SEXUAL SELECTION AND SEX DIFFERENCES IN SPATIAL COGNITION

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ABSTRACT: It is argued that a reliable and substantive sex difference, favoring males, exists in dynamic forms of spatial cognition, in particular, in the ability to mentally manipulate 3-dimensional representations of information, track movement in 3-dimensional space, navigate, and in terms of an implicit understanding of Euclidean features of physical space. It is proposed that these sex differences arise from the greater elaboration of the neurocognitive systems that have evolved for navigating and tracking movement in the 3-dimensional universe in males than in females. An evolutionary model of these sex differences is specified and examined in terms of the pattern of sex differences in navigational abilities that is evident across mammalian species, as well as in terms of anthropological, hormonal, and developmental patterns.

The thesis of this article is that a substantive sex difference exists, favoring males, in dynamic 3-dimensional spatial abilities and that this sex difference is largely the result of sexual selection and associated proximate biological (e.g., sex hormones) and developmental (e.g., play patterns) mechanisms. The sex difference in 3-dimensional spatial abilities appears to reflect the greater elaboration of the neurocognitive systems that support habitat navigation and representation in males than in females (Gaulin 1992). Sex differences are expected to be the largest for tasks that require the dynamic processing of information in three dimensions, because the neurocognitive systems that support habitat navigation directly mirror the 3-dimensional physical universe and are responsive to movement within physical space (Shepard 1994). Sex differences are expected to be smaller or nonexistent for processing 2-dimensional representations, because the neurocognitive systems that support habitat representation have evolved in a 3-dimensional, not a 2-dimensional universe, as well as for more static forms of spatial cognition (e.g., object

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location; Eals & Silverman 1994). Thus, the position presented herein should not be taken to mean that males have an advantage over females in all forms of spatial cognition (e.g. Caplan, MacPherson, & Tobin 1985; Halpern 1992).

As an organizing framework, the consideration of the sex difference in 3-dimensional spatial cognition will be in terms of goal structures and procedural and conceptual competencies, rather than simply in terms of the mental operations underlying this form of spatial cognition. This is because it appears that many forms of cognition are best understood in terms of goal structures, and conceptual and procedural competencies (Gelman 1990). Consider counting as an example of these competencies: the goal of counting is to determine the number of items in a set. Counting is achieved by means of procedures, such as pointing to or tagging with a word name each item as it is counted. The use of counting procedures, in turn, is constrained by conceptual knowledge. For instance, counting appears to be constrained by an implicit understanding that each item must be tagged once and only once (Gelman & Gallistel 1978). As in counting, a complete understanding of all forms of cognition might require models that accommodate each of these competencies, as well as biological and environmental influences on their development and expression (Hall 1992).

A complete consideration of the sex difference in 3-dimensional spatial cognition also requires a consideration of the pressures that might have differentially affected the evolution of males and females, that is, sexual selection. The first section below briefly describes the principles of sexual selection and how sexual selection might have operated to create a sex difference in 3-dimensional spatial cognition. The second section describes sex differences on relevant spatial tasks, while the third presents a consideration of hormonal and developmental mechanisms in the expression of spatial skills.

SEXUAL SELECTION

Darwin (1859/1872) argued that sexual selection "depends, not on a struggle for existence in relation to other organic beings or external conditions, but on a struggle between the individuals of one sex . . . the result is not death to the unsuccessful competitor, but few or no offspring" (p. 69). If sexual selection has operated in the evolution of a species, then males and females of that species differ, to some extent, in reproductive strategies (i.e., relative amount of time devoted to finding mates or raising offspring). A sex difference in reproductive strategies, in turn, is typically associated with physical and behavioral differences, shaped by sexual selection, between males and females (Daly & Wilson 1983). Trivers (1972) argued differences in male and female level of investment in offspring "governs the operation of sexual selection" (p. 141), and, as such, is the ultimate cause of any associated sex difference in reproductive strategies. The model predicts that the sex that invests the least in