A Gradual Transition Over Developmnet in Spatial Working Memory

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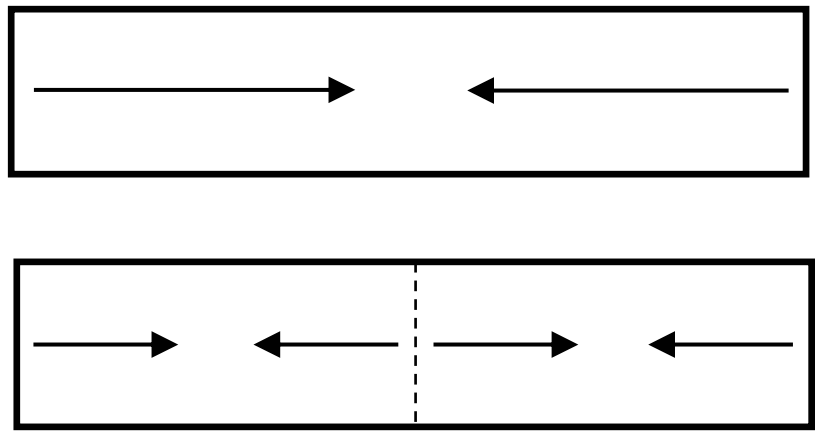
Spatial Working Memory (SWM)

Early in development there is a transition in SWM (Huttenlocher, Newcombe & Sandberg, 1994)

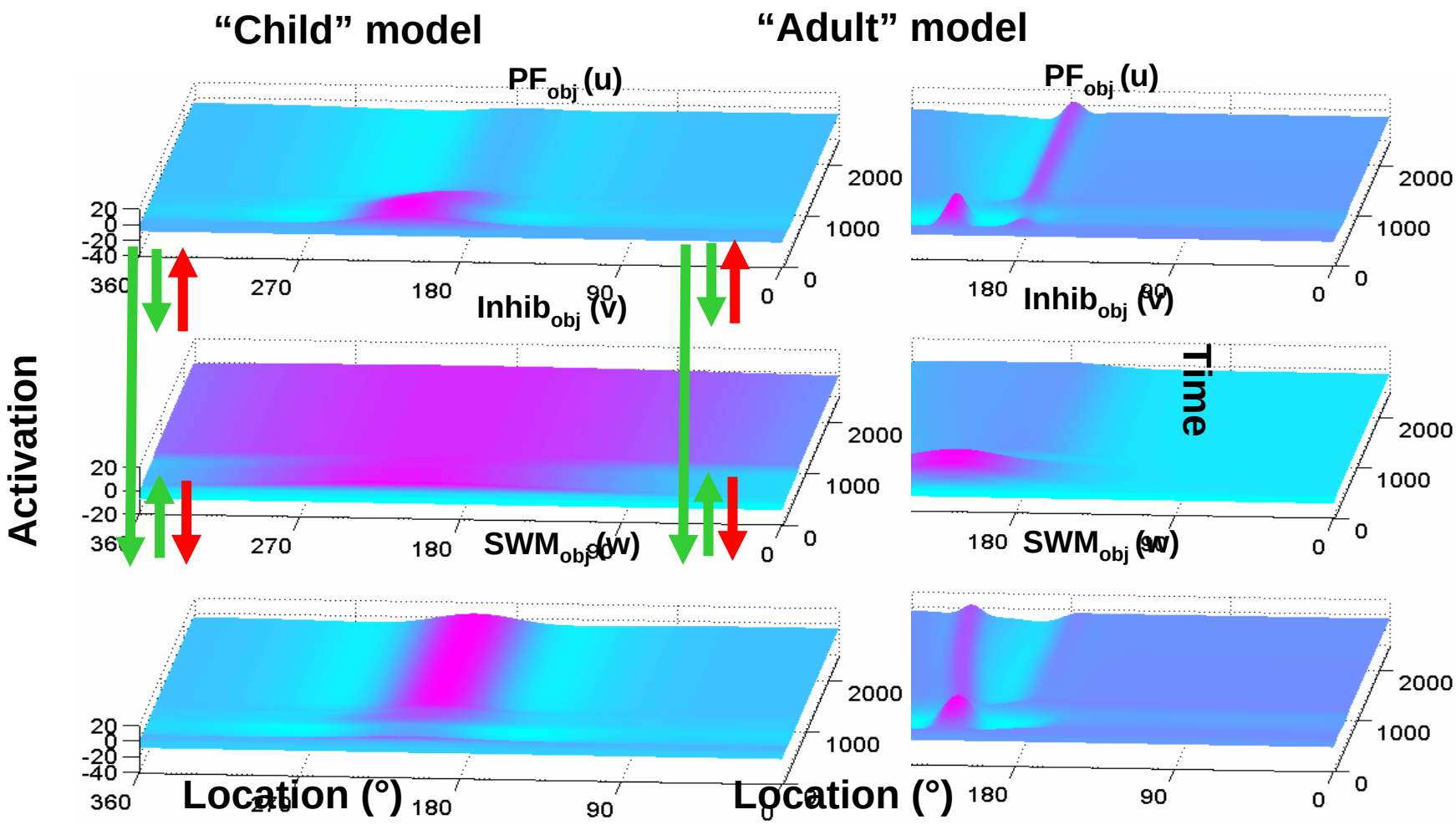
- Young children are biased toward the midline reference axis
- Older children and adults are biased away from the midline reference axis
- This has been explained as a change in spatial categorization



