

RESPONSE: A BIOSOCIAL FRAMEWORK FOR STUDYING COGNITIVE SEX DIFFERENCES

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The diversity of opinion and approaches exemplified by the articles in this special issue attest to the need for an organizing framework for studying cognitive sex differences. Any such framework must allow for a consideration of cognitive sex differences from multiple levels, ranging from broad evolutionary and cultural influences at the most general level, to differences in the ways in which males and females approach individual items on cognitive tasks at the most specific level. In the first section below, a conceptual framework for considering evolutionary and cultural influences on sex differences in cognition is presented. The second section provides a suggestion for examining more task specific sex differences.

EVOLUTION, CULTURE, AND COGNITIVE SEX DIFFERENCES

One approach to studying children's cognition might also prove to be useful in the study of cognitive sex differences (Geary 1995 in press). With this approach, cognitive abilities are conceptualized as being biologically-primary or biologically-secondary. Biologically-primary cognitive abilities are those that have been directly shaped by evolutionary pressures, that is, by means of either natural or sexual selection. Primary abilities, such as language, are found pan culturally, appear to be supported by a neurobiological architecture that is designed to process domain-specific information (e.g., processing language sounds), and develop

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in natural contexts, that is, during children's play or social activities (Geary 1995; Pinker & Bloom 1990; Witelson 1987).

Biologically-secondary abilities, in contrast, tend to be found only in technologically complex societies and largely develop in unnatural contexts, that is, schools. Reading would be one example of a secondary cognitive ability. Although evolved neurocognitive systems appear to be designed for the acquisition and maintenance of primary abilities, for human beings it appears that these systems can also be adapted for the acquisition of secondary abilities. I have argued elsewhere that there are at least two ways in which primary abilities can be used to support the acquisition of secondary abilities (Geary in press). The first involves the co-optation of primary systems for use on secondary tasks. For instance, the phonological systems that enable the automatic segmentation of language sounds during social discourse appear to be co-opted during the early phases of reading acquisition, specifically for word decoding. If a word is not recognized during reading, then word decoding is used to sound the word out. The phonological processing systems did not evolve for word decoding but can be co-opted for this purpose.

The second way in which evolved primary abilities might influence the acquisition of secondary abilities is by access to knowledge that is implicit in the organization of the neurocognitive systems that support primary abilities. An implicit understanding of the essential features of primary domains is likely realized as the associated neurobiological systems are activated during the processing of domain-specific information. For instance, the implicit understanding that the fastest way to move from one place to another is to "go as the crow flies" is likely built into the architecture of the neurocognitive systems that support habitat navigation and realized during the act of navigating from one location to another. It appears that the neurocognitive systems that support habitat navigation are co-opted during the solution of some secondary tasks, such as the items on Mental Rotation Test (Vandenberg & Kuse 1978), and that the associated implicit knowledge also influences the conceptual understanding of some secondary domains, such as high school geometry (Geary in press).

Even though the same neurocognitive systems must, perforce, support primary and secondary abilities, there appears to be an important difference in the ease with which primary and secondary abilities are acquired. The competencies that are associated with primary abilities appear to be acquired more or less effortlessly during the child's natural activities. For most individuals, the acquisition of secondary abilities requires engagement in more deliberate and effortful activities, which are typically organized by cultural goals and implemented in schools. Thus, language acquisition and developing cognitive maps of one's habitat are less effortful than learning how to read or learning high school geometry.

There are several important implications of this framework for the study and interpretation of cognitive sex differences. The first concerns whether the ability in question represents a primary or secondary domain. For instance, the finding that females are typically better, on average, than males on measures of language fluency (e.g., speech production) probably represents a primary sex difference. Stated differently, there is reason to suspect that sexual selection, broadly defined,

has resulted in the greater elaboration of many sociocognitive systems (e.g., language, reading nonverbal facial expressions) in females than in males (Eibl-Eibesfeldt 1989; Geary in press; McGuinness & Pribram 1979), and the sex difference, favoring females, in verbal fluency is one manifestation of these differences. Although analogical problem solving is probably a primary ability (Gillan, Premack, & Woodruff 1981), the solving of verbal analogies, such as those on the SAT, is more likely to represent a secondary ability. On this view, the "contradictory" findings that females are often better on verbal fluency measures and males are often better on verbal analogy tests is understandable because these are two different classes of verbal ability.

The argument is essentially the same as Halpern and Wright's (1996)—that the examination of sex differences must be based on underlying processes—with the addition that the initial classification of tasks might be facilitated by considering whether they are likely to represent relatively primary or relatively secondary abilities. This distinction places the examination sex differences within the wider context of human evolution, provides a framework for decomposing cognitive tasks, and for considering the source of the sex difference on the tasks. For instance, one potential source of any sex difference is the pattern of experiences needed for the acquisition of primary and secondary abilities, as noted by Baeninger and Newcombe (1995).

