<tr>
<th></th>
<th>No distractor</th>
<th>0° distractor (on midline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-old model</td>
<td>-2.41 (toward midline)</td>
<td></td>
</tr>
<tr>
<td>6-year-old model</td>
<td>.14 (away from midline)</td>
<td></td>
</tr>
</tbody>
</table>
### -20° target

<table>
<thead>
<tr>
<th></th>
<th>No distractor</th>
<th>0° distractor (on midline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-old model</td>
<td>-2.41 (toward midline)</td>
<td>-11.6</td>
</tr>
<tr>
<td>6-year-old model</td>
<td>0.14 (away from midline)</td>
<td>1.16</td>
</tr>
</tbody>
</table>
Predictions of Model

- Young children will be biased toward distractor when it is near the target
  - due to excitatory input
- Older children will be biased away from the distractor when it is near the target
  - due to inhibitory input
Experiment 1

Methods

Participants
- 15 3-year-olds
- 13 4-year-olds
- 15 5-year-olds
- 15 6-year-olds
Method

- SWM tasks
  - Spaceship search
  - Treasure find
  - Bubble burst

- Delay: no delay, 1 s, 4 s, or a 9 s
Method

- Targets: -20 degrees from midline or 40 degrees from midline
- Distractor appeared on half of the 4 and 9 s delay trials
  - 20° toward midline (inner)
  - 40° away from midline (outer)
Results

3-year-olds

5-year-olds

4-year-olds

6-year-olds

<table>
<thead>
<tr>
<th>mean error (°)</th>
<th>20°</th>
<th>40°</th>
</tr>
</thead>
<tbody>
<tr>
<td>inner distractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>outer distractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no distractor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3-year-olds

- inner distractor
- outer distractor
- no distractor

mean error (°)

20°  40°

0°  -20°
Discussion

- 3-year-olds were biased toward distractor
  - Supported prediction

- Other ages not influenced by distractor
  - 4 years: transitional age
  - 5 and 6 years biased away from midline, also biased away from closest distractor

- Experiment 2
  - Changed distractor locations
Experiment 2

Method

- Participants
  - 10 3-year-olds
  - 12 4-year-olds
  - 12 5-year-olds
  - 11 6-year-olds

Target and distractors:
Results

3-year-olds

4-year-olds

5-year-olds

6-year-olds

* 9 s delay data

- Inner distractor
- Outer distractor
- No distractor

toward midline
away from midline
6-year-olds\textsuperscript{a}

\textbf{60°} - 20°

\textsuperscript{a} 9 s delay data
6-year-olds

a 9 s delay data
Discussion

- Experiment 1 results support the predicted bias toward distractors in 3-year-olds
- Experiment 2 results support the predicted bias away from distractors in 6-year-olds
- Children at or near transition not significantly influenced by distractors
Discussion

- Spatial attention influenced maintenance in spatial working memory in early childhood
  - Shifted bias
  - How distractors influenced bias changed over development

- Supported predictions of the DFT

- Future directions:
  - Examine SWM performance in children with attention deficits
    - ADHD
    - Preterm children
Thanks:

- Parents and children
- Dr. Kimberly Andrews Espy
- Dr. Sandra Wiebe
- Members of the Spatial Memory Lab:
  - Brian Keiser
  - Heidi Fleharty
  - Margaret Ortmann
  - Chelsie Guerraro
  - Marisa Sevick
  - And all of the undergraduates in the lab
- Research supported by R03 HD053359 and UNL Laymans grant
Results

4-year-olds
### -20° target

<table>
<thead>
<tr>
<th></th>
<th>No distractor</th>
<th>-40° distractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-old model</td>
<td>-5.56</td>
<td>8.60</td>
</tr>
<tr>
<td>6-year-old model</td>
<td>4.89</td>
<td>.73</td>
</tr>
</tbody>
</table>
### -20° target – Empirical data

<table>
<thead>
<tr>
<th>Age Group</th>
<th>No distractor</th>
<th>-40° distractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-olds</td>
<td>-6.48</td>
<td>-0.96</td>
</tr>
<tr>
<td>6-year-olds</td>
<td>4.43</td>
<td>-2.70</td>
</tr>
</tbody>
</table>
Results

A-not-B-type errors
Results

3-year-olds
- Mean error ($) for near distracter
- Mean error ($) for far distracter
- Mean error ($) for no distracter

5-year-olds
- Mean error ($) for near distracter
- Mean error ($) for far distracter
- Mean error ($) for no distracter

4-year-olds
- Mean error ($) for near distracter
- Mean error ($) for far distracter
- Mean error ($) for no distracter

6-year-olds
- Mean error ($) for near distracter
- Mean error ($) for far distracter
- Mean error ($) for no distracter

Target (°):
- 20°
- 40°

Away from midline

Toward midline
Dynamic Field Theory
Dynamic Field Theory

Young child: biased toward distracter
Dynamic Field Theory

Older child: biased away from attractor