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Biology, Experience, and Sex-Dimorphic Behaviors

8

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The question of the existence and origin of sex differences has been debated by philosophers and scientists for centuries. Much of the debate has centered around the relative importance of biological versus experiential influences. At one extreme, it has been argued that men and women are destined by biology to play quite different roles in society and to have quite distinct personalities (see Freud 1965). At the other extreme, it has been argued that sex roles in modern-day society result totally from markedly different socialization experiences for boys and girls; biology is assumed to play a minimal role in the maintenance of sex roles. Most scientific investigators today do not take a simple either-or position concerning the determinants of sex differences. Instead, human development is seen as the result of the dynamic interaction between an individual's biological makeup and experiences with the environment. The crux of the debate lies in disagreement over the exact nature of the interactions between experience and biology in shaping the sex-dimorphic patterns associated with some social behaviors.

In considering the interactive role of biological and experiential processes, several important issues arise. First, we must identify those sex-dimorphic behaviors that are influenced to some degree by biological processes. It is safe to assume that all behavior is influenced by socialization and experience. Man is just too adaptable for this not to be true. It is also very likely that some behaviors are shaped totally by experiential factors. The question becomes, Which of the remaining behaviors are shaped at least to some degree by biological processes? Typically, social scientists have relied on four sources of information in deciding which sex-dimorphic behaviors these might be: (a) demonstrations of an association between hormonal and behavioral variations, (b) behavioral patterns among infants or very young children, (c) cross-cultural universals, and (d) cross-species consistency, especially among higher primates. While a clear result in any one of these categories suggests the importance of biological influences, congruent findings from two or more categories provide much stronger evidence of a biologically mediated mechanism. Taking this more conservative criterion, it now seems likely that biological processes are involved in the following sex-dimorphic behavior clusters: aggression and/or activity level; a set of limited cognitive skills associated with spatial visualizations and

perhaps mathematical reasoning and verbal skills as well; and parenting. Each of these will be discussed in more detail later.

Having identified plausible candidate behaviors, the next question becomes, How are the biological effects mediated? To say something has a biological basis does not, in and of itself, tell us much. It simply narrows the search of possible causal determinants. Real progress depends on the identification of the specific biological mechanisms responsible. In addition, the nature of the interaction between specific biological and experiential processes in shaping behavioral development must be delineated. Biological processes do not unfold in a cultural experiential vacuum. Likewise, experience does not accumulate in a biologically neutral organism. The interaction between these two forces is undoubtedly quite complex and extremely varied in its specific details. Nevertheless, a complete understanding of the origins and development of sex-role dimorphic behavioral systems is dependent on our knowledge of both the biological mechanisms themselves and the nature of their interaction with experiential forces.

In seeking this understanding, two additional issues need to be considered. First, it should be noted that the distinction between biological and experiential causes is rarely a clear issue. The empirical data are generally ambiguous enough to allow room for interpretations based more on the scientist's theoretical perspective than on the actual data. Key to these interpretations is the individual scientist's assumptions regarding the behavioral phenomena to be explained, the presumed mechanisms of the biological effect, and the malleability of this effect. Take the impact of anatomical differences on development as an example. In deeming anatomy to be destiny, Freud was suggesting that a child's anatomical structure, which is biologically determined, has an *inevitable* and *irreversible* effect on the child's personality development that is *independent* of any differential treatment from socialization agents. This stance has been classified within the domain of biological influences on behavioral development because it stresses an *inevitable* effect of anatomical features that originates *inside* the individual.

In contrast, a number of investigators have focused on the effect of the child's anatomical sex on caregiver behavior. For example, several studies have demonstrated that people respond differently to the same baby depending on whether they think the baby is a boy or a girl (for example, Condry and Condry 1976). While these studies suggest that one causal source of parents' behaviors is a child's anatomy, this work is generally cited as evidence supporting an experiential explanation of the origin of sex-role dimorphism. The link of anatomy to behavioral development is *not* assumed to be direct, internally generated, or inevitable; it is assumed that caregiver responses could be changed if the meaning of anatomical differences were changed and that the impact of caregiver responses can be modified by sub-

sequent experiences. Thus, while these theorists acknowledge that anatomy is a biological event of some note, they assume that it exerts its influence primarily through social processes.

Second, one has to be aware of the fact that there is a wide range of effects that might reflect biological processes. For example, hormones have a direct effect on prenatal morphological development leading to anatomical sex dimorphism (see Money and Ehrhardt 1972; Wilson, George, and Griffin 1981). Hormones also have a direct effect on the development of the brain such that exposure to specific prenatal steroids programs subsequent brain activity including cyclicity of gonadal control and postpubertal responsivity to the various steroids (see McEwen 1981). Further, studies with primates clearly suggest that the effects of prenatal exposure to various steroids on the brain include behavioral dimorphism as well as anatomical and neural dimorphism (see Bardin and Catterall 1981; McEwen 1981; Money and Ehrhardt 1972; Reinisch 1981). For example, exposure to androgens has been found to increase the frequency of rough-and-tumble play in primates. These examples illustrate a direct link between a specific biological process and a sex-dimorphic consequence.

At a more indirect level, boys and girls may differ not because of the sex-linked hormonal effect itself but because of interactions between gender and other biological processes that themselves have a direct effect on behavior and experience. Consider for example maturation rate, a biological process that influences both behavior and experiences. Girls on the average mature more rapidly than boys. They are born neurologically more mature, pass many of the developmental milestones earlier, and reach sexual maturity sooner than boys (see Frieze et al. 1978). Because boys and girls differ in their maturational rates, they may develop different skills, thus eliciting different responses from their social environment. For example, Sherman (1971) has suggested that the early advantage girls have in language could predispose them to rely on verbal modes of problem solving rather than to acquire both verbal and nonverbal problem-solving skills. This, in turn, could account for the fact that girls do less well than boys on tasks requiring spatial visualization. Waber (1979) has suggested an alternative explanation for the sex difference in spatial visualization that also relies on the fact that girls reach sexual maturity earlier than boys. She suggests that brain lateralization (the degree to which each hemisphere of one's brain specializes in certain functions) proceeds until one reaches puberty, at which point brain lateralization, like growth, slows dramatically. Because boys mature later, their brains are more lateralized. Finally, Waber argues that greater lateralization facilitates spatial visualization and consequently, delayed puberty is responsible, in part, for males doing better on the average than females on spatial-visualization tasks. These examples indicate that some sex-dimorphic patterns may be mediated by the interaction of sex

and other biological processes such as maturation rate rather than by biological processes linked more directly to sex such as the hormonal effects discussed in the previous paragraph.

Even more indirectly, biological processes may affect some factor that is correlated with sex (like size) and is *assumed* by parents to be related to other factors (like fragility). Consequently, parents may respond differently to boys and girls and thus socialize, unnecessarily, consistent patterns of sex-dimorphic behavior. For example, males are born larger and remain somewhat larger than females. Size and muscle mass may be linked phenomenologically to perceived fragility. In turn, boys may be assumed to be tough and because, in fact, they are born bigger and have stronger neck muscles they may be treated less gingerly than girls. As a consequence boys may develop more active play patterns (see Maccoby and Jacklin 1974).

It can be seen from these examples that determination of what constitutes a biological effect is a complex issue. Biological processes can impinge on sex-role dimorphism directly (females have babies while males do not); males have penises while females do not; males have higher levels of testosterone; females have higher levels of estrogens and progesterone), or quite indirectly (through maturational rates, body size, or morbidity rates). Further, no matter how the biological processes are manifest, their influences on behavior are undoubtedly mediated by their interaction with experiential forces. It is to this issue that I now turn.

