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Review

Identifying and explaining apparent universal sex differences in cognition and behavior

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ABSTRACT

With growing recognition that there are universal sex differences in cognition and behavior, four theories have been proposed to account for these differences: the *founder effect theory*, the *social structuralist theory*, the *evolutionary theory*, and the *evolutionary neuroandrogenic* (*ENA*) *theory*. The latter of these theories is described in considerable detail as offering an explanation for most of 65 recently identified *apparent universal sex differences* (*AUSDs*) in cognition and behavior. Regarding "ultimate causes" (why), ENA theory asserts that (a) evolutionary-genetic factors incline females to bias their mate choices toward males who are loyal and competent provisioners of resources and (b) males are merely a genetic variant on the female sex selected for responding to female mating biases. In terms of "proximate causes" (how), the theory maintains that high exposure to androgens has evolved to alter the male brain functioning in two specific ways relative to most female brains: (a) suboptimal arousal and (b) a rightward shift in neocortical functioning. These two functional patterns are described and hypothesized to incline males and females to learn differently in many respects. The most fundamental differences involve males learning ways of either complying with or circumventing female mate preferences. Numerous universal sex differences in cognition and behavior are hypothesized to result from these evolved neurohormonal factors, including most of the 65 AUSDs herein summarized in seven categorical tables.

1. Introduction

At least since the writings of Margaret Mead (1935/1950, 1949/1968), many social scientists have assumed that human sex roles are highly flexible, subject almost entirely to the expectations and dictates of the particular culture in which one happens to live (Pinker, 2002). Such a view was largely reinforced by a literature review of 1600 studies by Maccoby and Jacklin (1974) in which only four sex differences were identified that they deemed consistent across all relevant studies: superior verbal ability in females, and greater visual-spatial ability, mathematical ability, and aggression in males.

In the mid-1990s, an 11 year project was undertaken to update and expand Maccoby and Jacklin's book. This resulted in a thousand page summary of findings from over 18,000 studies, about two-thirds of which pertained to cognitive and behavioral traits (Ellis et al., 2008). The latter book's final chapter catalogued sex differences that were deemed universal, 65 of which were of a cognitive and behavioral nature.

As was the case for Maccoby and Jacklin, the criteria used for identifying what I will call *apparent universal sex difference* (*AUSD*) traits involved a vote counting methodology wherein each study of a particular trait constituted a separate vote. At least ten "votes" from independently published studies were required for a sex difference to be eligible for consideration. Then, if any of these ten or more studies failed to agree that there was a statistically significant sex difference in the same direction, that trait was no longer eligible. In other words, to qualify as an AUSD, at least ten relevant studies must have been found, every one of which had to have reported a statistically significant sex difference in the same "direction" (i.e., either males were always exhibiting the trait to a greater degree or females were).

Applying the above methodology to the studies now available resulted in none of the four traits identified by Maccoby and Jacklin (1974) being among the 65 AUSDs. This is not to say that verbal ability, visual-spatial ability, mathematical reasoning, and aggression are not universal sex differences; they may be. However, the stringency of the criteria we set for AUSDs forced us to exclude all four of these traits.

Tables 1–7 present the 65 cognitive and behavioral traits that met the conditions stipulated for being AUSDs. For each trait, a brief description is provided and the number of pertinent studies is reported. Also indicated to the right of each trait are the number

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of countries in which the studies were collected and the range in years when these studies were published. These latter items of information provide a sense of the geographic and temporal breadth of the findings pertinent to each trait. Each trait specified in these seven tables will be individually addressed after the theories for universal sex differences in cognition and behavior have been presented.

2. Theoretically explaining apparent universal sex differences

Aside from the one to be advocated here, the three theoretical explanations offered for universal sex differences in cognition and behavior are the *founder effect theory* of Fausto-Sterling (1992), the *social structuralist theory* of Eagly and Wood (1999, 2003, 2002), and the *evolutionary theory* of Buss (1995); Geary (2010), and Okami and Shackelford (2001). Each of these theories is summarized below.

2.1. The founder effect theory

In discussing the possibility of universal sex differences in behavior, Fausto-Sterling (1992, p. 199) asserts that "the entire population of the world all evolved from a small progenitor stock, and these behaviors have been faithfully passed down a thousand times over". This argument seems at odds with the tremendous diversity that has developed over the same time span in human languages, religions, and other customs. Also, anthropologists have documented that cultures usually diverge within just a few generations whenever they are geographically separated (Pratt & Hanson, 1994; Weinreich et al., 1968). Why would large numbers of sex differences in behavior have remained so stable?

As noted by one of the theory's critics (Browne, 2006, p. 152), "the idea that any, let alone many, cognitive and behavioral sex differences would have been preserved in all human cultures simply because those differences happen to have been arbitrarily established in some primordial culture hundreds of thousands of years ago defies credibility." It is also noteworthy that there is little in Fausto–Sterling's theory to identify which sex differences would have been "faithfully passed down" and which ones would have been free to change from one culture to another over time.

2.2. The social constructionist theory

From the perspective of social structuralists, all cultures must accommodate the fact that women alone bear children. For example, men have become the primary bread winners, although the extent to which this is true varies greatly from one culture to another. Because males are the main bread winners, all cultures encourage greater competitiveness among males and greater nurturing tendencies among females. Eagly and Wood (2003); Wood and Eagly (2002) were quick to add to these premises that they do not argue for a biological basis for sex differences in competitiveness or nurturing. Instead, the theory they offer stipulates that because all societies have a self-perpetuating interest, they all must culturally promote certain sex differences such as those of greater male competitiveness and female nurturing. Thereby, these and other related sex differences are universal.

