



Tracking moving locations: Eye movements of 6-month-olds reveal dynamic spatial indexing of multi-modal objects



Natasha Z. Kirkham (nzk2@cornell.edu), Daniel C. Richardson, Michael J. Spivey and Scott P. Johnson
Department of Psychology, Cornell University, Ithaca, NY, 14853, USA

Poster Presented at the 13th Biennial International Conference On Infant Studies, April, 2002, Toronto.

ABSTRACT

Spatial indexing has been proposed as a mechanism that links mental representations of objects (e.g., object properties, feature bundles) to physical entities in the world. This mechanism uses a limited number of pointers to tag objects by their spatio-temporal location. Converging evidence from studies with adult participants suggests that spatial indices are employed to track objects, link incompatible sensorimotor and cognitive codes, and organize working memory. For example, recent eye tracking work shows that adults tag auditory, semantic information with a spatial index, even if location is task-irrelevant (Richardson & Spivey, 2000).

If this mechanism is prevalent in adults, perhaps it also plays a key role in how infants organize their knowledge about the physical environment. Indeed, some researchers have argued that infants' use such spatio-temporal information to bind object features (Leslie, Xu, Tremoulet & Scholl, 1998). Recent research has shown that infants can integrate multi-modal cues in order to bind the sound of an object with its location (Kirkham & Richardson, 2001; McMurray & Aslin, 2000). The current study has extended these findings by providing evidence that infants' spatial indexing has some of the hallmarks of the flexible, dynamic system found in adults.

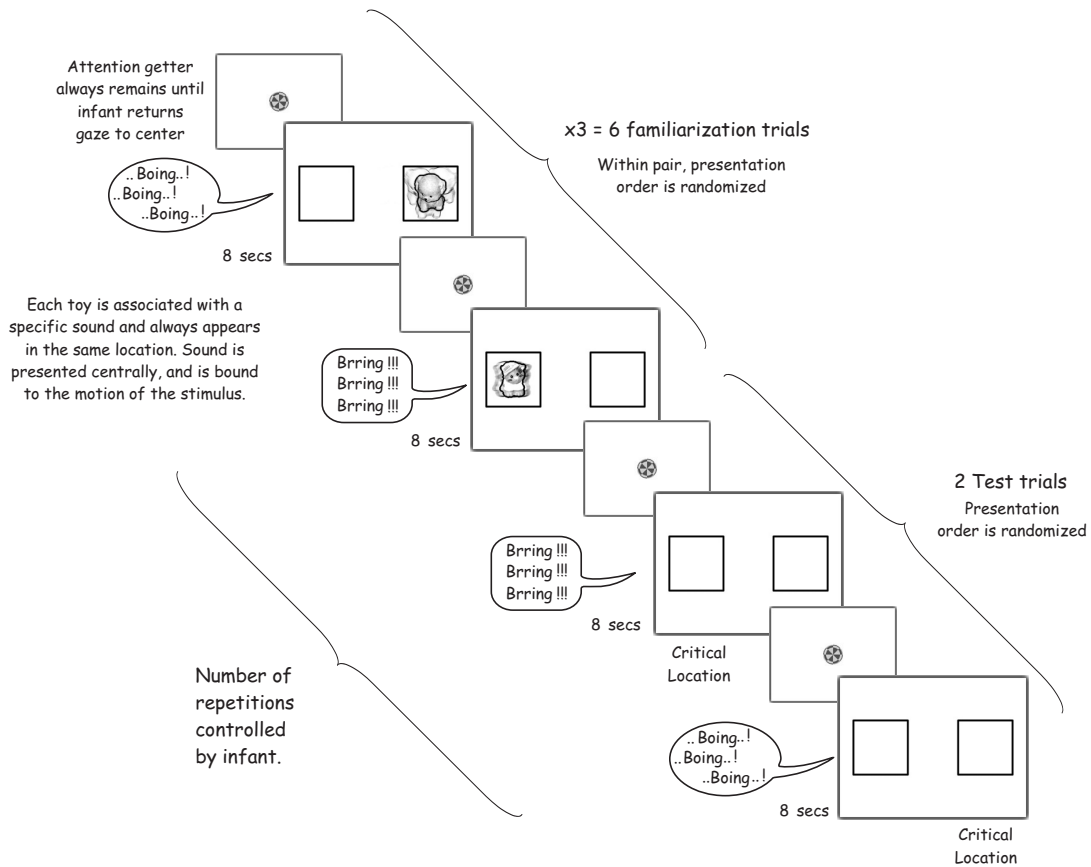
Six-month-olds were shown two different animated objects on a computer screen. Each object had a distinct sound, and appeared in a certain location in one of two square frames in the top and bottom halves of the screen. The objects appeared, one at a time, for eight seconds. After six presentations, the two squares frames smoothly rotated 90° into a horizontal alignment on the left and right sides of the screen. In two test trials, the sound associated with one of the objects was played while the infants looked at the frames. The infants looked significantly longer at the empty frame associated with the test sound, even though it occupied a new location in space.