As was stressed in the preceding paragraph, the delineation of biological effects independent of consideration of experiential effects is impossible. Biological processes do not unfold in a cultural, experiential vacuum. Likewise, the delineation of experiential effects independent of a consideration of biological processes is futile, if not impossible. Experience does not accumulate in a biologically neutral organism. In addition, neither of these processes (biological and experiential) take place in a sociohistorically neutral context. It is the interactions of all of these processes (biological, psychological, and sociohistorical) that determine behavior.

Peterson (1980) has recently outlined a dialectical model of the interactive effects of biology and experience based on the thinking of Sameroff (1977) and Riegel (1976). The model makes the following assumptions. First, individuals continue to grow and change throughout their life spans. Second, this growth is determined by the interplay of biological, psychological, sociocultural, and historical processes. Third, the interactive nature of development is itself not static but is shifting and accumulating across time. For example, at some points in one's life span, biological processes may have greater influence than at other times, for example, during the prenatal and pubertal periods or while one is pregnant. Similarly, the nature of the interaction between experience and biology may vary across one's life time. For example, maturational rate may have little influence on the effects

of experience among twenty-year-olds but may have a direct and powerful effect on the entire course of one's early adolescent experiences. Furthermore, a specific form of biological or experiential interaction can have a lasting effect on all subsequent development of one person and little or no effect on another person. For example, consider a girl who matures very early. Not only will this biological event affect basic processes such as brain lateralization; it will also affect social events at a very critical developmental time. If attractive, she may be drawn into an early social-dating pattern that, in turn, may distract her from her studies. Thus, her rate of maturation can affect both her career possibilities and the spatial-visual training she receives during high school. Together these forces could shape the direction of her future life as well as the social experiences she has while an adolescent.

As can be seen in the previous example, it is not only the relative importance of biological and social processes that one must consider; the very form of the interaction between them may change as an individual grows and develops. Consequently we can not expect an easy answer to the question of the origin of sex-role dimorphism. It is necessary to specify not only the particular behavior but also both the developmental age of the individuals being considered, and the sociocultural environment in which these individuals are developing. Such an analysis will not only help us to describe the interaction of biological and experiential forces at one point in time; even more interestingly, such an analysis will also lead us to an investigation of the nature of the interactive processes themselves rather than to a static analysis of the differential causes of temporally fixed behavioral events.

Before turning to a discussion of specific patterns of behavior I must address the final issue—the malleability of biological effects. Biological processes are often assumed to be stable, inevitable, and relatively immutable while social and psychological processes are assumed to be more unstable, variable, and arbitrary. Both these assumptions are now being questioned, especially as we learn more about specific biological mechanisms and about their interaction with social forces. Indeed, identifying the specific biological mechanisms underlying a particular behavior may provide the means of behavioral modification and cultural change rather than sealing our "fate." For example, tooth decay is determined in part by soft enamel, which is an inheritable characteristic. Soft enamel can be eliminated, however, by providing fluoride to developing fetuses and young children. In this instance, then, an environmental manipulation can override a biologically based individual difference. Similarly, while increasing evidence points to the role of sex-dimorphic brain lateralization patterns in sex-differentiated spatial-visualization skills (Wittig and Peterson 1979), appropriate training can largely eliminate the sex differences in performance (Connor, Serbin, and Schackman 1977). Thus, to conclude that

some characteristic or behavioral system has a biological substratum is *not* to say that it is immutable to exogenous influences.

Having introduced the complexities of the relation between biology and experience in shaping sex-dimorphic patterns of behavior, I will now turn to a more specific discussion. As noted earlier, there is some consensus now that biological processes are implicated in certain sex-dimorphic behavior patterns. In particular, sex differences in certain limited cognitive skills, in aggression, and in parenting behaviors occur with such regularity that it is highly probable that biological processes are involved. The remainder of the chapter will be devoted to a discussion of these behavior patterns and the current state of our understanding of the forces shaping these patterns.

Sex Differences in Cognitive Skills

Three areas of cognitive functioning are commonly cited (see Maccoby and Jacklin 1974; Wittig and Petersen 1979) as revealing fairly consistent patterns of sex differences. These are verbal skills, quantitative skills, and spatial visualization. The findings with regard to verbal skills (a) are equivocal, depending on the particular measures of verbal skills used; (b) seem to be limited primarily to area of verbal fluency; and (c) are either not present or are not very large among older adolescents and adults (cf. Frieze et al. 1978). Furthermore, no consistent theories of possible biological mediators have emerged with the exception of early brain lateralization and maturation rates. These theories will be discussed in more detail in connection with spatial skills.

More extensive research has focused on the sex differences in spatial-visualization and quantitative skills. In both areas the patterns of results are fairly consistent both within our culture and cross-culturally. Males do better than females in these skills after puberty. Since these differences are often linked to each other, and since the sex difference in spatial skills is repeatedly nominated as the cause of the sex difference in tests of quantitative reasoning, the evidence for each will be discussed separately; then the possible link between them and the possible biological mediators of both differences will be discussed together.

Quantitative Skills

The pattern of sex differences in mathematics achievement is fairly consistent across studies using a variety of achievement tests. High-school boys usually do somewhat better than girls on tests of mathematical reasoning

(primarily solving word problems); boys and girls do about the same on tests of algebra and basic mathematical knowledge; and girls occasionally outperform boys on tests of computation skills. The differences favoring boys, however, do not emerge with any consistency prior to the tenth grade, are typically not very large, and even in the advanced high school groups are not found universally (see Fox, Brody, and Tobin 1980; Maccoby and Jacklin 1974; and Wittig and Petersen 1979 for reveiw of studies prior to 1975. More recent work includes Burnett, Lane and Dratt 1979; Fennema and Sherman 1977, 1978; Schratz 1978; Sherman 1980a, in press; Starr 1979; Armstrong 1980; Connor and Servin 1980; ETS 1979; Steel and Wise 1979). Several of the recent studies have used large national samples (for example, Armstrong 1980; ETS 1979; and Steel and Wise 1979). The pattern of results with these national samples is quite consistent and provides strong support for the conclusions reached above. Nonetheless, even these studies reveal some inconsistencies, and studies of smaller, more specialized samples yield an even more inconsistent picture. For example, while ETS (1979) replicated the typical sex differences on the Scholastic Aptitude Test (SAT) scores, the magnitude of this difference varied across ability levels, being most pronounced in the top 10 percent of the students. In addition the school grades of the test takers did not differ by sex. Similarly, Fennema and Sherman (1977) found the expected sex difference in achievement in only two of four high schools studied; and finally, Schratz (1978) found that the direction of the sex difference varies across different ethnic groups.

There is one recent study that runs counter to the developmental pattern commonly reported. Benbow and Stanley (1980) have found a very consistent pattern of sex differences in mathematical achievement among highly gifted seventh-grade participants in the Johns Hopkins Study of Mathematically Gifted Youth. Year after year these boys outperform the girls by an average of 30 points (equivalent to 2 problems) on the Scholastic Aptitude Test for Mathematics. Why this might be the case is not yet known. But, it is interesting to note a consistency between this finding and the finding reported by ETS (1979). Sex differences on SAT-M are more marked among the most gifted high-school test takers. Apparently, sex differences also emerge earlier among the gifted.

In conclusion, adolescent males typically outperform adolescent females on tests of mathematical achievement. Furthermore, in most studies these differences exist, although to a lesser degree, even when one corrects for the number of mathematical courses taken (Armstrong 1980; Sherman 1980a; Starr 1979; Steel and Wise, 1979). But, even though the pattern of sex difference is fairly consistent, it is not inevitable; when it is found it is generally small; it is not apparent in the normal population prior to adolescence; and it is not typically reflected as a sex difference in course grades.