Eagly and Wood suggest that support for their theory comes from noting that the degree to which males are more competitive than females varies considerably from one culture to another. They also argue that while men appear to earn more than women do throughout the world – reflecting their greater competitiveness – the extent to which this is true is less in cultures where gender role expectations are relaxed (e.g., Western societies) than in cultures where expectations are most rigidly enforced (e.g., most Middle Eastern countries). Similarly, the universal tendencies for women to prefer men who are capable breadwinners may be stronger in cultures where the differences in men's and women's earnings are the greatest (Eagly & Wood, 1999). Social constructionist theory has thus far not been developed to predict very many sex differences beyond those just specified.

2.3. The evolutionary theory

Proponents of evolutionary theory envision natural selection playing a central role in producing universal sex differences. For example, studies showing sex differences in desires for promiscuous sex have been cited as evidence for the influence of natural selection (Schmitt, 2003). Theoretically, a strong male desire for sex reflects two related facts: First, males have a much higher reproductive potential (or ceiling) than females. Second, the main way males can realize this higher potential is by having numerous sex partners (Buss, 2003; Buss & Schmitt 1993). In other words, males who have multiple sex partners will usually leave more copies of their genes in subsequent generations than females with the same number of sex partners. While desiring many partners and having them is obviously not the same, the second is unlikely to occur without the first.

Another line of evidence cited in support of evolutionary theorizing regarding universal sex differences has involved tendencies for women to choose mates on the basis of financial prospects (Buss & Schmitt, 1993). The argument in this case has been that females with a reliable supply of resources can bear and successfully rear more offspring than females who must continually obtain resources on their own. To explain sex differences in cognition, some evolutionary theorists have proposed that male spatial reasoning abilities have been naturally selected for eons as part of their need to navigate while hunting and to judge distances when throwing projectiles (Geary, 2010; Kolakowski & Malina, 1974). Indeed, numerous studies have shown that males are better than females in spatial reasoning (Ellis et al., 2008, p. 311).

In the above described ways, evolutionary thinking has provided a solid platform for predicting the existence of several universal sex differences. I believe that the main shortcoming has been the failure of evolutionary theory to specify any of the genetic or neurohormonal processes that might have actually produced the evolved differences. For this reason, I offer the following theory.

2.4. The evolutionary neuroandrogenic (ENA) theory

The theory that I espouse for sex differences in cognition and behavior was first débuted about a decade ago to account for sex differences in social status and criminality (Ellis, 2001, 2003). A few years later, it was extended to explain sex differences in smiling (Ellis, 2006) and, more recently, an even wider range of cognitive and behavioral sex differences (Ellis, 2011). The theory has two major components; one focuses on genetic-evolutionary factors (the *why* component) and the other on neurological–endocrinological factors (the *how* component).

2.4.1. Genetic-evolutionary factors

The theory's first component states that females can leave more offspring in subsequent generations when they have the help of a mate who is at least modestly capable of being a dependable provider of resources. To be most helpful, this provisioning should occur throughout the gestation and rearing of all offspring the couple produces. This serves to naturally select for females who bias their mate preferences toward males who at least appear to be loyal and competent provisioners (Ellis, 2001).

In order for traits to have evolved by natural selection, they must have some genetic underpinnings (Pinker, 2002, p. 50). Thus, an essential assumption of ENA theory is that genes have contributed to variations in female tendencies to prefer mates who are capable resource provisioners. This means that the proportion of genes inclining females to exhibit such biases should become more prevalent than genes that incline females to use other criteria for choosing mates. Likewise, as explained more below, genes must be contributing to male responses to whatever preferences females exhibit for mates.

To the extent that genes for choosing mates who are loyal provisioners have come to prevail in a population, genes for males who comply with the female bias should also increase. However, males may also use deception or force as part of their mating efforts, options that females will be favored by natural selection for detecting. Presumably, genes for these "unpleasant" alternatives to being a loyal provisioner should also gain a foothold in any population where females bias their mate choices based on provisioning capabilities (Ellis, 2005).

ENA theory also assumes that the default sex is female (Dennis, 2004; Woodson & Gorski, 2000; but see Breedlove, Cooke, & Jordan, 1999). This appears to be a fairly safe assumption given that the Y chromosome has been shown to contain genes that cause the would-be ovaries to become testes, thereby producing testosterone and other androgens in large (male-typical) quantities (Vergnaud et al., 1986). These hormones in turn should have evolved the capability to alter the would-be female brain (and the rest of the body) in ways that help males comply with female biases for resource procuring mates (or to circumvent these biases).

2.4.2. Neuro-endocrinological factors

Throughout life, males produce higher levels of androgens than do females. As shown in Fig. 1, most of the average sex difference in androgen levels occurs perinatally and within the first couple of decades following the onset of puberty. ENA theory postulates that exposing the brain to androgens during these two phases of life is critical in sexually differentiating cognition and behavior.

Theoretically, exposing the brain to androgens has two important effects on how the brain functions, both of which go on to impact cognition and behavior. First, high androgen exposure promotes suboptimal arousal. Among other things, *suboptimal arousal* refers to the tendency to tire of one's environment relatively quickly, thereby inclining individuals to seek new environmental experiences more often even in the face of considerable risk. It also helps to insulate one from feeling pain (Ellis, 2011). The most crucial part of the brain that is involved in regulating arousal is the reticular formation, although its neuronal networks extend up into all higher brain regions (Kinomura, Larsson, Gulyas, & Roland, 1996).