These results provide evidence for the early emergence of a flexible spatial indexing mechanism, and can be allied with current theoretical attempts to find commonalities between infant and adult usage of spatial indices.

On the project homepage, you can view our stimuli and download recordings of infants' eye movements

<http://node15.psych.cornell.edu/home/babysquares.html>

PREVIOUS RESEARCH

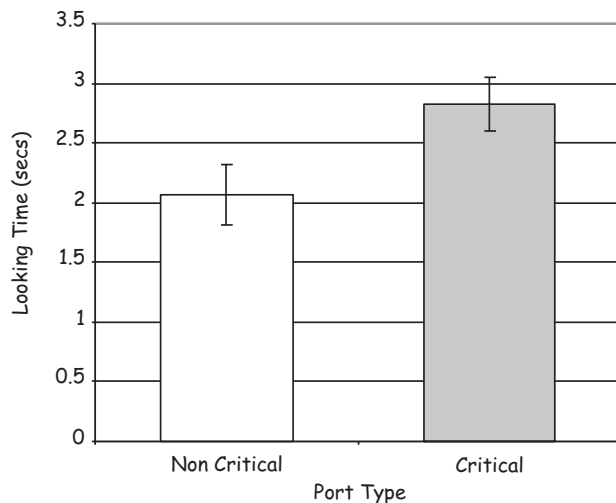


Schematic of Kirkham & Richardson (2001). Stimuli were presented on a computer screen with a black background, white box lines and full color shapes. Infants' eye movements were recorded with a table mounted eye tracker.

The amount of time the infant spent looking at each side of the screen during the test trials was coded. The figure shows these looking times in terms of looking time to the critical and non-critical locations.