Spatial Skills

As was the case with mathematical achievement, the findings regarding sex differences in spatial skills are fairly consistent, though not universal, and do not emerge prior to the tenth grade. After junior high school boys begin to outperform girls on some measures of spatial skills (see Maccoby and Jacklin 1974; and Wittig and Petersen 1979 for reviews of earlier studies). Recent studies (including Burnett, Lane, and Dratt 1979; Connor, Schackman, and Serbin 1978; Fennema and Sherman 1977, 1978; Sherman, 1980a, Steel and Wise 1979) support the earlier conclusions but suggest that the magnitude of this effect varies depending on maturational timing (Waber 1979; Herbst and Petersen 1980), on body type (degree of masculinization; Petersen 1979), on personality characteristics associated with masculinity and femininity (Nash 1979), on previous experience with spatial activities (Connor, Schackman, and Serbin 1978; Sherman 1980c), on ethnic background, parental styles, and socioeconomic status (Fennema and Sherman 1977; Nash 1979; Schratz 1978; Gitelson 1980), and on the particular test given (Connor and Serbin 1980). In fact, in a recent national survey study of 3,240 junior and senior high-school students, thirteen-year-old girls were found to do better on a test of spatial skill than thirteen-year-old boys; twelfth-grade boys and girls did equally well (Armstrong 1980). Thus, as Connor and Serbin (1980) conclude, "junior and senior high school males . . . perform better than females on some visual-spatial measures, some of the time" (p. 36).

Relation of Spatial Skills to Quantitative Skills

The possibility that sex differences in spatial skills (supposedly biologically determined) mediate sex differences in mathematical achievement has become a popular hypotheses (see Burnett, Lane, and Dratt 1979; Hyde, Geiringer, and Yin 1975; Maccoby and Jacklin 1974; Sherman 1967; Wittig and Petersen 1979; Connor and Serbin 1980; Sherman 1980c). In assessing the hypothesis that the sex difference in spatial skills underlies the sex difference in mathematical achievement, three issues need to be discussed. First, is there a relation between spatial skills and mathematical achievement? Second, is this relation equivalent for both boys and girls? And third, does the sex difference in spatial skills mediate the sex difference in mathematical achievement?

With regard to the first question, several studies have demonstrated a strong positive correlation (r, ranging from .50 to .60) between spatial skills and a variety of measures of mathematical achievement test scores (Burnett, Lane, and Dratt 1979; Fennema and Sherman 1977, 1978; Sherman 1980a;

Armstrong 1980; Connor and Serbin 1980; Steel and Wise 1979). But it should be noted that verbal abilities also correlate quite highly with mathematical performance (Fennema and Sherman 1977, 1978; Sherman 1980a; Armstrong, 1980; Connor and Serbin 1980). In the most comprehensive study of the relation between spatial skills, verbal skills, and mathematical achievement, Connor and Serbin (1980) found a very inconsistent pattern of relations. While some measures of both verbal and spatial skills emerge as significant predictors of general mathematical achievement, not all measures of spatial skills correlated significantly with all measures of mathematical achievement, and the patterns of these relations varied among grade level and sex. Furthermore, when they factored their measures, the spatial skills scores factored together and independent of the factors containing all the measures of mathematical achievement.

Thus, it appears that the relation between spatial skills and mathematical achievement is not yet fully understood. While studies have yielded a fairly consistent positive relation between these two cognitive tasks, whether this relationship has the unique quality suggested by proponents of the spatial-visual skills to mathematical reasoning ability link is still an open question. It is quite possible that the unique link of mathematical reasoning to spatial-visual skills is operative only at the higher levels of mathematical reasoning. Perhaps at the levels of mathematical reasoning encountered by most high-school students, the link between verbal abilities and mathematical reasoning is just as powerful. If this were the case, then we would expect spatial skills to become an increasingly important skill for mathematical achievement and verbal skills to become less important as students move into more advanced mathematics courses. The findings of Fennema and Sherman (1977) provide support for this suggestion, but more work is needed.

Several investigators have addressed the question of whether the relation between spatial skills and mathematical achievement varies across the sexes. No consistent findings have emerged: Sherman (1980a) found the relation to be stronger among girls. In contrast, Hyde, Geiringer, and Yen (1975), Steel and Wise (1979), and Connor and Serbin (1980) have all found the relation to be stronger among boys. (In fact, Steel and Wise 1979 found attitudinal factors to be a stronger predictor of mathematical achievement than spatial skills for girls; and Connor and Serbin (1980) found verbal abilities to be a stronger predictor than spatial skills for girls). Finally, Fennema and Sherman (1977, 1978) and Burnett, Lane, and Dratt (1979) found no sex difference in the strength of the relation.

The issue most central to this discussion is the question of whether the sex difference in spatial ability mediates the sex difference in mathematical achievement. Basically one approach has been used to answer this question, namely, an evaluation of the effects of statistically partialling out spatial skill differences on the pattern of mathematical achievement scores. By and

large, sex differences in mathematical achievement scores are significantly reduced or eliminated when spatial skills are partialled out (Burnett, Lane, and Dratt 1979; Fennema and Sherman 1977; and Hyde, Geiringer, and Yen 1975). However, as Burnett, Lane, and Dratt (1979) point out, one can not conclude from these results that the spatial-skill differential is causing the mathematical-achievement differential. One can conclude only that the data are consistent with that hypothesis. The findings reported earlier on the relations of verbal skills to girls' mathematical achievement scores make this caveat even more critical. Additionally, Fennema and Sherman (1977) found that the sex differences in mathematical achievement can also be statistically eliminated by partialling out either the number of courses taken or a set of attitudes toward math that are sex differentiated.

What can we conclude? There are sex differences in both mathematical achievement and spatial skills among eleventh and twelfth graders. These differences seem to persist into adulthood in those limited populations studied (primarily college students). Whether or not the sex difference in spatial skills is contributing to the sex difference in mathematical achievement is still an open question. The pattern of findings to date is consistent with that hypothesis, but a causal relationship has yet to be established.

Further, whether or not the sex differences in either mathematical ability or spatial skills are contributing to the sex differences in participation in or attitudes toward mathematics is an even more open issue at present. Attitude differences emerge at a younger age than do the sex differences in either achievement or spatial skills. While it is possible that the girls are already sensing that they are less "able" in mathematics in spite of the fact that they are doing just as well as the boys, it seems more likely that the drop in girls' attitudes is a consequence primarily of social factors.

In contrast to the drop in girls' attitudes toward math, the drop in girls' participation rate is more likely to reflect, to some degree, whatever sex differences in mathematical aptitude are ultimately uncovered. In the few studies that have attempted to predict participation rates in high-school students, spatial visualization sometimes emerges as a significant predictor, though not always, for both girls and boys (Sherman, in press, spatial skills predicted for girls only; Wise, Steel, and MacDonald 1979, spatial skill predicted for boys only). Participation is also predicted by scores on vocabulary tests (Sherman, in press), by past math achievements (Fennema 1981; Parsons et al. 1981; Armstrong 1980; Wise, Steel, and MacDonald 1979; Dunteman, Wisenbaker, and Taylor 1979), by interest in mathematics and career plans (see Fennema 1981; Parsons et al. 1981; Wise, Steel, and Mac-Donald 1979) and by a variety of attitudinal and social factors that will be reviewed in the next section. Additionally, spatial visualization skills can be trained. Thus, the magnitude of the contribution of biological factors, the inevitability of their effects, and the exact nature of these effects are still to be determined.