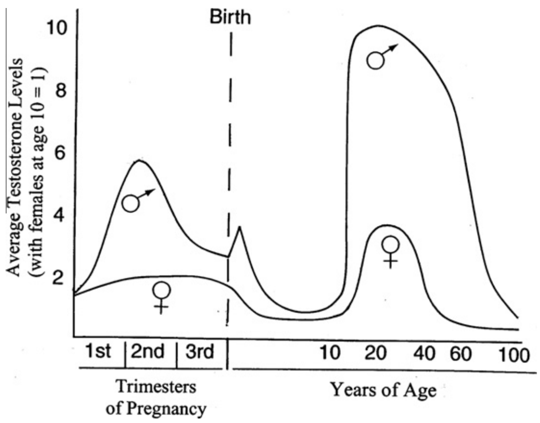

Fig. 1. Testosterone levels in human males and females from conception through old age.

Second, exposing the brain to high androgen levels causes *a rightward shift in neocortical functioning*, which refers to the relative dominance of the two hemispheres. Studies have shown that for most people, the left hemisphere is dominant (Chiron et al., 1997; Schlutera, Kramsb, Rushwortha, & Passingham, 2001). ENA theory asserts that this normal left dominance tends to shift rightward with increasing exposure to androgens, especially during fetal development. As a result, individuals with highly androgenized brains will rely less on language-based reasoning, emphasizing instead reasoning which involves spatial and temporal calculations of risk and reward probabilities (Cohen-Bendahan, Buitelaar, van Goozen, & Cohen-Kettenis, 2004).

The result of these two androgen-promoted differences is that males will be less prone to reason in strictly linguistic terms, will be inclined to be more competitive and victimizing in their behavior, and will be less likely to feel pain and empathize with the pain others experience (Ellis, 2004, 2005; Ellis, 2011). According to ENA theory, these behavioral differences have evolved in males more than in females because such behavioral patterns in males facilitate the acquisition and retention of resources, which in turn make males more appealing to females as mates, thereby contributing to the reproductive success of those males (see Genovese, 2008).

2.4.3. Why most sex differences are small

Following her review of 46 meta-analyses of sex differences in cognition and behavior, Hyde (2005) concluded that the vast majority of sex differences are quite minor. More specifically, Hyde found that 78% of the differences exhibited effect sizes of .35 or less. This lead her to use the term *gender similarities hypothesis* to describe most sex differences, which was then contrasted with the popularized "men are from Mars and women are from Venus" hypothesis.

While Hyde's concept can be applied to most sex differences, it should not obscure the fact that several effect sizes have been shown to far exceed 0.35. These include 0.66 for mental rotation (Voyer, Voyer, & Bryden, 1995), 0.96 for throwing accuracy (Ashmore, 1990), 0.81 for toleration of casual sex (Oliver & Hyde, 1993), 0.87 for desired number of sex partners (Buss & Schmitt, 1993), 0.98 for mechanical reasoning (Findgold, 1992, p. 76), and 0.93 for interest in objects versus people (Su, Rounds, & Armstrong, 2009). Also, in proportional terms, males throughout the world are three- to four-times more likely to commit violent crimes, especially those that are most serious such as murder, robbery, and rape (Brookman, 2003; Ellis, Beaver, & Wright, 2009). Nonetheless, Hyde convincingly argues that most sex differences in cognition and behavior are in fact of a minor nature.

ENA theory is compatible with Hyde's gender similarities hypothesis. The reasoning behind this compatibility is as follows: Even though males and females have been subjected to quite different natural selection pressure for eons, the fact that they share nearly 99% of the same genes has prevented the sexes from separating very far from one another for most traits. To illustrate, adult males are universally taller than adult females (Ellis et al., 2008, p. 14) even though females throughout the world have a distinct preference for mates who are taller than themselves (Ellis et al., 2008, p. 441). Theoretically, average sex differences in height continue to be small because nearly all the genes controlling human height are located on chromosomes other than the Y chromosome (Weedon et al., 2008). This makes it difficult for height-influencing genes to give males more than a slight edge. Put another way, because males and females share approximately 99% of the same genes, major restraints are imposed on the extent to which males can be genetically programmed to surpass females in height. It should be added, however, that genetic programming for substantial sex differences in height is not impossible, given that in some species, one sex (nearly always males) are more than twice the size of the other sex in adulthood (Leutenegger, 1982).

Paralleling the argument just made for height, nearly all of the same genes are involved in brain development for males and for females. Therefore, most of whatever sex differences in neurology exist are likely to be subtle no matter how strong the natural selection pressure may be. This leads one to expect that most (but not necessarily all) of the cognitive and behavioral differences between the sexes will also be modest. Stated another way, the human genome only has a narrow range within which to respond to natural selection pressure to program males and females differently. The natural (including sexual) selection pressure may be great, but the ways that the brains of males and females can be genetically configured to respond to this pressure are primarily restricted to one relatively small chromosome, the Y chromosome.

2.4.4. The role of learning

The role played by learning in ENA theory is substantial in the case of behavior but relatively minor when it comes to motivations and capacities. For instance, the theory assumes that females must learn what to look for in order to identify males who are competent resource provisioners, and they must learn many of the skills that enhance and maintain their attractiveness to males. Average sex differences in underlying feelings and motivations, however, are assumed to be too fundamental to sexual reproduction for them to be subjected to high degrees of cultural conditioning.