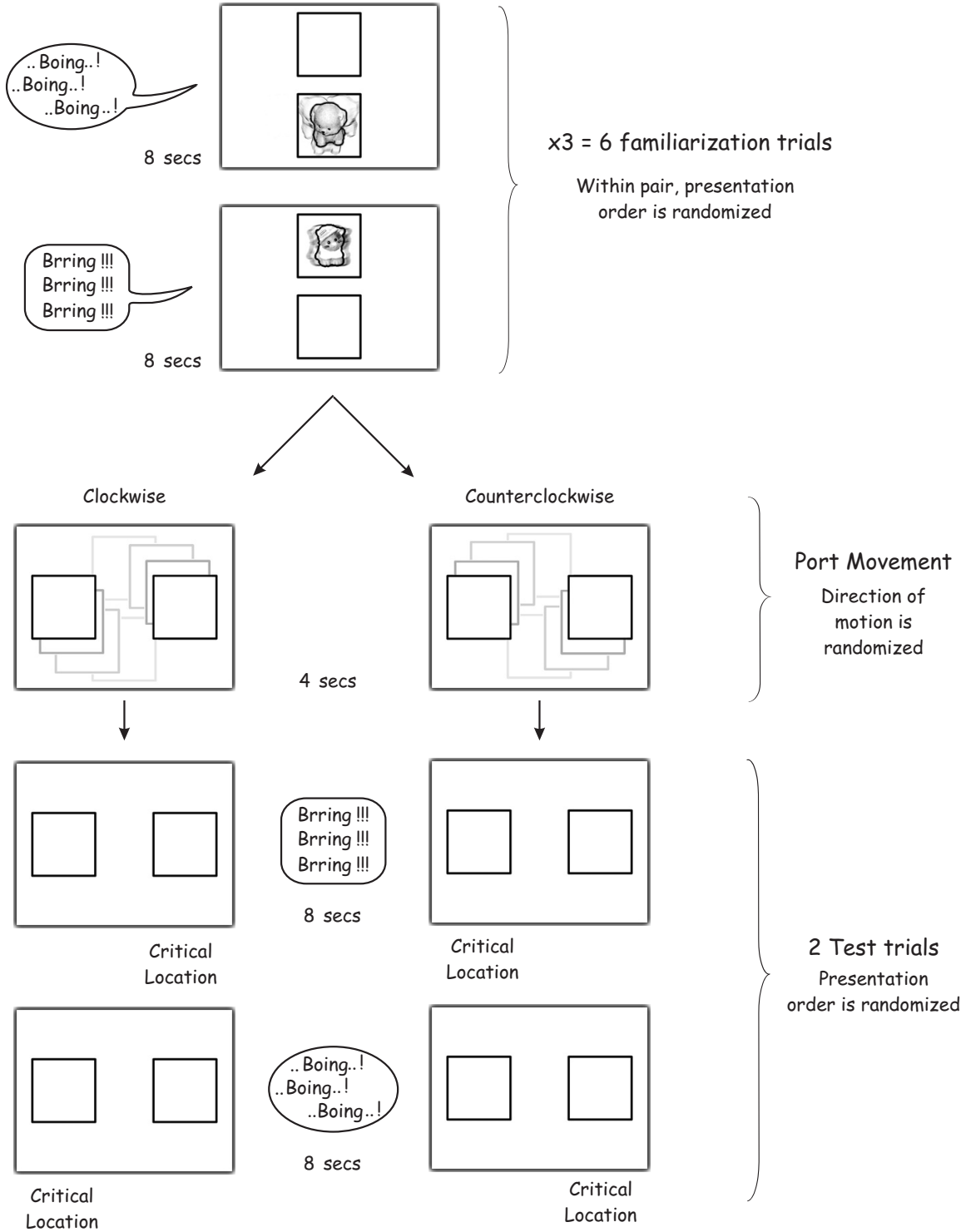
As in previous studies, but without explicit training (e.g. McMurray & Aslin, 2000), infants appeared to use spatial indices in order to bind object properties, in a manner analogous to Richardson & Spivey (2000).

It could be argued, however, that the infants have simply associated a certain sound with a certain location.

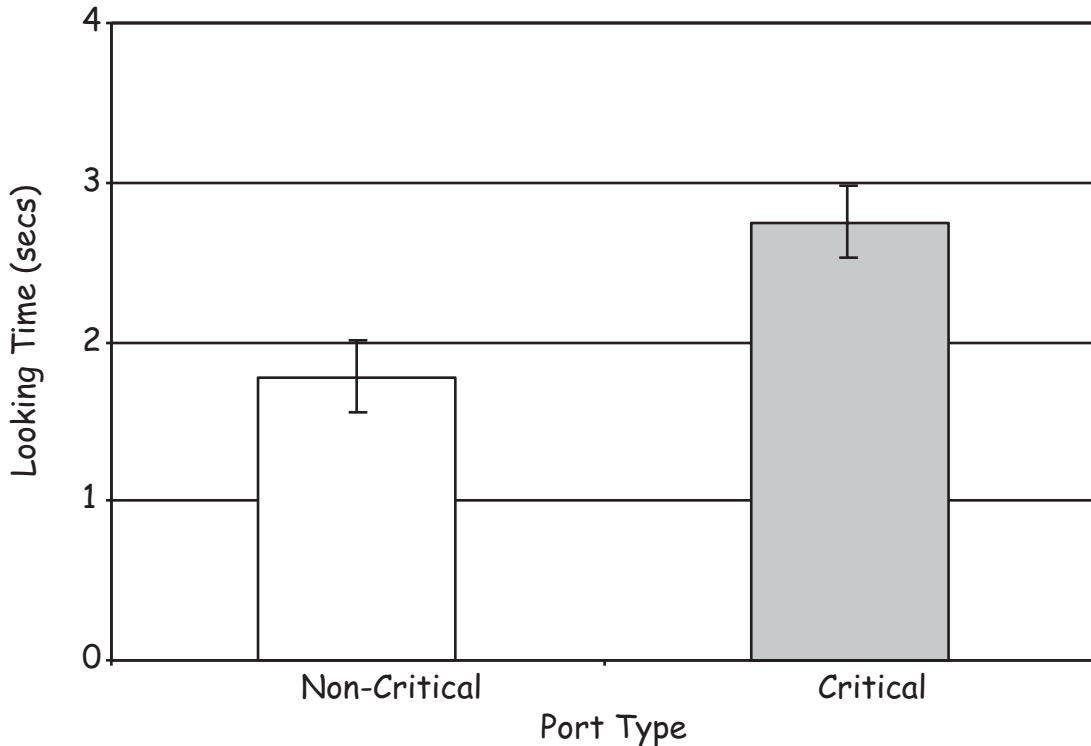


DESIGN

Schematic of the port movement manipulation of the current experiment.



RESULTS



There was a highly significant effect of port type ($F(1,10)=35.27, p<0.001$). Infants spent over 50% more time looking at the critical port.

Since the ports move position between familiarization and test trials, infants are not simply associating a sound with a look to the right or left. Our data suggest that the infants are binding the multimodal event to a something like a spatial index, which can be dynamically updated as the ports change location.

This indexing behaviour in six month olds is analogous to that reported in older infants (Leslie, Xu, Tremoulet & Scholl, 1998) and adults (Ballard, Hayhoe, Pook, & Rao, 1997; Richardson & Spivey, 2000; Scholl & Pylyshyn, 1999).

References

- Ballard, D. H., Hayhoe, M. M., Pook, P. K., & Rao, R. P. N. (1997). Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences*, 20, 723-767.
- Kirkham, N.Z., & Richardson, D.C. (2001, Oct). Eye tracking evidence of spatial indexing in infants: Binding multimodal properties by location. Poster presented at the Cognitive Development Society Conference, Virginia Beach, VA.
- Leslie, A.M., Xu, F., Tremoulet, P.D. & Scholl, B.J. (1998) Indexing and the object concept: developing 'what' and 'where' systems, *Trends in Cognitive Sciences*, 2, 1, 10-18.
- McMurray, B. & Aslin, R. N. (2000, July). Anticipatory Eye Movements: a technique for assessing auditory categorization in infants. Poster presented at the International Conference on Infant Studies, Brighton, England.
- Richardson, D. C., & Spivey, M. J. (2000). Representation, space, and Hollywood Squares: Looking at things that aren't there anymore. *Cognition*, 76, 269-295.
- Scholl, D. J., & Pylyshyn, Z. W. (1999). Tracking multiple items through occlusion: Clues to visual objecthood. *Cognitive Psychology*, 38, 259-290.

Acknowledgements

We gratefully acknowledge Scott Johnson and Michael Spivey for their support and helpful comments, Ernie and Ernestine for their tireless efforts in keeping the babies happy, and all the infants and parents without whose participation this research would not be possible. This research was supported by NSF grant BCS-0094814 to Scott P. Johnson.