Biological Theories for the Sex Difference in
Spatial Skills

Setting aside the issue of whether or not sex differences in spatial skills underlie sex differences in quantitative skills or interests, the pattern of sex differences in spatial skills is certainly consistent enough to suggest a biological mediator. Several have been proposed, of which three have received the most attention: (a) an X-linked recessive gene, (b) brain lateralization, and (c) hormonal effects on cognition.

Recessive Gene Hypotheses. Geneticists have suggested that there might be a recessive gene on the X chromosome that has a positive influence on spatial perception. Since males have only one X chromosome, if they receive the recessive gene it would express itself as exceptional spatial perception. In contrast, since girls have two X chromosomes, they would need two recessive genes in order to have exceptional spatial perception. Consequently, since the likelihood of getting two recessive genes is less than the likelihood of getting one recessive gene, males on the average should have a greater chance than females of developing exceptional spatial perception. Thus, if it could be demonstrated that spatial perception is influenced by a recessive gene on the X chromosome, then one would have uncovered a biological basis for the average advantage males have on tasks involving spatial perception (Stafford 1961).

To test this hypothesis, the intrafamilial correlations of performance on spatial tasks have been examined. Since sons receive their X chromosome from their mothers and not their fathers, correlations of performance between sons and mothers should be much higher than the correlations between sons and fathers. Data from early studies confirmed this prediction (Bock and Kolakowski 1973; Corah 1965; Hartlage 1970). However, two recent studies with very large samples have found no evidence for the X-linked recessive gene hypothesis (DeFries et al. 1976; Williams 1975). Thus, present evidence seems to discount the hypothesis of an X-linked recessive trait of high spatial ability.

Brain Lateralization Hypotheses. Another biological explanation for sex dimorphic spatial abilities is differential brain lateralization. The human brain is divided into two hemispheres: the right and the left. Recent studies on split-brain subjects (individuals whose hemispheres have been separated) suggest that each hemisphere of the brain specializes in certain abilities, the left hemisphere specializing in verbal abilities and the right hemisphere specializing in spatial perception (Levy-Agresti and Sperry 1968; Sperry and Levy 1970). At some point in development, lateralization (the specialization in the functioning of each hemisphere) begins, and one hemisphere, usually the left, becomes dominant in its control of an individual's behavior. It has

been argued that the timing of this lateralization may affect the development of both spatial and verbal skills. Since the most consistent sex differences in cognitive functioning are found on tasks involving either spatial or verbal skills, it has been suggested that differential timing of lateralization might underlie, to some extent, these sex differences (Harris 1978). The reasoning goes something like this: Males perform spatial tasks better than females, and females perform verbal tasks better than males. There is lateralization of the brain in relation to these two skills. Lateralization may begin earlier in females than males. Perhaps delayed lateralization gives males an advantage on spatial skills, while early lateralization gives females an advantage on verbal skills.

The sex difference in the timing of lateralization does receive fairly consistent support. Several developmental studies suggest that lateralization begins earlier in girls (Kimura 1967; Knox and Kimura 1970) although this claim is still quite controversial (see Bryden 1979; Maccoby and Jacklin 1974).

The findings with regard to more complete lateralization in postpubertal males are more consistent (see McGlone 1980; Bryden 1979). When sex differences emerge, postpubertal males exhibit a pattern of responses congruent with the hypothesis that their brains are more lateralized for both verbal and spatial-visual information processing. Bryden (1979) has offered three possible explanations for this difference. "First, there may be a real biological difference in cerebral organization between males and females, so that cognitive and perceptual functions are more likely to be bilaterally represented in females than in males" (p. 138). Based on her review of the clinical studies of brain-damaged patients, McGlone (1980) concluded that this hypothesis now has sufficient support to be taken seriously. While the majority of the commentors on her review agreed at least in part with this conclusion, several did not (for example, Denenberg 1980; Fairweather 1980; Kinsbourne 1980; Sherman 1980b). Thus, whether males' brains are structurally lateralized to a greater extent than females is still an open question.

As a second possible explanation, Bryden (1979) suggested that the observed differences might arise from the test procedures employed. Females may use different strategies when performing the tasks used to measure cerebral lateralization. Sherman (1971), Harris (1978), and Rudel, Denckla and Spaltar (1974) have all made a similar suggestion, namely, that the sex difference in spatial skills may result from females relying on a verbal rather than a spatial mode in solving spatial-visualization tasks. Since verbal strategies are less efficient than spatial strategies for these tasks, females will perform more poorly than males, especially in comparison to their relative performances on verbal tasks. Both Bryden (1979) and Rudel, Denckla, and Spaltar (1974) have found some empirical support for this

suggestion. But the extent to which this explanation accounts for the apparent sex differences in brain lateralization is still unknown.

Bryden's (1979) third suggestion is the most plausible and the most complex: specifically, Bryden suggests that sex differences in apparent brain lateralization reflect the interactive effect of strategy differences and cerebral organization. "That is, perhaps females pursue different strategies . . . because their cerebral organization is different" (p. 138) and conversely, perhaps adopting different strategies solidifies or augments the magnitude of cerebral organizational differences. Harris (1978) has made a similar suggestion and there is some rudimentary empirical support for this interactionist position (see Bryden 1979). But the exact nature of differences in cerebral organization and the nature of the interactions between experience, available cognitive strategies, and cerebral organization are as yet unknown. The relations will be quite complex because the interactionist position is really suggesting that not only is the interaction of specific experiences with specific cognitive skills important but so also is the interactions among various cognitive skills and cerebral organization in determining the cognitive strategy which an individual will use for any given problem situation.

Hormonal Hypotheses. Several researchers have suggested the possibility that hormones may be implicated in the sex dimorphism of cognitive skills, especially spatial skills. The hypotheses have taken two basic forms. The first set of hypotheses focuses on the impact of hormones on the brain during the prenatal period; sex-differentiated exposure to prenatal testosterone, it has been argued, might account for later sex dimorphism in cognitive functioning. Early studies of adrenogenital syndrome girls (girls who have been exposed to unusually high levels of an androgen due to genetic problems) and of the effects of exposure of the mother to exogenous, androgen-like compounds during pregnancy have yielded some support for this suggestion. These studies indicated that the females exposed to such compounds had slightly higher IQs than normal (see Ehrhardt and Meyer-Bahlburg 1981). However, recent studies with appropriate controls have failed to find any relation between prenatal exposure to abnormally high levels of androgens and later cognitive functioning.

Two other clinical syndromes have yielded an interesting pattern of results related to the hypothesized relation between prenatal hormones and subsequent cognitive functioning. Both androgen-insensitive (XY) females (individuals who are anatomical females because their bodies are insensitive to androgen) and Turner syndrome females (individuals who are anatomical females because they lack a second sex chromosome) do relatively poorly on spatial tasks (see Reinisch, Gandelman, and Spiegel 1979). These groups were exposed prenatally either to very low levels of androgens or to no func-

tional androgens. The pattern of their performance scores is consistent with the hypothesis that exposure to prenatal androgens facilitates later performance on spatial tasks. The results, however, are also compatible with other explanations. The evidence from the Turner syndrome females is especially difficult to interpret since the level of their exposure to prenatal hormone is confounded with the absence of a second sex chromosome.