Experience is almost certainly necessary for the normal development of most primary abilities. Any sex difference in primary domains is likely to be preceded by biologically-mediated differences in the play patterns of boys and girls (McGuinness & Pribram 1979). In contrast, for any sex differences in secondary domains, wider cultural influences need to be considered. For instance, changes in the schooling of boys and girls, or changes in the opportunities available to boys and girls in the wider culture, might result in historical changes in the magnitude of sex differences on secondary cognitive tasks, such as the verbal SAT, but little change in more primary domains, such as verbal fluency.

In addition to schooling and wider cultural influences, when sex differences are found in secondary domains, the possibility that these differences reflect more primary cognitive differences also needs to be explored. For instance, I have recently argued that the male advantage in certain secondary mathematical domains, such as geometry, reflects a more primary sex difference, favoring males, in the degree to which the neurocognitive systems that support habitat navigation have been elaborated over the course of human evolution (Geary in press). As noted above, knowledge implicit in architecture of these systems appears to reflect Euclidean features of the physical universe, which, in turn, appears to facilitate the acquisition of certain geometric principles (e.g., Euclid's basic postulates). Note, however, that the argument here is for a very specific sex difference, not a general male advantage in geometry. Sex differences in other secondary mathematical domains might reflect cultural, as well as biological, influences, such as the sex difference in the number of higher-level mathematics courses taken during high school.

The implication of this argument is that the interpretation of any cognitive sex differences must be based on a careful consideration of whether the task repre-

sents a primary species-typical cognitive domain, such as language, or whether the task in question represents a more secondary culturally-specific cognitive domain, such as reading. The dissection of any sex differences in secondary domains should, in turn, consider which primary abilities support the domain, whether there are any sex differences in these more primary domains, as well as the effects of schooling on the acquisition of the competencies associated with the secondary domain. For the latter, we should consider whether schooling contributes to the observed sex differences. For instance, the organization of classroom activities can differentially influence the acquisition of secondary mathematical abilities in boys and girls— competitive environments facilitate skill acquisition in boys whereas small-group cooperative learning environments facilitate skill acquisition in girls (e.g., Peterson & Fennema 1985).

STRATEGY CHOICES AND COMPONENT PROCESSES

Moreover, whether the domain in question is primary or secondary, a complete understanding of the nature and implications of any cognitive sex difference will almost certainly require a much more fine-grain assessment of task performance than is typically done (Halpern & Wright 1996). An example of the utility of this approach can be found in children's arithmetic. In this area, trial-by-trial assessments of the strategies, and speed of executing the underlying processes, used for solving simple and complex arithmetic problems are obtained. Though time consuming, this approach has yielded insights into children's arithmetical development and the source of individual and group differences in arithmetical abilities that would not have been possible with grosser psychometric and information-processing measures (Geary, Fan, & Bow-Thomas 1992; Siegler 1987). The adoption of such an approach for the study of cognitive sex differences will likely reveal that both males and females use of variety of strategies during problem solving in many, if not all, domains, that males and females often use the same types of strategies, but for domains in which consistent sex differences are found the mix of strategies will consistently differ for males and females. Of course, sex differences in the speed of executing certain component processes might differ as well (e.g., Kail, Carter, & Pellegrino 1979).

SUMMARY AND CONCLUSION

All cognitive abilities must to some extent be supported by evolved neurocognitive systems. However, evolutionary pressures have not directly shaped all measurable cognitive abilities, nor are these pressures likely to be responsible for all

observed cognitive sex differences. This is because human beings are capable of using evolved cognitive systems in ways unrelated to their original evolutionary function (Gould & Vrba 1982). Thus, in the study of cognitive sex differences, it might be useful to consider whether any such difference is found for an evolved biologically primary domain or whether the difference is found for more secondary, culturally-specific domains.

Experience is likely to be needed for the normal acquisition of both primary and secondary abilities (Geary 1995). The acquisition primary abilities appears to be facilitated by children's natural activities, such as play, whereas the acquisition of secondary abilities appears to be strongly influenced by schooling. For primary domains, the experiential component of any sex difference in cognition is likely to be reflected in the early play activities of boys and girls (McGuinness & Pribram 1979). For secondary domains, the schooling of boys and girls and the different ways in which they might react in instructional environments need to be considered as important experiential factors contributing to the sex difference (Geary in press). Finally, progress in this area, whether for primary or secondary domains, will likely depend on the adoption of finer-grain assessments of the mix of strategies that boys and girls use in problem solving and the processes that govern these strategy choices.

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