Dynamic Field Theory (DFT)

- Neural network model of Spatial Working Memory (SWM) (Schutte, Spencer & Schöner, 2003; Spencer & Schöner, 2003)
- The DFT predicts a gradual transition of SWM in reference axis biases

Dynamic Field Theory (DFT)

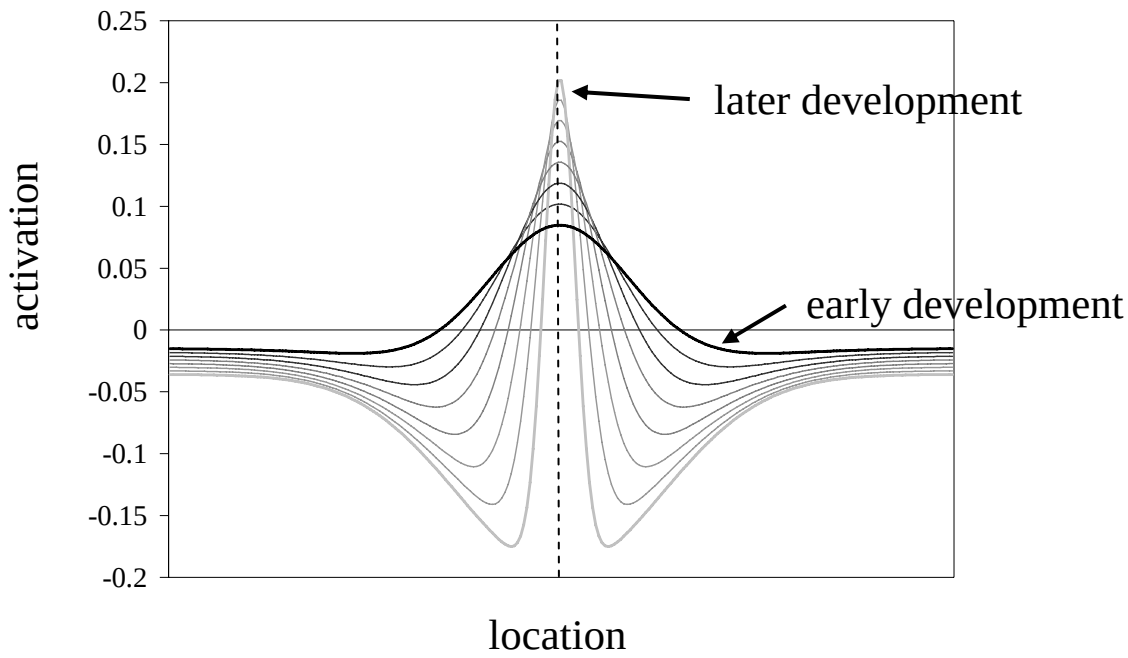


What happens in a trial:

- Start of trial: The target turns on, and activation marking the target location is fed into SWM.
  - This sets up a peak of activation at the target location.
  - Peak self-sustains through the neuronal interactions.
  - During the delay, the peak drifts toward the location of maximal activation.
    - **Child model**: Toward the midline reference axis because it overlaps with reference axis input
    - Adult model: Away from the midline reference axis because overlaps with the inhibitory input from midline reference axis

DFT: Spatial Precision Hypothesis

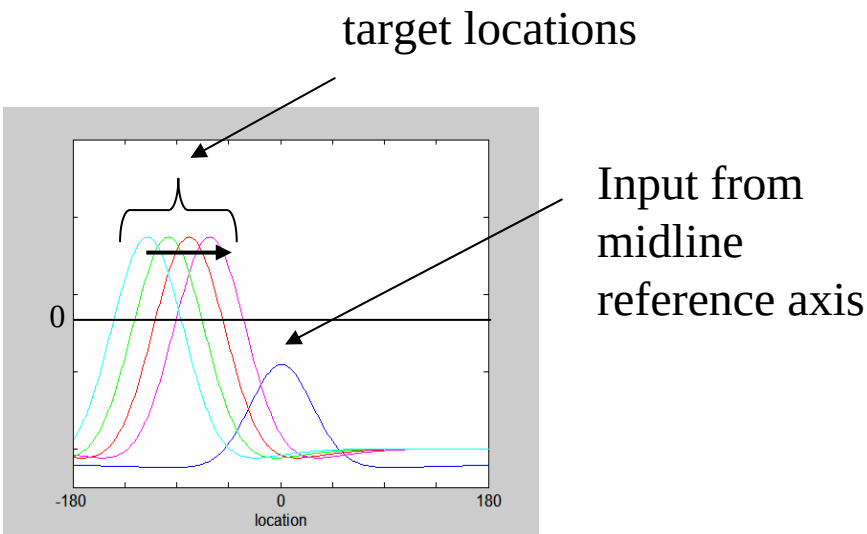
- Why does direction of drift change over development?
- Spatial Precision Hypothesis: over development neural interaction becomes stronger and more precise (Schutte, Spencer, & Schöner, 2003):



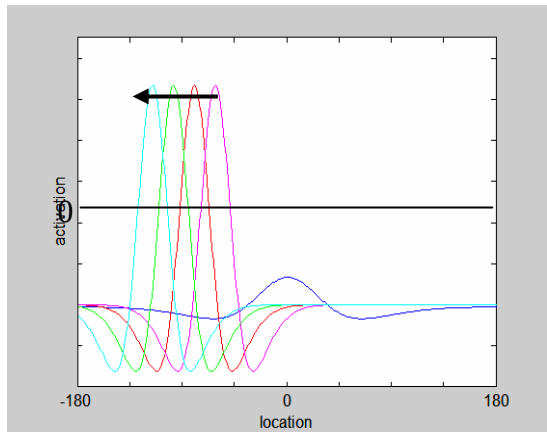
DFT: Spatial Precision Hypothesis

- This leads to a change in bias around reference axes:

Early in development:

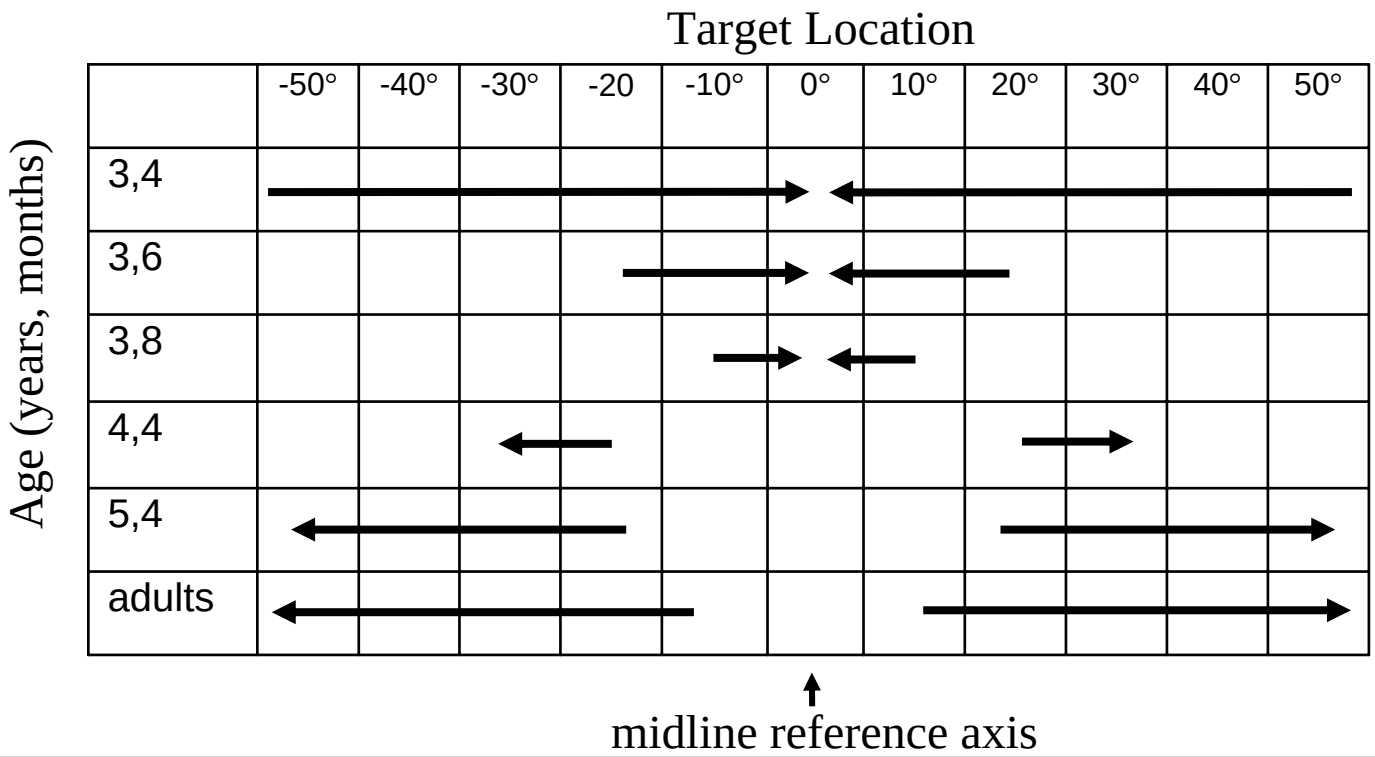


Later in development:



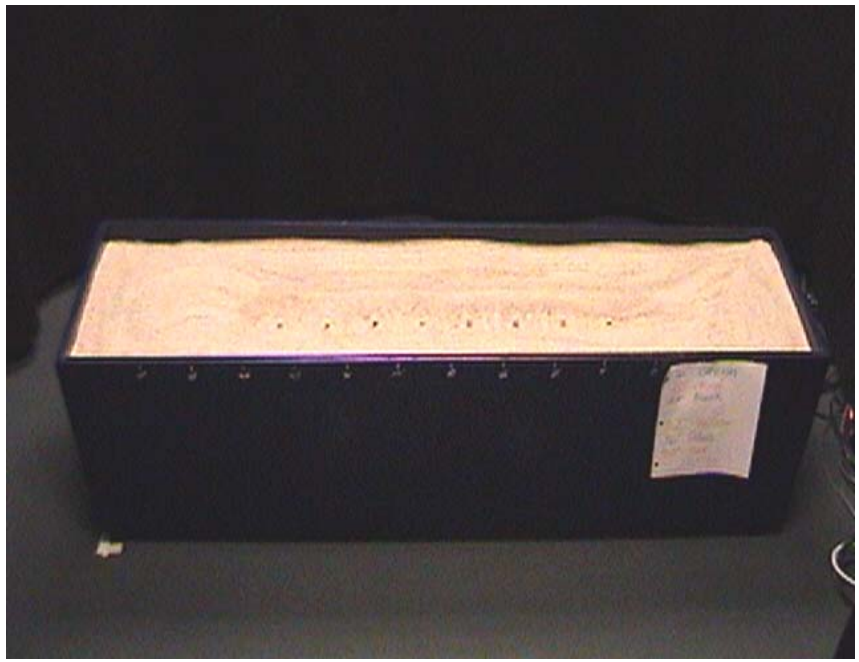
Spatial Working Memory (SWM)