Reinisch, Gandelman, and Spiegel (1979) have offered an alternative suggestion regarding the effects of prenatal hormones on later cognitive function that could explain both the general patterns of sex dimorphism in spatial skills and the specific patterns exhibited by individuals with either of these two syndromes. Since exposure to prenatal androgens is related positively to activity level in childhood (this will be discussed more extensively later), Reinisch and his co-workers argue that activity-level differences resulting from variation in the level of prenatal androgens could produce differences in experience that, in turn, could account for the sex dimorphism found on tests of spatial skills. Consistent with this point of view, Connor, Serbin, and Schackman (1977) have suggested a relation between preschoolers' preference for large-muscle, exploratory play and their performance on tests of spatial skills. The success of training studies in increasing females' performance on tests of spatial skills also provides support for the importance of experience in developing spatial skills (see Connor, Schackman, and Serbin 1978; Goldstein and Chance 1965). However, whether sex differences in activity level per se are sufficient to produce sex-dimorphic performance on tests of spatial skill is still unknown. What is most interesting about Reinisch, Gandelman, and Spiegel's (1979) hypothesis is that it points out quite clearly that one must entertain a very broad view of the possible interactions between biological processes and experience in shaping behavior.

The second set of hormonal hypotheses focuses on the possible direct effects of postpubertal hormone level on cognitive functioning. Broverman and his colleagues (1980) have carried out an extensive investigation of the relation between sex hormones (primarily androgens) and cognitive performance. Most of their work has focused on males. Within that body of research it is now fairly clear that relatively high levels of testosterone impede the performance of males on the kinds of tasks commonly used to measure spatial visualization (see Broverman, Klaiber, and Vogel, 1980). In a study using the degree of androgenization of one's body as an indicator of testosterone levels, Petersen (1979) found comparable results for males; the males who had the least androgenized body type in terms of muscle mass, body shape, penis size, and pubic hair distribution did the best on tests of spatial ability. However, for females, the results ran counter to the effects found in males; the females who had the most androgenized body type did the best on the tests of spatial skills. Petersen (1979) concluded that "an-

drogynous males and females tend to excel at spatial ability . . . whereas individuals who are more sex-stereotypic in appearance tend to do poorer at spatial ability" (p. 204).

Thus, a simple hormonal explanation of sex dimorphism on spatial tasks seems unlikely. It is not the case that low levels of androgens are always associated with spatial skills. If that were true then females would have higher spatial skills than males. Nor is it the case that patterns of relations will be the same in males and females. As Petersen (1979) suggested, the effects of hormones on cognitive functioning are quite complex and probably interact with several mechanisms such as maturational rate, body type, brain lateralization, and the social channeling of experiences resulting from early or late maturation and body type. For example, Waber (1979) has demonstrated that late maturation facilitates spatial skills. Late maturers also tend to have greater brain lateralization and more androgynous body types (that is, tall, slender, and athletic). While hormones may be implicated in each of these processes, they may or may not be a cause of sex dimorphism in spatial skills. Given the similarity of these relations, it is difficult to separate out what is actually causing what and how these variables might be interacting with each other or with other causally critical variables.

In conclusion, a variety of biological processes are being investigated in the attempt to explain sex differences in cognitive functioning. The research is still in its infant stages; no definitive answers are now available. The following conclusion, however, seems clear at present: (1) the factors shaping sex differences in cognitive functioning will be complex and highly interactive; (2) different factors may shape the performance of males and females; (3) different factors may shape performance at different ages; and (4) experience in interaction with biology will play a major causal role.

Sex Differences in Parenting

The consistency of both cross-cultural and cross-species behavior suggests that a biological component may be associated with the sex-dimorphic pattern of parenting. Parenting in both primates and humans is generally the female's job. But whether this role assignment is biologically based is an extremely difficult question. In considering cross-cultural patterns, for example, it must be noted that there is considerable overlap in both the socialization patterns and the ecological realities to which cultures must adapt. For example, while women are the child-raisers in most cultures, at the same time most cultures actively socialize girls into this role (Barry, Bacon, and Child 1957). Additionally, in many cultures mothers are the primary protein food source for infants and thus, by necessity, must be assigned the role of nursing the infants. Since women are needed to nurse

the infants they bear, and since contraceptives are often not readily available, women have to spend most of their adult years around the children. It makes practical sense, then, to assign them the role of raising the children. Thus, it is difficult to know whether this division of roles was selected according to evolutionary factors or whether it reflects a common solution to a common survival problem (Archer 1976).

Such overlaps in socialization patterns, ecological demands, and cultural universals make evaluation of the relative importance of socialization and biology very difficult. Socialization could be producing the differences, it could be exaggerating a small biologically based difference, or it could be mirroring a powerful biologically determined behavioral system (Archer 1976; Goldberg 1973; Maccoby and Jacklin 1974; Reiter 1975, 1976; Rosaldo and Lamphere 1974). Because these distinctions between relative weighting are crucial in our conceptualization of sex-role malleability, they have important implications for social change. Unfortunately, for most behaviors, including parenting, it is not possible as yet to decide this issue, and much of what is being debated today is primarily speculative. Having women do the major parenting is adaptive from both a cultural and an evolutionary perspective. Thus, it is plausible that both biosocial and socialization forces are pushing women to fulfill this role. The role of socialization has been demonstrated time and time again; the role of biosocial forces is much harder to assess.

In one of the most persuasive discussions of this issue, Rossi (1977) argued that evolutionary forces have selected for heightened maternal investment in children, greater propensity for acquiring parenting skills in females, and reciprocal, physiologically based bonding systems in both infants and mothers. The evidence she cited speaks most directly to the last of these three, namely, the physiologically based bonding system. There are physiological events associated with early attachment. For example, an infant's cry stimulates the mother's secretion of oxytocin, which, in turn, prepares her breasts for nursing. The hormone oxytocin is also involved in sexual responsiveness. Thus, there is a link between the sexual response and the lactation system such that nursing can produce enjoyable sexual sensations. On a more behavioral level, Rossi cited several studies indicating that there may be a biosocial component in early attachment. For example, mothers regularly exhibit a fixed sequence of behaviors when they first explore their new infants. In addition, Klaus and Kennell (1976) have argued that mothers are in a "sensitive period" just after birth such that exposure to their infants then solidifies the mother-infant attachment bond. Supposedly a solid bond facilitates later interaction while disruption of the early contact between mothers and infants may have long-range effects on mother-child attachments evidenced by such behaviors as child abuse and neglect. While early studies provided some support for Klaus and Kennell's

suggestion, more recent studies have failed to demonstrate any long-term advantage of early contact that cannot be accounted for by the general excitement associated with the birthing process and the positive social and emotional milieu associated with those early days of parenting (see Lamb and Goldberg, 1980; Parke and Sawin 1977). These processes are potentially available to fathers as well as mothers.

Thus, while it does seem that biosocial forces may be involved in mother-child bonding, the nature of these forces and the extent to which they operate differentially in men and women are unknown. While evidence from the animal literature suggests that hormonal changes associated with pregnancy and parturition might be involved (see Lamb 1975), generalizations across species are problematic. This is especially true for parenting since there is little similarity between human parenting behaviors and the parenting behaviors of rodents. Until more work is done with higher primates and humans, the role of hormonal shifts in "priming" parenting behavior in human mothers is still unknown. And it seems likely that whatever hormonal effects may emerge, their impact on mother-child bonding has undoubtedly been heightened by a heavy overlay of socialization pressures.

We know very little about bonding in fathers. Because child-rearing is assumed to be the domain of women, bonding processes have rarely been studied in men. Further, in many cultures, fathers are systematically excluded from the birth process and from early contact with infants. If bonding is affected by early contact (still a debatable hypothesis), then cultures effectively block the natural attachment between fathers and their infants. Some evidence does, in fact, suggest that early contact between father and infant affects subsequent measures of attachment in the predicted direction (see Lamb and Goldberg 1980). Thus, it is not yet possible to assess the *extent* to which biosocial forces foster parent-child bonding as opposed to mother-child bonding. An examination of cross-cultural and cross-species fathering can at least provide some insights into the potential for and range of expression of father-child attachment. By showing the range of potential father-child involvement, we can at least speculate on the possible malleability of parenting role assignments.