Because learning occurs within an environmental context, cultural factors can exercise great influences over how males and female behave. These cultural influences will sometimes serve to exaggerate the motivational aspects of sex differences and other times blunt the differences. Nevertheless, ENA theory leads one to hypothesize that cultures will never be able to reverse or even fully equalize feeling and motivational aspects of sex differences, even in the most egalitarian societies. Nor will cultural influences ever be able to eliminate sex differences in interests and *capacities* to learn skills that have been subjected to natural selection pressure. Examples should include occupation related interests and skills that have helped males acquire resources with which to attract mates as well as interests and skills by females that incline them to care for offspring.

If the above arguments are correct, one should find more universal sex differences when it comes to desires, preferences, interests, and intellectual talents than in the case of actual behavior. This should be especially true in societies that foster the greatest sex equality in education and other forms of socialization. In addition to sex differences in behavior, one can also consider cultural responses to behavior. Many of these responses can have substantial effects on behavioral outcomes. For example, even fairly minor sex differences in desires to be competitive can often result in major differences in resource accumulation, particularly in free market economies.

2.4.5. Intra-sex variability

As noted above, ENA theory envisions learning as playing an important role in producing sex differences in behavior. Learning can both blunt and exaggerate these differences, although learning should have fewer effects on motivations and abilities than on most forms of behavior.

It should also be noted that considerable variability within each sex should exist in terms of motivations, abilities, and behavior due mainly to the tremendous genetic diversity on the 22 pairs of non-sex chromosomes within the human population. This leads one to expect greater variability within each sex than any average differences between the sexes for most traits that are sexually dimorphic.

Just as with average sex differences, nearly all of the within-sex variability in motivations and drives should be the result of neurohormonal factors. For instance, male brains will be exposed to quite varied levels of testosterone both perinatally or postpubertally. This differential exposure should cause a great deal of intra-male variability in the extent to which brains are being masculinized. As a result, males should vary amongst themselves in their motivations to compete for resources.

Likewise, not all female brains will be exposed to the same low-to-modest level of androgens (Hines, Golombok, Rust, Johnston, & Golding, 2002). Consequently, females should also vary among themselves regarding their desires to fulfill care-giver versus resource procurement roles and these desires should ultimately have behavioral and ultimately reproductive consequences, especially in cultural milieu that encourage or at least tolerate intra-sex diversity.

2.4.6. ENA theory's testability

The most important feature of a scientific theory is its ability to make testable predictions; the more predictions and the more accurate they turn out to be, the better. By combining specific genetic-evolutionary and neurohormonal arguments, ENA theory makes many predictions. In the most fundamental terms, the theory predicts that every sex difference that is truly universal will have both genetic-evolutionary and neurohormonal causes, and no universal sex difference should be entirely the result of learning. There should be no exceptions.

The extreme specificity of ENA theory makes it highly vulnerable to disproof. Sex hormones (especially testosterone) must be affecting brain functioning in at least two ways, one involving suboptimal arousal in and around the reticular formation, and the other having to do with the functional balance between the two hemispheres. One or both of these two brain functioning patterns should be responsible for most of the average universal sex difference in cognition and behavior that are documented. All the remaining universal sex differences should be attributable to evolutionary/genetic factors or some combination of neurohormonal and evolutionary/genetic factors. Culturally based learning should never be powerful enough to completely suppress these biological forces.

2.5. Explaining sixty-five apparent universal sex differences with ENA theory

To explore the predictive power of ENA theory, the AUSDs listed in Tables 1–7 will now be individually examined. As this is done, each sex difference will be identified according to its entry number within the table where it appears. For example, the first entry in Table 1 (indicating a sex difference in time spent studying and attending classes) is identified with the number 1.1. The tables containing most of the remaining 64 traits are considered in order except where they have a notable affinity to traits appearing in one or more other tables.

2.5.1. Work and occupations (Table 1)

Because females choose mates on the basis of resource procuring tendencies, ENA theory leads one to expect greater proportions of men to be employed full time (1.2) and to spend more time working for pay or profit (1.3). Finding exceptions would seriously cripple the theory. Likewise, males should always hold more managerial, administrative, and supervisory jobs (1.6) and more corporate executive positions (1.7) since these jobs are relatively competitive and lucrative.

Table 1
Universal sex differences involving stratification and work and occupations.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Females spend more time studying, attending class, and paying attention in class	15	7	1929–2005
2. Males are more likely to be employed full-time	31	11 (6)	1967–2003
3. Among employed persons, males work longer hours	19	5 (1)	1985–2004
4. Males work in male-typical occupations more	42	12 (2)	1911–2004
5. Females work in female-typical occupations more	22	8 (2)	1970–2003
6. Males hold more managerial, administrative, and supervisory jobs	58	8 (4)	1967–2001
7. More corporate executive officers are males	18	7 (1)	1977–2004
8. Males hold more law enforcement jobs	14	4	1953–2002
9. Females are more likely to be nurses	12	7	1975–2004
10. Males are more likely to be scientists and engineers	21	4	1965–2000
11. More college professors are males	18	7 (2)	1969–2004
12. Females are more involved in parenting and childcare activities	17	7 (1)	1980–2004

[a] The numbers in parentheses refer to studies based on samples drawn from more than one country.

Regarding specific types of work, one would expect women to predominate in caring for infants, whether their own (3.2) or those of others (1.12). The tendency to be nurses (1.9) would be similarly predicted for women given the care-giving aspects of this profession. Societal recognition of this sex difference would lead one to expect that in the case of divorce primary custody of children will be awarded more often to mothers than to fathers (3.3).

Why would higher proportions of law enforcement officers (1.8), scientists and engineers (1.10), and college professors be males (1.11)? The theory would attribute these sex differences partly to the fact that more males are in the overall workforce (due to the female preference for resource procuring mates). Otherwise, work in law enforcement is often confrontational, an aspect of behavior that is most likely to appeal to individuals who are suboptimally aroused (a male-typical neurological trait). In the case of being scientists and engineers, these professions draw heavily on spatial reasoning skills, which males should be better at because of their greater rightward brain organization.

The theory does not specifically predict that more men than women would be college professors. Instead, the theory leads one to expect that the sexes will be drawn into distinct fields of higher learning. In particular, the proportion of males should be relatively low in the humanities and the social sciences (where language skills are emphasized), while it should be high in the physical sciences and mathematics (with biology probably being about equally attractive to both sexes). The extra attraction of males to the physical sciences and mathematics should be the result of their greater ability to independently engage their right hemispheres in higher thought. Ultimately, ENA theory would not specifically predict an overrepresentation of men in higher education professions without first knowing the specific demand for professors in the various disciplines and the sex ratio of those who are available for hire.

The last sex difference needing to be explained in Table 1 involves studying, attending classes, and paying attention in class (1.1). Also relevant is enjoying school (5.1). Because education can provide a competitive edge for acquiring resources (at least in industrialized societies), males might be expected to be more studious. However, when one considers that education emphasizes the acquisition of language skills (especially in primary school), expectations change. Because males are more suboptimally aroused, and less reliant on their left hemisphere for thought, ENA theory leads to the expectation that females will find school more enjoyable and should therefore be more attentive in class. As males slowly come to learn language skills to the same extent as females, or as they take courses that rely less exclusively on left hemispheric functioning (e.g., advanced mathematics), the sex differences in school enjoyment and performance should diminish. All of this reasoning is consistent with the finding that males have more of an interest in physical science and technology courses (5.2) and with evidence that males are more often bored (7.3). Male boredom should be especially high when required to focus on language acquisition tasks.

2.5.2. Consuming and institution-related behavior(Table 2)

The tendencies for males to have an earlier age of beginning to consume alcohol (2.1), to binge drinking more (2.2), and to have more drinking problems (6.6) can be explained in terms of neurological arousal. Specifically, males would be expected to experiment with alcohol and other drugs more as part of a general neurological tendency to seek new experiences, thereby seeking to avoid boredom (7.3). Exposing the brain to high levels of androgens may cause other sex differences in brain responses to alcohol and other drugs but suboptimal arousal should explain much of the sex differences in the appeal of these drugs.

Males' greater tendencies to have committed property crimes (2.3), to have carried weapons (2.4), and to have engaged in sexual assault (2.5) can be accounted for as follows: From an evolutionary standpoint, greater male involvement in property offenses should be part of their overall effort to acquire resources. Weapons-carrying likely reflects a general tendency toward competitiveness and dominance-striving. In the case of sexual assault, as will be explained more shortly, males have a stronger sex drive (5.8) and desire more sex partners than is true for females (5.7). Sadly, the use of assaultive tactics is one of the ways to satisfy sexual desires.

Regarding neurohormonal factors, many studies point toward testosterone as a contributor to criminality (e.g., Studer, Aylwin, & Reddon, 2005; van Bokhoven et al., 2006). ENA theory predicts

Table 2
Universal sex differences involving consuming behavior and interactions between individuals and social institutions.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Males begin alcohol consumption at an earlier age	12	2	1937–1997
2. Males are more likely to binge drink	15	6	1978–2004
3. Self-reported property crimes are more common among males	20	6 (1)	1926–2004
4. Males carry weapons more	11	4	1995–2001
5. More males engage in sexual assault	10	1	1980–1994

[a] The number in parentheses refers to a study based on a sample drawn from more than one country.

such a connection, first, because suboptimal arousal increases all sorts of risky and excitement-oriented behavior. Second, a rightward shift in hemispheric functioning results in individuals being less attentive to linguistic rules, including those of a legalistic nature (Ellis, 2005). It is also relevant to note that in both males and females testosterone has been associated with an increased sex drive (Sjogren & Gottlieb, 2001).

2.5.3. Social and play behavior (Table 3)

Greater socializing among females expresses itself by an increased tendency to interact in small groups (3.4), their having more intimate friendships (3.5), and their sharing secrets more (3.6). ENA theory accounts for these findings as reflecting left hemispheric dominance of higher thought since social settings provides the primary context within which linguistic exchanges occur. Also, research has shown that the left hemisphere has a "friendlier" emotional tone than the right hemisphere (Canli, Desmond, Zhao, Glover, & Gabrieli, 1998). Even the tendency for females to maintain greater eye contact with social interactants (3.1) can be seen as reflecting a desire to continue verbal exchanges with others.

The greater female involvement in playing house (3.10) and playing with dolls (3.9) fits well with evolutionary arguments that females have been naturally selected for fulfilling their reproductive role as primary care-givers. This explanation leaves open the question of the neurological basis of such behavioral tendencies. At least part of the neurology could have to do with hemispheric brain organization for social interactions, but more may be involved. At the very least, ENA theory predicts that exposing the brain to androgens will diminish care-giving behavior, whether real or pretend.

Male enjoyment of competitive activities (3.11) is predictable from the perspective of ENA theory. In particular, competition is a type of risky behavior promoted by a suboptimally aroused brain. Also, from an evolutionary standpoint, competition should help males secure resources with which to attract mates. Similar factors may incline males to focus on leisure and work (3.7) more, given that both activities frequently entail competition.

The tendency of males to play with masculine toys more, particularly toy versions of moving vehicles and weapons (3.8), theoretically reflects the greater spatial orientation of the right hemisphere. Greater male inclinations to initiate sexual activities (5.12) can be explained in evolutionary terms, given that individual males have a much higher reproductive ceiling than do individual females. In terms of proximate causes, as noted earlier, testosterone is known to enhance sexual motivation (Sjogren & Gottlieb, 2001).

2.5.4. Personality and general behavior (Table 4)

ENA theory predicts that exposing the brain to relatively low levels of testosterone (i.e., levels that are typical of females) will facilitate femininity (4.5). As an aspect of femininity, the tendency to use a "cradling" book carrying style (4.6) should have both an evolutionary and a neurohormonal basis. Evolutionarily, the behavior may be seen as reflecting a greater tendency to care for infants even to the point of sometimes holding an inanimate object as they would an infant. As far as neurohormonal factors are concerned, the exact processes remain to be determined, but ENA theory predicts that exposing the brain to high (male-typical) levels of androgens should inhibit such cradling types of behavior.

Female tendencies to be friendlier (4.2) as well as male tendencies to exhibit greater hostility (4.3) are theoretically rooted in the more social affiliating nature of females and the greater competitiveness of males. Regarding the underlying neurology, the left hemisphere has been shown to have a more positive social tone than the right hemisphere (Canli et al., 1998).

More risk-taking in career and business decisions (4.4) and a greater exploration of the environment (4.1) can be interpreted as more typical of males due to suboptimal arousal and a rightward functioning brain, both androgen-promoted neurological traits. From an evolutionary standpoint, these behavioral tendencies should contribute to male competitiveness and willingness to explore their environment for resources, thereby making them more attractive to prospective mates. It is also worth mentioning

Table 3
Universal sex differences involving social (and play) behavior.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Females are more likely to establish and maintain eye contact in social interactions	10	2	1963–2002
2. Females provide more care to their offspring	38	9 (6)	1967–2000
3. In the case of divorce, females retain primary custody of their children more	14	4	1975–2001
4. Females interact socially in small groups more	23	6	1902–2004
5. Females are more likely to have intimate friendships	35	5 (1)	1963–2005
6. Females confide/share secrets with friends more	31	6	1958–2005
7. Males engage in more conversations focused on leisure or work	14	2	1922–1993
8. Males play more with masculine toys	13	2	1961–1997
9. Females play with dolls and stuffed animals more	16	3	1910–1994
10. More females play house and parenting	12	3	1910–2002
11. Males are involved in directly competitive types of sports more	30	5	1913–2001
12. Males initiate sexual intimacy more	13	2	1979–2003

[a] The numbers in parentheses refer to studies based on samples drawn from more than one country.

Table 4
Universal sex differences involving personality and general behavior.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Males explore their environments more	24	8 (1)	1969–1996
2. Females are friendlier	11	4	1957–2001
3. Males are more hostile	14	2	1931–2003
4. Males take more risks in career and business decision making	17	3	1978–2002
5. Females are more feminine	30	9 (1)	1949–2004
6. Females are more likely to use a "cradling" book-carrying style	11	1	1976–1993
7. Females diet more	40	9 (1)	1950–2004

[a] The numbers in parentheses refer to studies based on samples drawn from more than one country.

that not only may androgens promote risk-taking and exploratory behavior patterns, but female sex hormones may inhibit them (Sherry & Hampson, 1997). If so, incorporating female hormones into future versions of ENA theory could eventually enhance its predictive power.

2.5.5. Attitudes, interests, and preferences (Table 5)

Theoretically, the greater interests that males have in both watching and participating in sports (5.4 and 5.5) and in athletics generally (5.6) reflect their greater competitiveness, a trait that has evolved because it contributes to the acquisition of resources. The same could be said for males being more accepting of aggressive responses to social conflicts (5.3).

Regarding sex differences in preferences for mates, ENA theory leads one to expect males to prefer mates who are relatively young (5.11). This should increase the chances of males choosing mates who are still capable of bearing children. Female mate preferences can also be explained theoretically. Their preference for mates of high social status or high status potential (5.10) reflects their need for resources in order to enhance their own reproduction. Likewise, preferring mates who are older than themselves (5.12) should help ensure that the males they choose have demonstrated some resource procuring capabilities.

As far as females preferring mates who are taller than themselves (5.9), this too makes evolutionary sense. Height has been shown to be among the best physical correlates of male wealth and social status yet discovered (Ellis, 1994; Komlos, 1990; Meyer & Selmer, 1999). Furthermore, studies clearly demonstrate that exposing the body to testosterone early in fetal development contributes to adult height (Johansen et al., 1988; McElduff, Wilkinson, Ward, & Posen, 1988).

2.5.6. Cognition and mental illness (Table 6)

ENA theory can explain several of the universal sex differences in cognition and mental illness/health. In the case of learning disabilities (6.1), the theory would attribute the high rate among males to the relatively slow pace at which they acquire language skills (Ellis et al., 2008, p. 294). This retardation in language development is theoretically the result of high androgen brain exposure shifting hemispheric dominance away from the left hemisphere. Secondarily, male tendencies to be suboptimally aroused will prevent them from paying attention in school, further delaying language acquisition.

The higher rates of autism and Asperger syndrome in males (6.11) fit with ENA theory's assertion regarding hemispheric dominance. The theory dovetails Baron-Cohen's (2002, 2003) proposal that both of these disorders can be substantially explained in terms of high brain exposure to testosterone or its metabolites.

The universal tendency for males to have higher rates of attention-deficit hyperactivity disorder (ADHD) (6.10) can be explained by ENA theory in terms of both suboptimal arousal and a rightward shift in neocortical functioning. The hyperactive aspects of the disorder should mainly result from suboptimal arousal, and the lack of attention (primarily to linguistic stimuli) should be the result of a rightward shift in brain functioning.

The other disorder that is male dominated is psychoticism, a condition typified by chronic hostility and aggression toward others (Eysenck & Nias 1978, p. 239). Given that both hostility and aggression appear to be androgen-promoted and are frequent concomitants of extreme competitiveness, ENA theory is entirely consistent with the greater prevalence of psychoticism among males.

Turning to conditions that are more typical of females, one can ask why females would be more likely to consider themselves overweight (6.2). ENA theory would account for this as follows:

Table 5
Universal sex differences in preferences, attitudes, interests, and intentions.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Liking school in general is more characteristic of females	21	8	1944–2005
2. Males have greater interest in physical science and technology	16	4	1931–1998
3. Males are more accepting of aggression as a response to social problem solving	23	3	1983–2002
4. Males have more interest in watching sporting events	15	6	1970–2002
5. Males have more interest in participating in sporting activities	18	6	1930–2003
6. Males have more interest in athletic activities in general	11	4	1933–2005
7. The desire for promiscuous sex/numerous sex partners is greater for males	15	4 (1)	1973–2003
8. Males have a stronger sex drive/are more interested in engaging in sex	30	7	1971–2005
9. Females are more inclined to prefer mates who are taller than themselves	11	2 (1)	1977–2002
10. Females are more likely to prefer mates who are high in social status	20	5 (3)	1966–2002
11. Males prefer mates who are younger than themselves more	38	15 (1)	1976–2002
12. Females prefer mates who are older than themselves more	11	8 (3)	1989–2002

[a] The numbers in parentheses refer to studies based on samples drawn from more than one country.

Table 6
Universal sex differences involving cognition and mental illness.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Males have more learning disabilities/difficulties	12	5	1949–2003
2. More females assess their weight to be excessive (or want to lose weight)	39	7	1965–2004
3. Females more frequently attribute failure to "internal" factors (i.e., their own shortcomings)	10	2	1973–1982
4. Females ruminate over negative emotional experiences more	21	5 (1)	1982–2002
5. Females experience more psychological distress/mental problems in general	14	4	1979–2004
6. Problem drinking/alcohol dependence is more common among males	14	3	1953–2002
7. Anorexia nervosa is more common among females	25	8	1976–2004
8. Females have higher rates of bulimia	30	9	1983–2003
9. Panic disorders are more common in females	29	5	1984–2002
10. Males exhibit higher rates of attention deficit hyperactivity disorder/hyperactivity	51	8	1963–2004
11 Males have higher rates of autism and Asperger syndrome	28	8	1960–2004
12. Psychoticism is higher among males	12	8	1960–2004

[a] The number in parentheses refers to a study based on a sample drawn from more than one country.

Both sexes are interested in the body appearance of prospective mates. However, females have been naturally selected for diverting much of this interest in body appearance toward a focus on a prospective mate's resource procurement capabilities; males have not. As a result of a greater male preoccupation with a prospective mate's body appearance as a criterion for mate selection, females have been sexually selected for being very concerned about their "looks".

To continue the above line of reasoning, one of the most important things a male should look for in terms of a prospective mate's physical appearance is evidence that she is not already pregnant. Thus, males are predictably enamored by a woman's so-called *hour-glass figure* (Jackson & McGill, 1996; Singh & Luis, 1995). Such a body shape is difficult for many women to maintain even when they are not pregnant, but the selection pressure on them to do so is theoretically substantial. Consequently, many females struggle to lose weight. So great are their efforts that some develop eating disorders such as anorexia nervosa (6.7) and bulimia (6.8).

Why females would suffer more panic attacks (6.9) and psychological distress or mental disorders in general (6.5) are only modestly predicted by ENA theory (as currently formulated). One possibility is that because of their greater tendencies to think in linguistic terms, females may be more likely to verbalize symptoms associated with these disorders. The tendencies for females to ruminate over negative experiences (6.4) and attribute failure to their own shortcomings rather than to outside factors as males do (6.3) are also not easily predicted by ENA theory. The best explanation at the present time would be that suboptimal arousal lowers sensitivity not only to one's surroundings but even to most internal feelings. Insight into all of the above four predominantly female disorders should come from studying how these disorders are associated with androgen levels within each sex at various stages in development.

2.5.7. Perceptions and emotions (Table 7)

ENA theory would link the tendency for females to feel greater stress associated with providing care to others (7.2) with the fact that they have a greater tendency to actually provide such care and do so in a committed way (3.2 & 1.12). A focus on care-giving seems to have evolved as part of the female's general tendency to provide child care.

In the case of crying frequency (7.4), studies have found no consistent sex difference during the first few years of life, but by adulthood, all studies agree that females surpass males (Ellis et al., 2008, p. 272). Crying is primarily a fronto-limbic brain function signaling intense emotionality, usually of a distressed nature (MacLean, 1987). This uniquely human behavior appears to have been favored for its tendency to elicit helping responses from care-givers (Lummaa, Vuorisalo, Barr, & Lehtonen, 1998). ENA theory predicts that exposing the brain to high (male-typical) levels of testosterone will inhibit crying, a prediction for which there is already some support (Van Tilburg, Unterberg, & Vingerhoets, 2002). Also, greater crying by adult females may be seen as potentially helping to screen for mates who will provide care to crying offspring.

ENA theory leads one to conceive of male tendencies to feel bored more (7.3) and female inclinations to perceive more hazards and injury risks in their environment (7.1) as similar phenomena. The link comes from the ability of androgens to promote suboptimal arousal. One result of suboptimal arousal is a tendency for one to tire from his or her environment more rapidly, often described as *boredom*. Given that the brains of most females are less often suboptimally aroused than males' brains, one would not only predict that they would be less often bored, but that they would be more sensitive to pain, a prediction for which most, but not all, evidence is supportive (Ellis et al., 2008, p. 232–234). This greater female sensitivity to pain would lead to their perceiving elevated risks of injury in their environments.

3. Conclusions

This article was written with two goals in mind: The first was to document that there are many sex differences in cognition and behavior that now appear to be universal. Second, the article identifies three theoretical explanations that have been offered so far for universal sex differences: the founder effect theory of Fausto-Sterling (1992), the social structuralist theory of Eagly and Wood (1999, 2003), and the evolutionary theory of Buss and Schmitt (1993); Geary (2010), and Okami and Shackelford (2001). None of these theories seem to explain most of the 65 AUSDs herein identified.

ENA theory offers a new explanation for universal sex differences primarily by adding specific proximate elements to a few evolutionary-genetic assumptions. In the broadest terms, ENA theory has two evolutionary-genetic components and two neurological–endocrinological components. The basic reasoning of the first two components is as follows: Females are able to produce more offspring with the help of a resource provider than without one. This has led to the evolution of females biasing their mate choices toward males who exhibit evidence of being reliable resource provisioners. Males have tended to respond to this female bias by becoming competent at resource provisioning, a tendency that is often accompanied by exaggerating their abilities during courtship, and by seeking mating opportunities with little up-front provisioning when possible. Because natural selection only works when genetic factors are involved, ENA theory compels one to look for genes that help to differentiate the sexes. In this regard, the theory stipulates that the basic sex is female, and that genes on the Y chromosome are primarily responsible for programming male brains in ways that help them accommodate, and sometimes circumvent, female mate preferences.

Learning is an important part of ENA theory when one attempts to understand sex differences in behavior. Varying motivations and capacities to learn, on the other hand, are assumed to be largely genetically programmed and therefore unlearned. In other words, each sex has evolved somewhat different motivations and intellectual talents that facilitate the roles they perform in the reproductive process. However, each sex must still learn how to behave in ways that build on and compensate for the particular motivations and talents they inherit, all within a complex cultural milieu. As a result, the theory predicts that males and females will differ more

Table 7
Universal sex differences involving perceptions and emotions.

Universal sex difference	Number of studies	Number of countries[a]	Publishing time range
1. Females estimate/perceive greater hazards and injury risks in their environments	14	6	1982–2004
2. Females have more stress/anxiety associated with providing care to others	10	2	1984–2001
3. Males are more prone to boredom	11	4	1970–1991
4. Females cry more as adults	12	4 (1)	1969–2004

[a] The number in parentheses refers to a study based on a sample drawn from more than one country.

from one another in terms of motivations and learning capabilities than in terms of overt behavior.

The theory's second component stipulates that sex differences in cognition and behavior result from two androgen-promoted brain factors. One factor is suboptimal arousal, a neurological condition that makes individuals less sensitive to their environment. The other is a rightward shift in neocortical functioning, which causes individuals to be less attentive to linguistic stimuli and more spatially oriented.

The theory accounts for why most sex differences in cognition and behavior are small as documented by Hyde (2005). Basically, because genes play a key role in producing sex differences and the sexes share more than 99% of the same genes, it is difficult to drive males and females very far apart for most traits. In other words, no matter how strong the natural (including sexual) selection pressure might be, there are major genetic restraints on the extent to which the sexes can differ in brain functioning, and thereby in average cognition and behavior. Further complicating the sexual differentiation of behavior is the influence of multiple cultural learning factors, some of which will accentuate and others blur the unlearned tendencies.

To minimize the risk of ENA theory being tantamount to a series of just-so stories of how sex differences in cognition and behavior *could* have evolved, two rules were followed in the theory's construction: First, only two evolutionary assumptions were made: (a) Females have evolved preferences for resource procuring mates. (b) Males are in essence *highly androgenized females* who reproduce by either complying with or circumventing female preferences. Second, only two sex differences in brain functioning was hypothesized as having evolved to comply with the two evolutionary assumptions (i.e., differences in arousal and in hemispheric functioning). In other words, rather than offering numerous arguments for how numerous cognitive and behavior traits might have been selected for differently in males and females, ENA theory allows one to deduce that many sex differences in cognitive and behavioral traits evolved with just four premises.

Overall, the present article provides a preliminary empirical assessment of ENA theory by considering how well it explains 65 apparent universal sex differences. The theory's predictions are consistent with findings pertaining to most of these differences. In the future, the theory may need to be elaborated by specifying more than just two androgen-influenced brain functions (e.g., see Ellis, 2003, 2005), but additions should be made parsimoniously.

If ENA theory is on the right track, one can expect many more pan-species sex differences in cognition and behavior to be found, all of which should be linked in one way or another to the influence of androgens on brain functioning. While scientific theories are never proven once and for all, many can be "retired" as evidence mounts against them. In this regard, the large number of universal sex differences that have now been identified seriously undermines "social learning" theories in which biological influences are assumed to play little or no role.

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