

# THE WHYS, WHATS AND WHEREFORES OF SPATIAL DEVELOPMENT

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Babies are born with limited abilities to move around the world or to manipulate objects in it. They wave their arms and legs, and they curl their hands into fists when their palms are touched. But they cannot find their way anywhere, or use any of the astonishing number of tools invented by their forebears. How does this situation change? How do infants become adults who can navigate through unfamiliar territory and who can not only use but invent tools? Why will some infants become adults who are exceptionally skilled at these activities, while other infants will grow into the sort of adults who constantly get lost, or who put together a bookshelf backwards – the kind of people who refer to themselves deprecatingly as “not good with maps” or “not a do-it-yourself person”? And how can we maximize the spatial skills of the population to help meet the demands of a technological society, both for people who are fascinated by spatial challenges and wish to augment their abilities, and for those who are the future klutzes?

These seemingly simple questions disguise a territory of much greater complexity, characterized by substantial disagreement and fractionation. To take outright disagreement first, considerable debate has centered on the nature of normative development. Do infants develop into competent adults in a protracted course of development propelled by interactions with the physical environment (as Piaget thought)? Or do they develop due to social interactions, linguistic input, and apprenticeship in the use of cultural tools such as maps or the use of star systems (as Vygotsky thought)? Or are they actually equipped from the beginning with core knowledge of objects and space, later augmented by the acquisition of human language (as argued in the past few decades by Spelke)? The long history of arguments on these theoretical issues has been reviewed by Newcombe and Huttenlocher (2000, 2006; see also Newcombe, 2002). Newcombe and Huttenlocher have proposed an overarching perspective on spatial development called *adaptive combination* theory that unites the important insights of constructivism, Vygotskianism and nativism, while discarding some of the least tenable propositions of each. In terms of developmental theory, the adaptive combination framework is an example of *neoconstructivism* (see chapters in Johnson, 2009b and in Woodward & Needham, 2009; N N Newcombe, 2002). In terms of spatial cognition, the adaptive

combination framework is an example of *Bayesian* theories (see Cheng, Shettleworth, Huttenlocher & Rieser, 2007). One purpose of this talk will be to offer an overview of issues involved with how to characterize the typical course of spatial development, focusing on why adaptive combination is to be preferred to a core-knowledge approach.

Disagreement can be distressing, but fractionation (lack of any talk at all as opposed to disagreement and heated debate) is arguably worse. Lack of engagement ensures a lack of progress. Such lapses in communication have been seen in the field of spatial development in several ways. First, there is a gulf dividing researchers interested in normative development from researchers interested in individual differences. These researchers work in communities that do not speak much to each other and that use different methods and statistical techniques—experiments and analysis of variance in the study of normative development, and psychometric tests and correlational techniques in the study of individual differences. The two research communities even concentrate on different aspects of spatial cognition. Newcombe (2002) divided her review of spatial cognition into two main areas, *navigation* and *mental rotation*. The study of normative development has concentrated largely on navigation (with some exceptions), beginning in infancy with the study of search for objects hidden in the environment. In contrast, the study of individual differences (again with some exceptions) has largely focused on mental rotation and other skills that center on mental manipulation of objects. However, more than 50 years after Cronbach called for uniting the “two disciplines of scientific psychology” (Cronbach, 1957), we have started to see significant progress in integrating the study of normative development with the study of the development of individual differences.

There is a second fractionation, stemming in part from the difficulties in connecting research on normative functioning with research on individual differences. Lack of a coordinated approach has limited the ability of research on spatial development to contribute to the solution of applied and educational issues, notably how to foster the development of

the spatial skill increasingly required in a complex technological society. However, again there is the beginning of good news. More than 40 years after George Miller issued his call to “give psychology away” (Miller, 1956)?, we have started to see significant attention to using our understanding of spatial development to help people realize their full potential in spatial tasks (Kastens et al., 2009; Liben, 2006; National Research Council, 2006).

This talk will clarify why we should care about spatial cognition (*The Whys and Wherefores of Spatial Development*). In this section, I will introduce the distinction between two sub-domains of spatial skill: skills related to navigation (where are objects in relation to each other) and skills related to tool-making (representing individual objects and ways to transform them). I will then discuss what spatial development is the development of (*The Whats of Spatial Development*). This section expands on the typology offered in the first section, involving a key distinction between skills supporting navigation and skills supporting tool making. The section also touches on many issues that relate to the study of individual differences and our ability to assess them. Then will come an overview of the recent study of spatial development (*The Nature of Normative Development in Early Spatial Behavior*), concentrating on the contrast between the Spelke and Kinzler (2007) core knowledge perspective and the view of spatial development advanced by Newcombe and Huttenlocher (2000, 2006; see also Newcombe, 2002). The relevant literature for this section largely centers on infancy and early childhood, and mostly concerns behavior in small-scale spaces that are directly experienced rather than presented symbolically using maps or spatial language. In the last section of the talk, I will turn attention briefly to how to use what we know about spatial development to have translational impact on increasing spatial skills, and on reducing sex and SES differences in spatial skills (*How to Use What We Know*). Aiming for translational impact necessarily involves engagement with the sources and nature of individual differences.

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