The degree of paternal involvement in the parenting of higher primates is quite variable. In some species, for example, rhesus monkeys, baboons, and chimpanzees, males play little if any direct role in parenting; in other species, for example many New World monkeys, particularly marmosets, males play a very active parenting role (Redican 1976). Further, there have been instances in which the males of a low-paternal species exhibited a high degree of involvement when the situation warranted these behaviors.

The range of parenting behaviors is also quite broad. According to Redican (1976), males exhibit, albeit with lower frequency, the full range of

parental behaviors commonly exhibited by females; for example, they "premasticate food for infants"; "carry, sleep with, groom, play with" and teach the young; and provide refuge "during periods of high emotional arousal" (p. 378). In addition, they exhibit the behaviors commonly associated with the male protector role. Thus it seems that paternal involvement is clearly within the repertoire of behaviors available to high primate species.

Are there factors that influence the extent of paternal involvement of primates? Redican (1976) suggests that the following factors influence the involvement of primate fathers in raising offspring: (a) monogamous social organization; (b) availability of stable food supply; (c) low levels of competition and hostility between different social groupings of the same species; and (d) relaxed, permissive maternal-infant interactions. These structural characteristics suggest that paternal involvement is high when paternity is readily identifiable, when males are not needed for the warrior-hunter role, and when females tolerate and encourage male parenting.

Can one generalize the findings concerning primate parenting to humans? With results similar to Redican, West and Konner (1976) conclude that plasticity in the extent and form of paternal behavior is also characteristic of human males. Like primates, human males are universally less involved in parenting than females, but they too exhibit a wide range of parenting behaviors when necessary. West and Konner (1976) suggest the following structural arrangements as facilitative of human paternal involvements: (a) monogamy; (b) nuclear family units; (c) low levels of local warfare; (d) maternal employment; and (e) a gathering and/or agricultural economy. As is the case with the subhuman primates, then, human paternal involvement is increased by easily identifiable paternity, low demand for the warrior-hunter role, and high opportunity and need for father-child interaction. Men take care of their children if they are sure they are the fathers, if they are not needed as warriors and hunters, if the mothers contribute to family resources, and if their parenting is both necessary and encouraged.

But, even when all of these conditions are present, men still play a less active role than women in child-rearing. Is this difference biologically based? We do not know. On the one hand, there is some evidence that testosterone lowers maternal behavior in lower animals (West and Konner 1976). Further, studies of adrenogenital syndrome females have repeatedly found that girls who have been exposed to unusually high levels of prenatal androgens are less interested in doll play than are the "normal" controls (see Ehrhardt and Meyer-Bahlburg, 1979, 1981). Whether these effects are related to adult parenting behavior, and whether they are a direct consequence of hormonal exposure or an indirect consequence of other variables such as activity level, are still unanswered questions.

On the other hand, neither socialization pressures nor birthing practices

encourage paternal involvement. For example, Ember (1973) found that helping to take care of younger children increases nurturing and socially responsible behaviors in boys. Whether these boys will exhibit more paternal behaviors as adults is yet to be seen. But if they do, then early experience with caring for younger children may be another of those precursors of "maternal" caring that is generally denied to males.

Similarly, several recent laboratory studies of parenting behavior have uncovered a pattern of results that run counter to the theme of biologically based sex differences in parenting. For example, Frodi and Lamb (1978) compared natural, unlearned psychophysiologically based responses with overt, learned behavioral responses. While the males and females in this study did differ in their overt behavioral response to infants, they did not differ in their psychophysiologically based responses. These results suggest that while the physiological responses associated with responding to infants are present equally in both males and females, males and females differ in their behavioral responses to these physiological cues. Females appear more likely to respond with parenting-like behaviors while males are more likely to ignore or withdraw from the infants. Studies with parents demonstrate even more clearly that both fathers and mothers have the capacity to parent. Fathers have been found to be as capable as mothers in performing childcare activities, and as sensitive as mothers in their responses to infant signals (Parke and Sawin 1977). Further, mothers and fathers display identical physiological responses to both infant cries and infant smiles even though the mothers report more extreme emotions (Frodi et al. 1978a, b).

What could account for this pattern of results? A recent series of studies by Feldman and her colleagues (Feldman and Nash 1978; Feldman, Nash, and Cutrona 1977; Abraham, Feldman, and Nash 1978) and by Frodi and Lamb (1978) demonstrate that the expression of parenting-like behaviors is under strong social control. For example, behavioral responsivity varies with life stage such that a sex difference is present at puberty and among very new parents but not among college students, young adults, childless couples, and cohabiting adults. Further, men and women report more attraction to babies in same-sex groups than in mixed-sex groups, and the likelihood of public disclosure increases women's expressed attraction to babies and decreases men's (Berman et al. 1975). These findings suggest that the overt expression of parenting behaviors are linked to sex-role socialization and to the salience of one's need to appear appropriately sex-typed. Whether the expression of parenting behaviors is also under biological control is an open question.

An alternative explanation for the lower participation of fathers in parenting is suggested by the dialectical perspective. Perhaps sex dimorphism in parenting is not a consequence of differences in response to infants alone but instead is a consequence of the broad array of tasks that involve

men and women. In addition to the cross-cultural consistency in the assignment of parenting to mothers, the warrior-defender-provider role is usually assigned to males. If you recall, fathers are more involved in child care when there is relatively little need for their involvement in the warrior-defender role and when the provider role is shared more equally with mothers. This pattern suggests that the factors influencing sex dimorphism in those behaviors commonly associated with males also influence men's involvement in the parenting role.

In line with this reasoning, it is also possible that men and women are equally invested in their children but express their investment in different ways. Most studies of parental investment have defined investment in terms of typical maternal behaviors. Few studies have attempted to assess investment in terms of male values or male behaviors. Can we conclude that males are less invested in their children if they are not actively involved in day-to-day child-care? Men may express their investment in their children through their provider-protector role rather than through a nurturing parent role. Children serve many different needs for adults; some needs are more typical of women while others are more typical of men (Hoffman and Hoffman 1973). Assessing the differential subjective importance of these various values will be an extremely difficult task.

In conclusion, it appears that adaptability in parenting styles for both males and females is as much a part of our biosocial heritage as is heightened maternal investment in children. In addition, it is clear that investment can be expressed in a variety of ways. More research is needed on the whole range of relevant behaviors, and on a wider array of possible biological inputs and mechanisms of interaction between biology and experience.

Aggression

For the most part, reviewers and researchers have both concluded that adult males (both humans and primates) generally exhibit more intraspecies physical aggression (see Archer 1976; Frodi, Macaulay and Thome 1977; Reinisch 1981; Rosenblatt and Cunningham 1976). They are far more likely than females to be involved in combat and in various other forms of antisocial aggression. For example, as noted earlier, the warrior-provider role is virtually always assigned to the male. Similarly, men are much more likely to be involved in violent crimes than women. In fact, while in recent years the general crime rate has been rising more rapidly among women than among men, the incidence of violent crime is still rising more rapidly among men (*Newsweek* 1975). Measures reflecting attitudes toward aggression reveal a similar pattern; Gallup polls have repeatedly indicated that women in the United States are much less likely than men to endorse either military

involvement of any kind, or capital punishment (see Frieze et al. 1978). Finally, younger males also typically exhibit more rough-and-tumble play and more physical aggression than females (see Maccoby and Jacklin 1974; Whiting and Edwards 1973).