- Using a “spaceship task”—a task in which children had to recall the location of a small, spaceship-shaped target on a table top , Schutte and Spencer (2002, 2006) determined that this transition is a gradual transition:



Goals Of The Current Study

- Goals of this study:
  - Replicate and extend Schutte and Spencer's (2005) work using a different task, a sandbox task
  - Examine age differences between the "spaceship" task and the sandbox task.



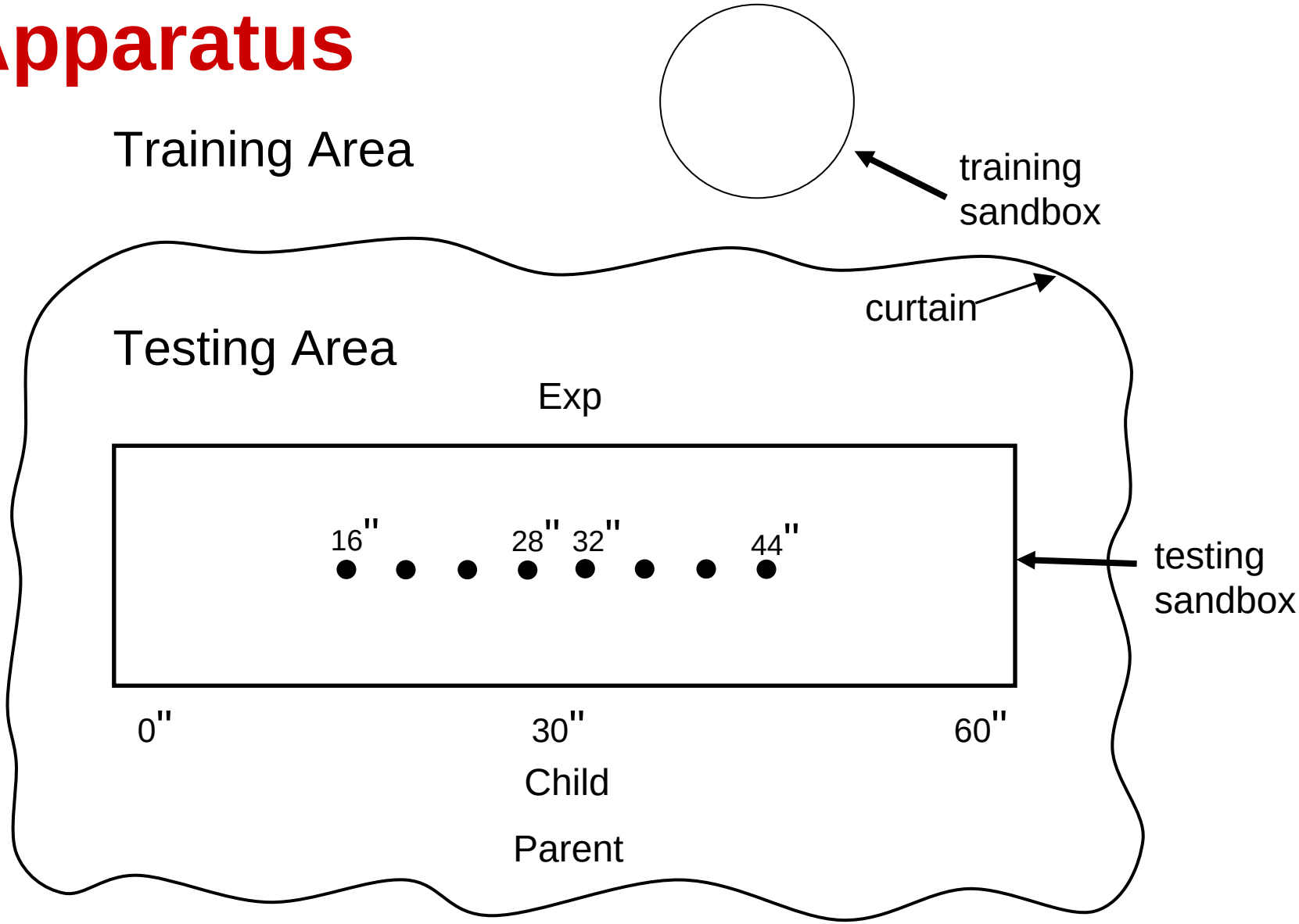
Methods

- Participants: 17 males and 13 females
- 3-year-olds: mean age = 3 yrs., 6.1 mos., range = 38.5– 45.4 mos. (n=8)
- 4-year-olds: mean age = 4 yrs., 3.8 mos., range = 45.8 – 56.4 mos. (n=7)
- 5-year-olds: mean age = 5 yrs., 3.4 mos., range = 59.9 – 65.4 mos. (n=8)
- 6-year-olds: mean age = 6 yrs., 1.7 mos., range = 65.4 – 79.9 mos. (n=7)

Methods

- Trials: 6 practice trials in a small, round sandbox followed by 16 in large sandbox
- The trial consists of the following: experimenter hides the toy, counts to five, child points and uncovers the toy

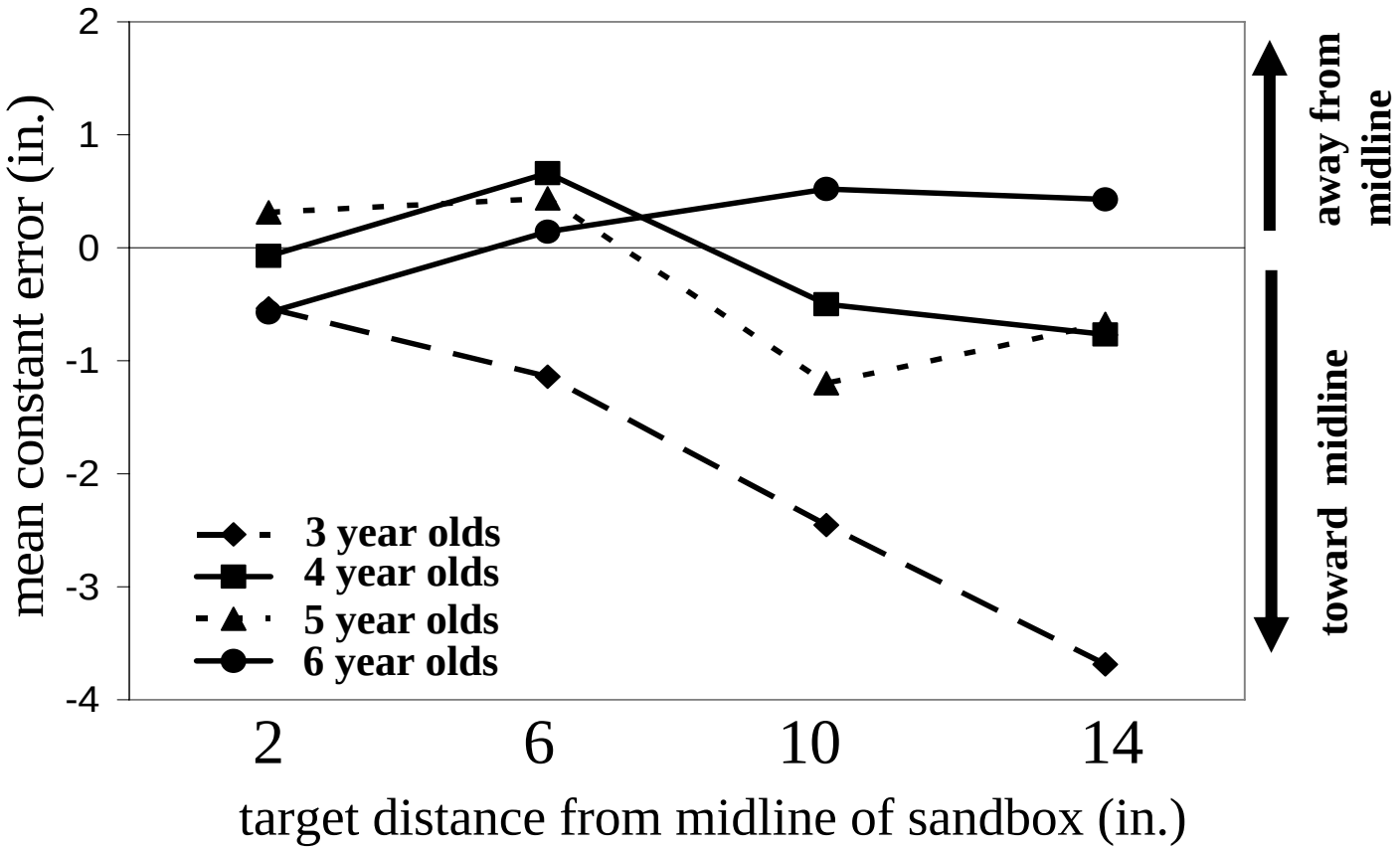
Apparatus


Training Area
training sandbox
curtain
Testing Area
Exp
16"
28"
32"
44"
testing sandbox
0"
30"
60"
Child
Parent

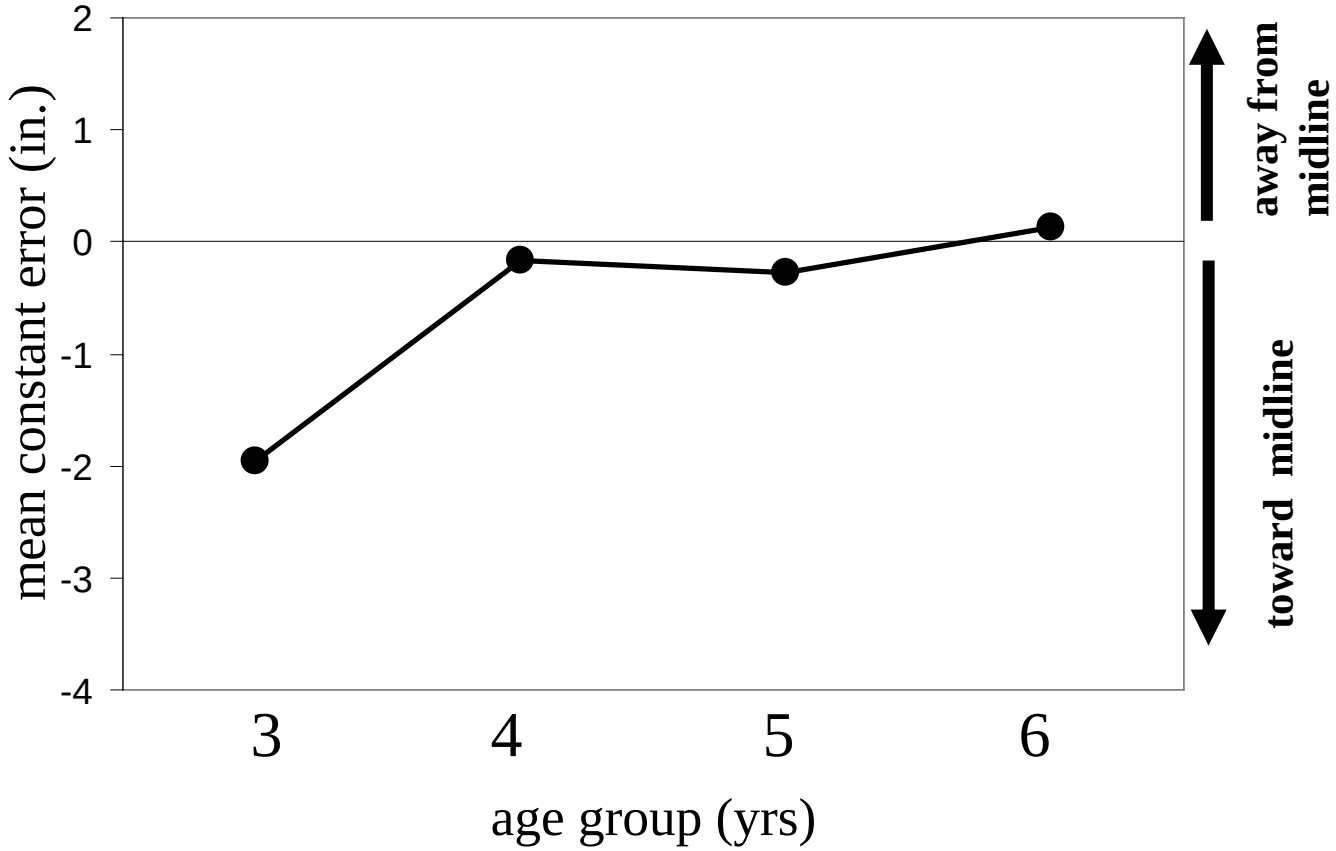
Methods

- toys were hidden every four inches starting at 16” ranging up to 44”
- two trials to each hiding location
- order of hiding locations was randomly chosen
- session was video taped and coded afterwards

Results


mean constant error (in.)
2
1
0
-1
-2
-3
-4
2
6
10
14
target distance from midline of sandbox (in.)
3 year olds
4 year olds
5 year olds
6 year olds
away from midline
toward midline

Results


2
1
0
-1
-2
-3
-4
mean constant error (in.)
3
4
5
6
age group (yrs)
away from midline
toward midline

Results

- significant age group by location interaction
- significant main effect of age group
  - As age increased, overall bias toward midline decreased
- significant main effect of location
  - Responses to locations furthest from midline were more strongly biased toward midline than locations closest to midline.
    - This effect was driven primarily by the youngest age group.

Discussion

- Preliminary results replicated gradual transition found by Schutte & Spencer (2006).
  - transition occurs slightly later in development and is prolonged
    - Even the 6 year olds were not biased significantly away from midline at any location.
    - Schutte & Spencer found that by 4 yrs., 4 mos. of age children were significantly biased away from midline
    - Difference may be due to sandbox being larger than the spaceship task (see Huttenlocher et al.,1994)

Future Directions

- Test older children to confirm bias away from midline emerges gradually
- Longitudinal studies are needed to confirm the transition is gradual within individuals
- Future experiments will examine the influence of experience on the transition.
  - Using microgenetic methods, examine whether experience with the sandbox task will "push" children near the transition point through the transition.

References

- Huttenlocher, J., Newcombe, N. & Sandberg, E. H. (1994). The coding of spatial location in young children. *Cognitive Psychology, 27,* 115-147.
- Schutte, A. R., & Spencer, J. P. (2002). Generalizing the dynamic field theory of the A-not-B error beyond infancy: Three-year-olds' delay- and experience-dependent location memory biases. *Child Development, 73*, 377-404.
- Schutte, A. R., & Spencer, J. P. (2006). *Tests of the Dynamic Field Theory and the Spatial Precision Hypothesis: A Developmental Transition in Spatial Working Memory.* Manuscript in preparation.
- Schutte, A. R., Spencer, J. P., & Schöner, G. (2003). Testing the dynamic field theory: Working memory for locations becomes more spatially precise over development. *Child Development, 74*, 1393-1417.
- Spencer, J. P., & Schöner, G. (2003). Bridging the representational gap in the dynamical systems approach to development. *Developmental Science, 6*, 392-412.