As consistent as these global patterns are, however, males are not always more aggressive than females. Recent reviews of the available literature suggest notable exceptions that are critical to any understanding of the determinants of aggression. According to Hoyenga and Hoyenga (1979), both the size of the animal and the reproductive state of the female must be taken into account. Sex dimorphism in aggression is much less marked among species in which males and females are of approximately equal size. Additionally, lactating females have been known to be quite aggressive in defense of their young (Floody and Pfaff 1977). Frodi et al. (1977) pointed out several other exceptions. In particular, they noted that female aggression goes up in situations in which aggression is condoned and in which cues likely to elicit empathical responses are minimized. Finally, several reviewers have argued that we have not yet studied the full range of aggressive behaviors. Researchers have tended to focus on those forms of aggression that are more characteristic of males—a problem that stems from the basic difficulty in defining aggression. Consequently we do not really know whether sex differences exist in many forms of aggressive behavior. Nonetheless, at least in terms of physical aggression and open displays of hostility, the pattern of results is consistent enough to entertain biological hypotheses. It is to these hypotheses that I now turn.

Hormonal Hypotheses

Two basic modes of hormonal influence have been proposed: an inductive mode and an activation mode. Hormonal induction refers to the process by which prenatal or perinatal hormones affect the development of the brain. Critical embryological periods have been identified in most species. In subhuman primates, exposure to the appropriate gonadal hormones at that period appears to "masculinize" the brain, increase the frequency of masculine behavior patterns, and sensitize the brain to postpubertal exposures of various gonadal hormones. Hormonal activation refers to the process by which exposure to different gonadal hormones affects an animal's ongoing behavior. With regard to gonadal hormones, activation usually occurs postpubertally.

There is ample evidence in subhuman mammals that prenatal and perinatal exposure to androgens influences aggressive behavior patterns. Both genetic male and female animals exposed to androgens at the critical period exhibit high levels of rough-and-tumble play as juveniles (Young, Goy and

Phoenix 1964) and other forms of aggressive display as adults (see Money and Ehrhardt 1972; Reinisch 1981). In addition, sensitivity to androgens postpubertally is also affected. Animals exposed to androgens pre- or peri-natally typically respond with increased aggression and activity level when given androgens postpubertally (see McEwen 1981; Money and Ehrhardt 1972; Reinisch 1981). Interestingly, in some species exposure to estrogens produces comparable results (Bronson and Desjardins 1968).

Whether prenatal exposure to androgens has a comparable effect in humans is a difficult question to answer, primarily because it is unethical to run comparable studies with humans. Instead, scientists have had to rely on "natural" experiments—experiments in which the prenatal hormonal environment has been varied for some "natural" reason. Ehrhardt, Money, Meyer-Bahlburg, and Reinisch have used these naturally occurring deviations from the normal pattern of sexual differentiation to assess the possible impact of prenatal hormones on human sex-role dimorphism.

A word of caution is necessary before beginning this review. Some of these studies are based on a small number of clinical cases in which subjects differed from a "normal" sample in several important ways, for example, prenatal hormonal history, appearance of genitalia at birth, and membership in a clinical population. Given the uniqueness of these individuals, generalizations must be made with extreme caution. In addition, the causal origins of the behavioral patterns in these samples are unclear. The patterns could have resulted from their exposure to the prenatal hormones, from their familiarity with the clinical setting, from their awareness of their own uniqueness, from the reactions of others who know about their unique status, or from some interaction of two or more of these. The more recent work of Reinisch, and of Ehrhardt and Meyer-Bahlburg, has avoided some of these problems by studying populations without abnormal genitalia at birth.

The classic work in this area (that of Money and Ehrhardt) involved children suffering from the adrenogenital syndrome. These children had been exposed to unusually high levels of androgen or androgen-like components prenatally either because their own adrenal systems were malfunctioning or because their mothers were given synthetic progestins to prevent miscarriage. The girls in these studies typically had "masculinized" genitalia at birth and were involved in clinical treatment of varying degrees. Both adrenogenital-syndrome boys and girls reported higher than "normal" involvement in active sports.

The more recent work of Ehrhardt and Meyer-Bahlburg (1979) and Reinisch (1981) has focused on children whose mothers were exposed to a synthetic progestin that has androgenizing properties in the fetus. Children in these studies did not have abnormal genitalia and were not undergoing clinical treatment. By and large results similar to those reported above have emerged. These children exhibit higher levels of activity usually in the form

of participation in active sports. One study (Zussman, Zussman and Dalton 1977) found that boys of mothers given a natural progesterone during pregnancy were more aggressive in school and more likely to get into trouble as a result than "normal" boys. Finally, Reinisch (1981) found a higher level of self-reported hostility and preference for physically aggressive solutions to problems than their sib-controls among both boys and girls whose mothers were given synthetic progestins.

These studies suggest a link between prenatal exposure to hormones and subsequent behaviors. But while the androgenized children did evidence higher activity levels, they did not in general exhibit more physically aggressive behavior. This failure to find a significant increase in aggression suggests that socialization dictates the expression, if not the emergence, of any potential for greater aggressive behavior that might be created by prenatal androgens. Perhaps instead of physical aggressiveness per se, prenatal androgens predispose the developing organism to a higher level of physical activity, the exact manifestation of which is dependent on socialization (Frieze et al. 1978). Alternatively, prenatal androgens may create a potential for aggressiveness that requires postnatal androgens for its expression. Consequently, since these females are being treated and therefore are not being exposed to postnatal androgens, it would not be expected that they would exhibit the typically high level of aggression displayed by males (Frieze et al. 1978).

Work demonstrating the activation effects of gonadal hormones has also revealed a consistent pattern among subhuman mammals. Aggression in normal males is increased by exposure to androgens; aggression in females does not appear to be as much under the control of androgens as male aggression unless the female is exposed to high dosages over a prolonged period of time; and finally, female aggression does seem to be somewhat under the control of hormonal variations associated with lactation (see Hoyenga and Hoyenga 1979 for a full review). Even these effects, however, are subject to social influences. The relation between aggression and androgens is lower among the more social species, among more mature animals, and after certain kinds of experience that are typically related to an animal's position in the dominance hierarchy. Further, in some species the effect of androgens on aggression depends on the levels of other circulating hormones; in particular, the female hormones. Finally, in subhuman primates it is clear that experience can have as much of an effect on androgen levels as androgen levels can have on behavior. In particular, both stress and dominance position affect testosterone levels (Macrides, Bartke, and Dalterio 1975; Rose, Holaday, and Bernstein 1979).

A similar pattern of mixed findings has emerged with humans. While Persky, Smith, and Basu (1971) found a positive relation between levels of circulating androgens and self-reported projective measures of hostility and aggression, these results were more characteristic of the younger men in

their sample. Subsequent studies have failed to replicate their result (see Ehrenkranz, Bless, and Sheard 1974; Kreuz and Rose 1972; Persky et al. 1977). Similarly, while some studies report that injections of testosterone lead to an increased level of aggression, activity, and a sense of well-being, other studies indicate that injections of antiandrogens do not significantly reduce aggressive behaviors in criminal and mentally ill populations unless massive dosages are used (see Rubin, Reinisch, and Hasbett 1981). Finally, while criminals imprisoned for violent crimes do tend to have higher levels of circulating testosterone than do criminals imprisoned for nonviolent crimes, the levels of testosterone do not correlate with ongoing levels of aggressive behavior at the time the measures are taken (Kreuz and Rose 1972).

Males and females differ on one other set of characteristics that is also related to androgens; namely, body characteristics. Males have body characteristics that may suit them better for physical aggression. They are bigger, have more muscle mass, have higher metabolism rates, and have a higher proportion of red blood corpuscles (Schienfeld 1958). Given the findings in the animal literature that larger animals are typically the more aggressive, sex differences in size could certainly contribute to the sex differences in aggression.

Reviewing this body of literature, Hoyenga and Hoyenga (1979) concluded that testosterones, if they have any causal impact, appear to have that impact during adolescence. The relation between aggression and testosterone is reduced during later adulthood, perhaps due to the effects of experience and socialization. Whether this is indeed true, however, is still unknown. As Petersen (1980) concludes, the relation between aggression and androgens in humans is unclear at present, but is likely to exist at some level and to be highly subject to learning and to environmental influences.

Other Hypotheses

Two other hypotheses have been offered for sex difference in aggression: (a) inhibition of aggression in women by other responses such as guilt and empathy, and (b) infant-parent interactions that dialectically evolve into a pattern likely to encourage greater aggression in boys. Each of these are discussed briefly below.

Several reviewers have suggested that females are less aggressive because they are more of something else. The most common competing responses are empathy and guilt. As Frodi, Macauley, and Thome (1977) point out, there is enough evidence from laboratory studies of aggression to support the conclusion that levels of aggression are affected by empathic responses and by guilt, and that females appear to be more subject to these effects than are men. Additionally, there is some evidence to suggest that

women's physiological responses to their own aggressive acts are different from those of men. Women do not display the physiological signs of relief as readily as do men following a counteraggressive act (see Frodi, Macauley, and Thome 1977 for full review). Consequently, it is possible that aggression in women is inhibited both by empathic responses prior to an aggressive act and by the guilt feelings that follow such an act. Together these two mechanisms would certainly reduce the likelihood of aggressive behaviors in women. But how these sex differences are acquired is not known, and the possible biological mediators have yet to be studied.

Another hypothesis, first proposed by Bell (1968), is based on the assumption that infant characteristics like irritability and activity level influence the response of parents. Parental responses, in turn, shape further infant development, which, in turn, shapes parent-infant interactions. Through their impact on this cyclical process of developing interactive patterns, then, individual differences in early infant characteristics can "create" individual differences in major behavioral patterns later in life. One specific example used by Bell to illustrate this process is the sex difference in aggression. He argued that, if boys are more irritable at birth, then one could expect a more negative infant-parent interaction to evolve and, consequently, boys would become more aggressive than girls. The process he described is outlined in table 8-1.

Table 8-1
Possible Interactions between Baby's Characteristics and Parental Responsiveness

Baby A (More likely to be a girl)	Baby B (More likely to be a boy)
Baby's characteristics	
Physically mature	Physically immature
Sleeps a lot	Cries a lot
Vocalizes to faces	Active and therefore gets into trouble
Smiles at faces	
Parent Response	
Affectionate	Irritable
Responsive when child does cry	Not necessarily reponsive to child's frequent cries
Talks to child	Uses physical restraints and punishments
Child Response	
Affiliative—likes people, expects people to satisfy needs	Aggressive
Early vocalization	Expects to get needs satisfied through own efforts

Source: I.H. Frieze, J.E. Parsons, P. Johnson, D.N. Ruble, and G. Zellerman, *Women and Sex Roles*, New York: Norton and Company, 1978, p. 78. Reprinted with permission.

Some evidence suggests that male infants are fussier or more irritable than female infants, for example Moss (1967). The results depend, however, on a variety of other factors, such as specific age at testing, prenatal and delivery complications (Parmalee and Stern 1972) and birth order. Nevertheless, when differences are found, male infants are generally the more irritable. And, whatever the cause of this early difference in irritability, the crux of Bell's hypothesis is that these sex-related differences in neonatal temperament could set in motion a social interaction pattern that would result in boys being more negative, resistive, and aggressive than girls. Circular interactive processes between the parent and child thus could turn the irritable baby into the aggressive child (Bell 1968).

Conclusion

What then can we say about sex differences in aggression? Aggression is an excellent example of the dialectical model of the interaction of biology and experience in shaping behavior. We know that biological events during the prenatal period can affect expression of aggressive behavior later in life. We also know that experience has a major impact on not only the expression of aggression but also on the biological system itself. For example, it is clear that stress and dominance placement in both humans and subhuman mammals affect levels of hormone production in males. Thus, the link between behavior and hormones goes in both directions. Further, we know that experience can alter the degree of the relation between hormones and behavior. For example, castration after puberty has a much less dramatic effect on aggressive behavior than does castration prior to puberty (see Hoyenga and Hoyenga 1979). We also know that the expression of aggression is multiply determined, that it is under the influence of a variety of factors including socialization pressures, the intercession of incompatible emotions such as guilt and empathy, and social norms, and that it can take a variety of forms ranging from murder to weekend college football. Finally, we know that the origin of the sex difference is multiply determined and is influenced not only by a variety of social events but also by a variety of biologically initiated processes including prenatal hormones and maturational rates. Like the two clusters of behaviors discussed earlier, aggression is a complex behavior that is shaped by a multitude of processes that wax and wane across each individual's life span.

Summary

This chapter began with two major goals: (a) the presentation of a dialectical model for the interaction of biology and experience in shaping behav-

ior; and (b) the presentation of three examples of these processes that relate directly to our understanding of the origins of sex-dimorphic behavior. Each of the examples (cognitive functioning, parenting, and aggression) were illustrative of the complex interaction between a wide range of forces in shaping human behavior. In addition, each example demonstrated the range of forces that might be responsible for channeling behavior along sex-dimorphic paths. It should be noted before closing that the sex differences in each instance are small, that variability in the expression of any of these behaviors is the norm, and that for the most part variability within each sex is as great, if not greater, than the average differences between the sexes.

This brings us back to the issue of malleability of behavior. It is on this issue that I wish to close my discussion. The extent to which biology sets in motion the dialectical processes that, in the end, produce sex-dimorphic behavior patterns is not yet known. But to the extent that biology is an important factor, it is still not the case that sex differences are inevitable. Biology may make it easier for one sex or the other to acquire certain behaviors, or may increase the likelihood that a given stimulus will elicit a particular response in one sex or the other. Nonetheless, the range of individual differences on all these behaviors, and the degree to which social forces also shape the behaviors in the sex-dimorphic direction, suggest that both sexes can learn these behaviors. The classic work of Mead (1935) tells us one thing if nothing else—socialization can redirect development of behavior such that sex differences are either minimized or maximized.

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9 Measuring the Impact of Environmental Policies on the Level and Distribution of Earnings

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With the exception of research on recombinate DNA and perhaps test-tube babies, policy research in this country is concerned with proposing and evaluating various changes in the environment. Such policies try to improve an individual's performance, eliminate harmful behavior, and, in general, overcome poor genetic endowments and family background. These policies operate either by providing services directly or by lowering the price of services. Economists have studied environmental policies that relate to many different subjects. This paper will focus on earnings and its relationship with schooling and with inequality of opportunity. These two subjects will be examined separately.

While most policies studied are environmental in nature, one's knowledge of their impacts may be sorely limited if one ignores or does not control for a person's genetic endowments. Perhaps the simplest way of illustrating this point is in terms of the impact of schooling on earnings. It is often argued that the reason the more educated have higher earnings is that the more educated are more able, irrespective of education, and that ability is rewarded in the marketplace. Thus, not controlling for this ability, which is partly attributable to differences in both family environment and genetic endowments, will cause the researcher to obtain a biased estimate of the effect of schooling on earnings.[1]

The argument can be formalized as the bias that arises when a variable is omitted. Let earnings be denoted by Y, years of schooling by S, ability by A, and random events by u. Let the equation to be estimated be:

$$Y = \beta S + \gamma A + u \qquad (9.1)$$

If one omits the variable A, under standard assumptions the expected value of $\hat{b}$, the least squares estimate of the coefficient on schooling is given by: