Do Psychological Sex Differences Reflect Evolutionary Bisexual Partitioning?

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This article analyzes sex differences in communicative and exploratory abilities and mental disabilities from the rarely discussed perspective of sex differences in the shape of phenotypic distributions. The article reviews the most consistent findings related to such differences and compares them with the evolutionary theory of sex (ETS). The ETS considers sexual dimorphism as a functional specialization of a species into 2 partitions: variational and conservational. The analysis suggests that male superiority in risk and sensation seeking and physical abilities; higher rates of psychopathy, dyslexia, and autism; and higher birth and accidental death rates reflects the systemic variational function of the male sex. Female superiority in verbal abilities, lawfulness, socialization, empathy, and agreeableness is presented as a reflection of the systemic conservational function of the female sex. From this perspective psychological sex differences in communicative and exploratory abilities might not just be an accidental result of sexual selection or labor distribution in early humans. It might reflect a global functional differentiation tendency within a species to expand its phenotypic diversity and at the same time to conserve beneficial features in the species' behavior. The article also offers an addition to the ETS by suggesting that the male sex (variable partition) plays an evolutionary role in pruning of the redundant excesses in a species' bank of beneficial characteristics despite resistance from the conservational partition.

Most Consistent Sex Differences in Psychological Abilities and Disabilities

This article does not discuss the well-known contribution of sociocultural factors. Instead, this article focuses on the evolutionary benefits of biologically based psychological sex differences, that is, in a systemic perspective, apart from the issue of adaptation to specific features of the environment. There are many systemic evolutionary benefits of species that are described in the evolutionary literature, including collective behavior in collective species (e.g., fish, ants, wasps, birds, mammals), variability and diversity of phenotypes, functional differentiation within parts of individual bodies or species, sex selection

mechanisms, and reinforcement of species' properties by specifics of the environment. One such systemic perspective concerns a rarely discussed aspect of the shapes of phenotypic distributions and its relation to such a global evolutionary "invention" as sex dimorphism. This aspect is the main focus of this article.

There is a well-recognized interaction between social and biological factors shaping sex differences in behavior that this article does not discuss because they can be easily found elsewhere (e.g., Archer, 2009; Wood & Eagly, 2012). Sociocultural factors interact with biological factors in human behavior more strongly than in animal behavior, making the task of studying evolutionary tendencies in psychol-

ogy challenging. There is also a large overlap in the distributions of psychological characteristics related to sexual phenotypes (allowing one to talk about such differences only in a statistical, not a literal sense), and, as will be discussed later, they might be statistically significant only in certain age groups. One of the common ways to extract the features of behavior that are probably a product of biological factors (even though these features undoubtedly interact with sociocultural factors) is to look at the consistency of their patterns across cultures. In theory, if some pattern of sex differences is consistently found in many cultures, and there are no reports of the opposite pattern, then this pattern may provide insights about human evolution.

The reinforcement or leveling of psychological sex differences by social factors is an important aspect of the nature of these differences. However, it is also useful to continue analysis of those aspects of human behavior related to the fact that we are, after all, a biological species, and there are systemic tendencies that regulate the genetic programs of a species regardless of how much their functioning uses environmental elements, including societal structures.

Most consistent sex differences in psychological abilities relate to communicative and physical exploratory aspects of behavior. Most aspects of psychological functioning appear to have no sex differences, a fact that is surprising to both the general public and researchers. For example, studies of the sex differences of various abilities in humans often contradict common beliefs that such differences exist (Halpern, 2012). Yet a few types of abilities show sex differences, at least in childhood and at a young age. The relevant references are listed in Table 1.

From early childhood females, in comparison to males, appear to have

> Superiority in verbal and communication abilities, demonstrating a higher fluency with words.
>
> Better reading ability, verbal memory, verbal analogy, spelling, language-related reasoning, object naming; in use of language females interrupt less and use more tentative speech than males.
>
> Superiority in prosocial abilities, such as empathy, recognition of emotions, sociability, obedience, agreeableness, and compliance with rules.

More hygienic and conservative behavior, higher attentive and discriminatory abilities, and higher sensitivity to punishment. This includes observations that women have more sensitive discrimination in taste, colors, and odors, and they are choosier when it comes to many aspects of their functioning, such as dating (Buss & Schmitt, 1993; Clark & Hatfield, 1989), dressing, shopping, choosing words and clarifying what was said during conversations, furnishing their houses, and taking care of their health, their children, and so on (Woodwell, 1997).

Another set of consistent sex differences relates to physical capacities and exploratory capacities, and that is where males are superior (Table 1). From a very early age males have, in comparison to females,

> A well-documented stronger upper-body constitution, higher abilities for intense and prolonged physical activity, and faster physical tempo
>
> Higher spatial–mechanical reasoning
>
> Higher sensation- and risk-seeking behavior and higher impulsivity and dominance

In addition to widely discussed impact of sociocultural factors in reinforcement of these rare sex differences, several aspects of these differences are better explained by biological rather sociocultural factors. Thus, these differences appear at an early age (Campbell & Eaton, 1999; Eaton & Keats, 1982; Reinisch & Sanders, 1992) and are consistent with sex differences in preferences for games or toys in early childhood (Berenbaum & Snyder, 1995; Servin, Bohlin, & Berlin, 1999; Serbin, Poulin-Dubois, Colburne, Sen, & Eichstedt, 2001), even in nonhuman primates (Alexander & Hines, 2002). Using measurement of cerebral blood flow, functional magnetic resonance imaging, and magnetic resonance imaging, neurophysiological investigations into sex differences in verbal and phonological processing showed differences in cortical complexity (Luders et al., 2004) and a greater hemispheric asymmetry of the plenum temporale in males than in females (Coney, 2002; Levy & Heller, 1992; Meyers-Levy, 1994; Shaywitz et al., 1995).

There is evidence for a strong contribution of hormones and other endocrine factors to these sex differences, especially in word processing (Beren-

TABLE 1. Consistent Sex Differences in Psychological Abilities

Difference	References
Males have higher rates of risk and sensation seeking, criminal behavior, and openness to experience and to mating with strangers than females.	Buss & Schmitt (1993), Clark & Hatfield (1989), Costa et al. (2001), Wilson & Daly (1985), Zuckerman (1994)
Males are 3.5 times more likely to die from all accidental causes and 2.5 times more likely to die in road accidents than are females.	Kruger (2004)
Males have higher rates of impulsivity and poor compliance with routine and prescribed behavior.	Black (1999), Cross et al. (2011), Davison & Neale (1994), Eysenck & Gudjonsson (1989), Rommelse et al. (2008), (Strüber et al., 2008)
Men use aggressive behavior more often than women. Recent reports suggest that men use more physical aggression, whereas women use more verbal aggression.	Archer (2004), Huesmann et al. (1984), Idaho State Department of Education (2013), Nebraska Health and Human Services System (2001), New Jersey Department of Education (2013), Youth Risk (2001)
Males have greater upper body strength and physical endurance and faster tempo than females, especially youths.	Bishop et al. (1987), Eaton & Enns (1986), Pheasant (1983), Thomas & French (1985)
Males have superiority in mechanical reasoning, spatial abilities, and ability to simplify and generalize new information. This coincides with a tendency of males to perceive ambivalent objects as more simple, easy to handle, and not challenging.	Halpern (2012), Kimura (1999), Trofimova (2012b, 2013)
Females have higher fluency with words and better verbal memory, verbal analogy, spelling, language-related reasoning, and naming objects.	Halpern (2012), Hyde & Linn (1988), Kimura (1999), McGuinness et al. (1990), Wagemaker (1996)
Females exhibit significantly higher empathic, teaching, parenting, rule-driven, and imitative behavior, and males exhibit significantly higher exploratory and competitive behavior from a very early age. This is consistent with their choice of toys and later choice of profession.	Baron-Cohen (2003, 2011), Kimura (1999)
Females exhibit better communication skills and use of language; they interrupt less and show more tentative speech than males.	Anderson & Leaper (1998), Leaper & Robnett (2011)
Females have higher rates of social endurance, extroversion, and agreeableness.	Costa et al. (2001), Tobin et al. (2000), Trofimova (2010)
In jobs with a need for a single ability, either verbal or physical, there is a preponderance of females in social and secretarial services and in children's education (more than 90% of U.S. bank tellers, receptionists, registered nurses, and preschool and kindergarten teachers are women) and a preponderance of males in physically demanding jobs (more than 90% of firefighters, mechanics, and pest exterminators are men).	Browne (2002), Lippa (1998)
Women are more sensitive to punishment.	Cross et al. (2011)
Cross-culturally, females are superior to males at recognizing emotions in faces, voice, gestures, and nonverbal cues and at interpreting a range of mental states.	Baron-Cohen (2011), Baron-Cohen et al. (1997), Hall et al. (2000), McClure (2000), McGuinness & Pribram (1981)
Females are superior to males at perception, discrimination, and remembering taste, odors, auditory tones, and colors.	Baker (1987), Doty & Cameron (2009), Halpern (2012), Rodriguez-Carmona et al. (2008), Schab & Crowder (1995)

baum & Snyder, 1995; Collaer & Hines, 1995; Fitch & Bimonte, 2002; Hogervorst et al., 2000; McGuinness, 1981), verbal memory (Goekoop et al., 2005), memory for emotional experiences (Canli et al., 2002), and sensitivity to odors (Doty & Cameron, 2009). Greater male size and female ability for childbearing, nursing, and sociability are also linked to hormonal differences between them (Berenbaum & Snyder, 1995). Nurturance and other prosocial skills were linked to adolescent and adult estrogen levels in females, both in humans (Nyborg, 1994) and in other mammalian species (Alexander & Hines, 2002; Carlson, 2001). A stronger drive in males for social status and power was found to be associated with testosterone levels (Archer, 2006; Schultheiss, Campbell, & McClelland, 1999; Tremblay, 2000).

Recent studies reported sex differences in dopaminergic function that can explain male higher impulsivity, considering the links between impulsivity and dopamine release (Robbins, 2007). Thus, men were reported to have higher D_2 dopamine receptor affinity in the striatum compared with women, with an associated decrease in endogenous striatal dopamine concentrations and synthesis (Laakso et al., 2002; Pohjalainen et al., 1998). At the same time, this difference was found only for a baseline dopamine release. When administered amphetamines, men were found to have greater dopamine release in the ventral striatum (Munro et al., 2006). Such contrast findings suggest that it is the dynamics of release and recovery to the baseline in dopaminergic networks, and not their anatomic features, that can underlie sex differences in impulsivity, schizophrenia, and alcohol dependence (i.e., disorders associated with dopaminergic dysregulation).

If this small set of sex differences in abilities is based on biological factors, then these differences might have evolutionary benefits for the human species.

Sex differences in psychological disabilities also relate to communicative and physical exploratory aspects. In terms of sex differences in mental disabilities, it appears that whatever inferiority in capacities a certain sex has, the pattern of mental disorders is formed around it. Table 2 lists the relevant references.

Thus, males show relative inferiority in verbal communicative aspects of behavior and significantly higher rates of autistic disorders, Asperger's

syndrome, schizoid and schizotypal personality disorders, and a variety of speech impairments. In terms of impulsivity and poor obedience, they have higher rates of attention deficit hyperactivity disorder (ADHD), sociopathy, psychopathy, substance abuse, conduct disorder, narcissistic personality disorder, compulsive personality disorder, and pathological gambling.

Females show relative inferiority in physical strength and also higher rates of major depression, dysthymic disorder, conversion disorder, pain disorder, primary insomnia, somatization disorder, anorexia nervosa, and bulimia nervosa. Likewise, females have exhibit more cautious, rule-driven, and social approval–oriented behavior and also have higher rates of separation anxiety and general anxiety disorders, specific phobias, borderline personality disorder, histrionic personality disorder, dependent personality disorder, and dissociative identity disorder.

The biological nature of these mental illnesses once they have developed (but not of their onset) is also well recognized.

Sex differences in verbal and physical abilities probably fade with age (middle age–middle sex phenomenon). The contribution of hormones to sex differences in the aforementioned psychological abilities becomes apparent as the gap in these differences follows age-related hormonal changes and tends to shrink after the main reproductive period (after 25–30 years of age). Reports of middle age–middle sex phenomena suggest that the significant female advantage in verbal fluency and male advantage in physical power fade with age in an asymmetric manner (Trofimova, 2012a). Males and females might indeed have different timings of maturation of physical and verbal systems. McGuinness and Pribram (1979) pointed out that during the first 2 years of life talking and walking rarely occur simultaneously, which suggests that these two abilities compete for the same set of neural connections or that one type of neural organization inhibits the other. This coincides with the higher mobility of boys, accompanied by their lower rates of speech development in childhood, in comparison to girls.

These different timings in maturation appear as sex differences in early age and probably level off in later adulthood (Barbu, Cabanes, & Le Maner-

TABLE 2. Sex Differences in Mental and Behavioral Disorders

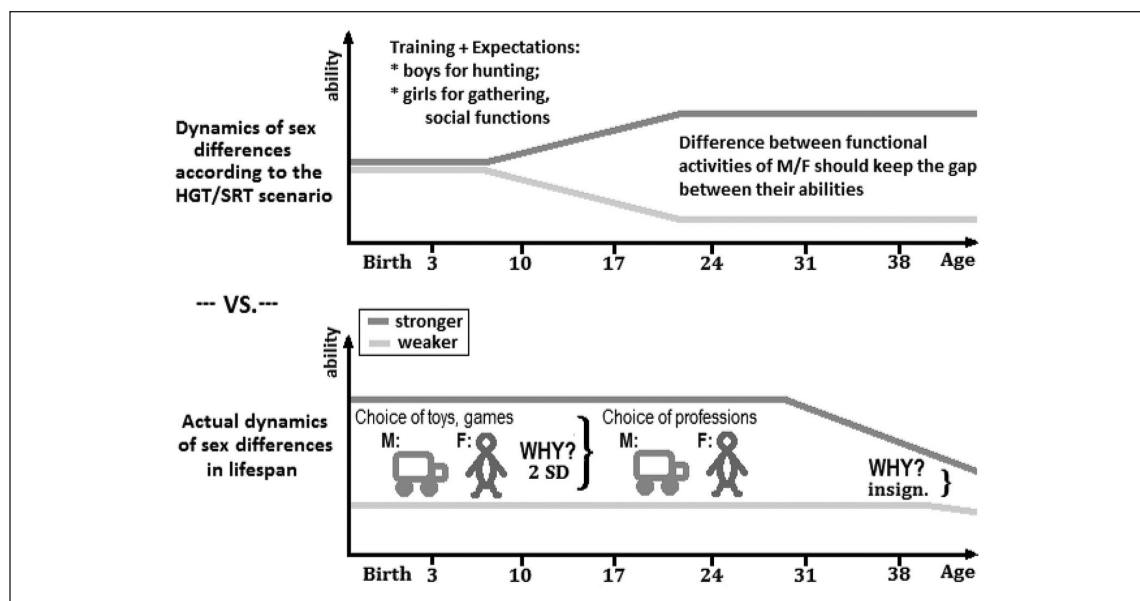| Difference	References
Males are 3–4 times more likely to be diagnosed with antisocial personality disorder, psychopathy, sociopathy, narcissistic personality disorder (M/F ratio 1–3:1), compulsive personality disorder (M/F ratio 2:1), and pathological gambling disorder (M/F ratio 2:1) than women.	Black (1999), Hare (1999), Hartung & Widiger (1998), Kaplan et al. (1995), Samuels et al. (2002)
Males have higher rates of conduct disorder (M/F ratio 4–12:1) than females. Males are 9% less likely to use seat belts and are 70% more likely to have guns than women and (when infanticides were excluded) are more likely to be involved in killings (M/F ratio 9:1).	Black (1999), Idaho State Department of Education (2013), Kaplan et al. (1995), Nebraska Health and Human Services System (2001), New Jersey Department of Education (2013), Youth Risk (2001)
Males have a higher rate of substance abuse, and gender differences are robust across societies around the world, especially in adolescence; males are more likely than females to drive a car drunk (M/F ratio 2:1), more likely to become alcoholics (M/F ratio 2:1), and 12% more likely to smoke and abuse drugs (M/F ratio 2.5:1).	Cooper et al. (1997), Eaton et al. (2012), Hartung & Widiger (1998), Helzer & Canino (1992), Idaho State Department of Education (2013), Nebraska Health and Human Services System (2001), New Jersey Department of Education (2013), Youth Risk (2001)
Males have higher rates of dyslexia (M/F ratio 4.5:1), reading impairments (M/F ratio 1.5–4:1), stuttering (M/F ratio 3:1), and learning disabilities than females.	Baron-Cohen (2003), Hartung & Widiger (1998), Lambe (1999), Miles et al. (1998, 2011), Rommelse et al. (2008), Vogel (1990)
Males have higher impulsivity and higher rates of attention deficit hyperactivity disorder.	Hartung & Widiger (1998), Rommelse et al. (2008), Strüber et al. (2008)
Males have higher rates of autism (M/F ratio 4–5:1), Asperger's syndrome (M/F ratio 7:1), schizoid and schizotypal personality disorders, and paranoid personality disorder. At the same time, females have higher rates of schizoaffective disorder.	Baron-Cohen (2003, 2011), Chakrabarti & Fombonne (2001), Fombonne (2005), Hartung & Widiger (1998), Kaplan et al. (1995), Risch et al. (1999)
Females have higher rates of major depression (M/F ratio 1:2), bipolar II disorder, dysthymic disorder (M/F ratio 1:2–3), conversion disorder (M/F ratio 1:2–10), pain disorder, primary insomnia, somatization disorder, anorexia nervosa (M/F ratio 1:9), and bulimia nervosa (M/F ratio 1:9).	Idaho State Department of Education (2013), Hartung & Widiger (1998), Nebraska Health and Human Services System (2001), New Jersey Department of Education (2013), Youth Risk (2001)
Females have higher rates of separation anxiety disorder, panic disorder (M/F ratio 1:2–3), generalized anxiety disorder (M/F ratio 1:2), dissociative identity disorder (M/F ratio 1:3–9), borderline personality disorder (M/F ratio 1:3–4), histrionic personality disorder, and dependent personality disorder than men.	Eaton et al. (2012), Hartung & Widiger (1998), Kaplan et al. (1995), Samuels et al. (2002), Torgersen et al. (2001)
Females are 4:1 more likely than men to have fears and phobias of snakes and spiders but not other stimuli (e.g., injections, heights, flying).	Fredrikson et al. (1996), Rakison (2009)
Females have higher rates of delirium and Alzheimer's dementia, whereas males have higher rates of vascular dementia and head trauma–related dementia.	Hartung & Widiger (1998), Kaplan et al. (1995)

Idrissi, 2011). The arguments about the role of sexual selection in maturational difference between males and females (Andersson, 1994; Tanner, 1989) do not contradict the idea about evolutionary benefits of such sex differences and just refer to the mechanisms of reinforcement of these differences. Between the two sexes, the superior group in some ability (dark line in Figure 1), regardless of gender, starts regressing toward the mean with increasing age, whereas the opposite gender group (with a weaker ability of the same kind) merely fluctuates about the mean for the same ability without trending (light line, Figure 1).

This middle age–middle sex phenomenon might explain why meta-analytic reports and several experimental studies of verbal abilities using adult participants reported no sex differences (Hyde & Linn, 1988; Savage & Gouvier, 1992) or male superiority (Elias et al., 1997). Zuckerman (1994) showed that the higher rate of sensation seeking in men, as measured by several scales, rises between ages 9 and 14,

peaks in late adolescence or the early 20s, and declines with age thereafter. A similar trend was found in a meta-analytic study of sex differences in risk taking (Byrnes, Miller, & Schafer, 1999). It is important to differentiate between unnecessary risk taking (in which men are superior) and risk taking for a peer's or one's own survival, such as actions in war situations or living organ donation (in which no sex differences were found). Only the first type of risks relates to exploration of additional alternatives without well-defined potential benefits.

Sex differences in the type of aggression (physical for boys and verbal for girls) are also stronger in youth than in adulthood (Archer, 2004; Bjorkqvist, Lagerspetz, & Kaukiainen, 1992; Tremblay, 2000). The male superiority in physical (Cooper et al., 2011; Lindle et al., 1997; Nagasawa & Demura, 2009) and spatial abilities was reported to fade after age 24–30 (Lacreuse, Kim, et al., 2005; Schwartz & Karp, 1967; Willis & Schaie, 1988), but some studies show that

FIGURE 1. Ontogenetic dynamics of sex differences in communicative and physical exploratory abilities. Only the abilities summarized in the Table 1 are considered. Their dynamics in lifespan appears to be independent from environment and functional adjustment, contradicting hunter–gatherer theory (HGT) and social role theory (SRT). There is no reason for a very early onset of these differences or for their decrease after the effect of hormonal differences starts to pass. This figure uses an estimate based on the contemporary statistics of child labor: The employment rate among 5- to 11-year-olds was 3.2%, increasing to about 7% among 12- to 14-year-olds and 15% among 15- to 17-year-olds on average, with fluctuations between countries as high as almost 50% (in Somalia). These statistics are available in UNICEF reports: http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/Child_Labour_Paper_No.1_FINAL_162.pdf. The tradition of marrying children at age 12 in several cultures includes preparation of girls for family life several years before it, and these practices are described in detail in various social and anthropological sciences

sex differences remain in grip strength even in old age (Cooper et al., 2011). The female superiority in verbal abilities and sensitivity to taste and odors has also been reported to fade with age (Halpern, 2012).

Similar changes were observed in chimpanzees (King, Landau, & Guggenheim, 1998) and rhesus monkeys (Lacreuse, Diehl, et al., 2005; Lacreuse, Espinosa, & Herndon, 2006; Suomi, Novak, & Well, 1996) in relation to physical capacities and affiliative behavior. An effect of aging was also found in sex differences related to dopamine release linked to higher impulsivity in men: Recent studies showed a decrease in dopamine activity with age in men but not women (Laakso et al., 2002).

The age-related reduction of the gap between male and female abilities should be investigated further because such leveling might be related only to a small set of abilities. Moreover, it is possible that meta-analytic studies that did not find significant sex differences did so because the ages of the samples were often not monitored, but they should be if such differences are more pronounced in early but not adult ages. Poor sensitivity of meta-analysis to additional complexity of the phenomena under study and its negativity bias demonstrate the limitations of this method when it is applied to a large number of studies (see Borenstein, Hedges, Higgins, & Rothstein, 2009; or http://www.improvingmedicalstatistics.com/Limitations%20of%20Meta-analysis1.htm and http://www.bmj.com/content/309/6957/789).

A possible leveling in sex differences at least in communicative and physical abilities is not surprising, considering that the main genetically controlled chemical determinants of sex differences—hormones—change in pattern after the peak of reproductive capacities is over. It is important to emphasize here that the "middle sex" phenomenon so far is noted only for the small set of sex differences in abilities described in Table 1: verbal communicative and physical exploratory abilities.

It is not clear to what extent sociocultural factors are the main forces behind the leveling of sex differences in these abilities. There are at least two groups of such sociocultural tendencies that have an opposite impact on sex differences. First, there are multiple suggestions that society amplifies sex differences by having different expectations for girls than boys, such as expectations of more compliant and social behavior from girls and more risky and physical behavior from boys. Second, equal standards at school or work suppress individual differences of any kind, including sex differences, and in theory should level them if the biological factors behind these differences are not very strong. After all, high demands for communication and an absence of requirements for physical fitness in most modern jobs force boys to talk more and decondition their physical capacities.

The question remains, Why do these equal standards not affect sex differences earlier, considering that even at age of 17 or 18 males have higher levels of physical activity and risky behavior than females? At the same time, if we follow the idea of social amplification of sex differences via different expectations, why do these expectations amplify sex differences only in early stages of life and stop having an effect after age 30? After all, with the sex differences in social and physical types of work (Browne, 2002; Lippa, 1998), society sends a clear message to both genders in terms expectations for their gender-specific behavior. Despite such expectations, the gap in verbal and physical abilities between men and women is probably decreasing with maturation.

In this sense both "sociocultural" explanations of either amplification or leveling of sex differences in verbal communicative and physical exploratory abilities are not sufficient, and an analysis of the bio-evolutionary factors might bring useful insights in this topic.

SUMMARY.

There is a small set of biologically based psychological differences between males and females. Despite an overlap in the distributions, the differences are statistically significant, especially in young humans. They have an early onset; they depend on hormones, and therefore they are genetically coupled with sex. Because the human hormonal system (controlling sex differences) is a biological and not a social phenomenon, and is therefore genetically regulated, there should be benefits for genes to make males and females behave differently, especially in youth. The question remains, What is the evolutionary value in making the sexes differ in these abilities, and with this particular allocation of abilities (physical superiority of young males and social–verbal superiority of young females)?

Hunter–Gatherer Theory (HGT) and Social Role Theory (SRT)
Cannot Explain the Early Onset of Sex Differences
and Their Fading in Adulthood

Sexual selection theory (SST) describes an important mechanism but not a direction of evolution. Formulated by Darwin and supported by 20th-century evolutionists, it suggests that primate (including human) females favored stronger, bigger, and riskier males for mating and that the most social and nurturing females achieved the greatest reproductive success (Andersson, 1994; Archer, 2009; Clutton-Brock & Vincent, 1991; Geary, 2010; Trivers, 1972). This theory illustrates one of the important mechanisms of peer and group selection (by sexual partners). However, it does not explain the evolutionary (species-level) benefits of the sex differences in psychological traits (i.e., why young females should be more verbally and young males should be more physically developed than the opposite sex, and not vice versa) or why males and females should differ in abilities at all. A question of "why," that is, a question about the systemic evolutionary benefits of certain features of species, is not the same as a question of how these features were selected and reinforced throughout evolution (i.e., mechanisms of selection). For example, when we point to the fact that humans do not have tails, in comparison with other primates, we rarely reason about it in terms of how but mostly in terms of why humans eventually evolved this way, as we all understand that there are environmental and sex selection mechanisms taking care of it.

In terms of sex differences in communicative abilities, males need high verbal abilities no less than females: The verbal path to mates, power, and status conserves more of a species' resources than does physical violence. Indeed, studies in evolutionary psychology report that males increase their talkativeness to impress females during dating, knowing that females prefer more verbally developed partners (Fisman, Iyengar, Kamenica, & Simonson, 2006; Miller, 2000; Rosenberg & Tunney, 2008). By the SST predictions (i.e., as a result of the selection of talkative males by females) we should end up with male and not female superiority in verbal abilities. Moreover, there is a reported preference of females for exploratory, risk- and sensation-seeking males (Miller, 2000), which opposes the interests of individual

female phenotypes, as it increases the risk of failed reproduction or of reproduction with poor subsequent care of the offspring. However, this preference is in the direct interest of the species as a system, as it is the species and not individuals that benefit from widening of the phenotypic diversity.

SRT and HGT Describe Important Intraspecies
but Not Global Tendencies

SRT (Eagly, 1987; Wood & Eagly, 2002) also points to important selection factors such as societal and family structure in human species, and the HGT (Barnard, 1983; Levy, 1978; Murdock, 1937) describes the process of reinforcement of sex differences by the division of labor. The common denominator between these theories is that the starting point for consideration of the origin of sex differences is at the onset of occupation-related factors. Occupation-related evolutionary theories, the SRT or the HGT, explain the sex differences in physical and communicative abilities by sex differences in human functional activities: labor-related (HGT) or related to social roles (SRT). Thus, men's stronger capacity for intense and prolonged physical activity is attributed to their training and selection as hunters and warriors; women's better verbal and empathizing abilities are supposedly the result of their greater involvement with child nurturing and family functioning, and women's higher perceptual sensitivity and inhibitory control are the result of involvement of women in gathering activities in early human history.

The evolutionary reinforcement of sex differences in abilities arising from their use in human communities is not a topic for debate in this article. The reinforcement of features by means of an interaction with the environment is a common global phenomenon in living systems. The question arises, however, as to why these specific differences in abilities emerge and persist, when the arguments of "functional fitness" would suggest the opposite (Figure 1). Childbearing and prolonged gathering activities by females are equally, if not more, physically demanding than the occasional carrying of carcasses and weapons in hunting by males. Besides, in raising small children females barely need sophisticated language, but in solving complex hunting problems, planning wars, and group control activities as well as

mating, men should develop verbal abilities no less than women.

Moreover, the prevalence of females in gathering and grooming activities was observed in *nonhunting* nonhuman primates, most of which live on vegetation. Such sex differences could not be explained by the HGT, because these primates did not have a hunter–gatherer division of labor in their ancestors. Besides, the division of labor in hunter–gatherer populations was seasonal, so males were engaged in gathering as much as females, without significant division of labor in rich habitats (Marlowe, 2007). It has even been suggested that males were occasional and optimal foragers targeting exceptionally nutritious food (Krasnow et al., 2011; Marlowe, 2007). Female superiority in the memory of object location (which is often described as a gathering ability) was also found in rats (Saucier, Shultz, Keller, Cook, & Binsted, 2009). This suggests that sex differences in abilities have a more global nature than the division of labor in early humans and that these differences were the cause, not the effect of the division of labor.

Finally, there is an inconsistency between this "previous employment" explanation of sex differences and the dynamics of these differences during an individual's lifetime (Figure 1). If they appeared as the result of a division of labor between the sexes in evolution, then the childhood stages of ontogenesis (before involvement in functional activities) should show fewer sex differences in abilities in comparison to the adult stages (like the delay in the development of reproductive organs until adolescence). After all, even early humans had an active functional life for at least 10 years after age 25. This is not the case, however, and the dynamics of sex differences are opposite to what the HGT or SRT would predict. The greatest sex differences in abilities remain during childhood and adolescence, both in humans and in nonhuman primates, fading over the years after the start of professional and family life, when the division of labor in early humans was becoming the most profound. A similar paradox contradicting the SRT was noted for the onset and development of sex differences in aggression (Tremblay & Côte, 2009).

In summary, all three theories (SST, HGT, and SRT) describe important selection and reinforcement mechanisms that influenced psychological sex differences, and the value of their contributions is discussed elsewhere (Archer, 2009; Wood & Eagly, 2012). However, these theories do not address the question of what are the evolutionary benefits for a species to have these differences before the division of labor or sex selection starts reinforcing them (considering similar patterns in primates and their neurochemical correlates).

Looking at Sex Differences Globally: Why Two Sexes?

SEXUAL REPRODUCTION EMERGES IN EVOLUTION BY ADDING MALE SEX.

Let us now consider the psychological sex differences from the global perspective of what sex dimorphism is about, in general, rather than limiting our view to the specifics of human activities (e.g., socialization, hunting, gathering). Throughout the 20th century evolutionary theorists debated about why bisexual systems emerged in evolution and paradoxically succeeded over asexual (all-female) species by "inventing" the additional, male sex. The evolutionary benefits of the bisexual system are often attributed to gene recombination and the resulting diversity of genotypes. The recombination of genes during sexual reproduction diversifies resulting phenotypes and widens the spectrum of a species' features.

The paradox of sex emerges from strong disadvantages of gene recombination during sexual reproduction, and here are some of them:

> It comes with a loss of half of the combinations (because males do not directly reproduce).
>
> It requires a wasteful maintenance of this male half of the population just for the fertilization of daughters.
>
> It means a loss of storage for best-fit combinations, because all combinations, from barely good enough to best for survival, are eventually mixed up during recombination.
>
> It complicates the reproductive process by the additional requirement for mating behavior.
>
> It has maximal combinatorial and reproductive possibilities in hermaphroditic species and not in species with only male and only female phenotypes (dioecism, as in humans).

Yet despite these disadvantages of sexual reproduction, most plants and animals shifted from her-

maphroditism and gonochorism to sexual dimorphism.

One of the most widely accepted explanations for this paradox is that sex differentiation increases genetic variation and phenotypic diversity, in which gene recombination is just a mechanism in this process but not the main role of sex. This brings us to the issue, rarely discussed in evolutionary psychology, of phenotypic diversity produced by a given genotype (Gould, 1988; Lewontin, 2006), with sex being an example of it.

The capacity of genes to produce a diversity of phenotypes, instead of one exact copy of an ancestor's features, facilitates their adaptation to environmental contingencies and overall increases their chances for survival. Diversification of phenotypes opens the possibility of having several partitions of a population performing different functional tasks using their diverse abilities, similar to functional differentiation in other living systems (Arnellos & Moreno, 2012; Neander, 1991; Trofimova, 2000). It is no wonder that natural selection favors strategies that increase genetic and phenotypic variability. *Sex dimorphism* refers to the fact that in many species, genes carry at least two configurations that can be reproduced as phenotypes: males and females. As a result, similar to other phenotypic characteristics, the same genes can use sex dimorphism for various functional purposes and produce various distributions of males and females suitable for specific environments.

Overall, comparisons of asexual and bisexual species, both in observations and simulations, point to a key evolutionary role for sex in changing and unpredictable but not in stable conditions. In fact, Bonner (1958) described examples of simple organisms, which demonstrated the following tendencies:

> If there are several asexual and one sexual generation in the life cycle, the latter occurs when two consecutive generations experienced the greatest ecological differences.
>
> When asexual and sexual reproduction both occur at the same time, the asexual progeny should grow immediately and close to the parents, whereas progeny from sexual reproduction can have latency or disseminate far away from parents.

> Many high plants reproduce both asexually and sexually (seeds, which spread far away and have long latency).
>
> Many parasites reproduce asexually in one host but sexually when changing hosts.
>
> Free-living lower plants, animals, and microorganisms, which regularly reproduce asexually and only occasionally use sexual reproduction, always switch to sexual reproduction in response to environmental changes.

Bonner (1958), Williams (1975), Maynard Smith (1978), and many other evolutionary theorists suggested that species use sex as a response to the contingencies of changing environment. In developing his environmental uncertainty hypothesis, Williams pointed out that features of asexual reproduction (closeness to parents, rapid maturation into adult stages without latent stages, low mortality) are most suitable for predictable and stable conditions. At the same time, species that reproduce sexually have features tuned to environmental conditions (e.g., wide location spread of offspring; small initial size; embryonic, larvae stages, and latent periods of childhood; and high mortality) more so than those that reproduce asexually. Indeed, species that have combined both sexual and asexual reproduction (e.g., aphids, or the water flea *Daphnia*) show a correspondence between the type of reproduction and the type of environment: They reproduce asexually when life is constant and good and sexually in stressful or prewinter conditions. Simulations also showed that asexual reproductive strategies can consistently outbreed bisexual ones in stable conditions, but variable environments favor bisexual systems (Perrot, Richerd, & Valero, 1991).

Overall, the tendency for continuous evolutionary inventions in order to survive competition between coevolving species was named the Red Queen hypothesis (Bell, 1982), emphasizing that species must constantly evolve in order to stay alive among other evolving species, including predators and parasites. Several authors focused on the benefits of sex differentiation in the coevolution of hosts and parasites, suggesting that the protection against pathogens by itself is the major factor behind this differentiation (Hamilton, Axelrod, & Tanese, 1990, Lively & Jokela, 2002; Tooby, 1982).

Despite the benefits of sex differentiation and gene recombination in protection against pathogens, however, it is unlikely that such protection was the crucial selective pressure favoring sex in evolution. First, common sense tells us it is very unlikely that such a sophisticated evolutionary invention as sexual reproduction emerged and spread widely among species only because of this single benefit (combating pathogens), especially because there are numerous examples of simpler and asexual biological forms, which combat intruders rather well, without sex differentiation. Second, pathogen defense theories of sex differentiation refer to gene recombination as the main mechanism allowing a species to shake off the negative epistasis (i.e., the coevolution and gene interaction of species that provide a negative impact on the given species). Hermaphroditic species would in this case win the evolutionary race (because they had twice as many chances for gene recombination as sex-differentiated species), but they did not. This means that gene recombination by itself is not an absolute defense against pathogens.

Third, Kaltz and Shykoff (1998) showed that even though the adaptation of parasites to their local hosts is a common phenomenon, it is not universal, and therefore cannot be a global factor behind such a major evolutionary change as sex differentiation. Moreover, they showed that the pattern of host–parasite adaptation can sometimes be reversed (Kaltz & Shykoff, 1998). Fourth, Parker (1994) pointed to the relationships between sex and specificity of genetic features as an argument against pathogen defense theories of sex differentiation. He showed that asymmetric specificity as a necessary feature in plant–pathogen interactions favor sex less than symmetric specificity. Fifth, the pathogen defense theories of sex differentiation overlook the fact that epistasis can be positive as well (Elena & Lenski, 1997), considering the coevolution and gene interaction of humans with species that belong to the same families as known pathogens; after all, 90% of all cells in the human body belong to bacteria. And finally, it appeared that the role of gene interaction and epistasis associated with sex dimorphism was overestimated (Rice, 2002). High variability among pairs of loci appeared to minimize epistasis (e.g., Bonhoeffer, Chappey, Parkin, Whitcomb, & Petropoulos, 2004; Elena & Lenski, 1997), with species interactions (including host–pathogen interactions) selecting against sex in the latest mathematical models (Otto & Gerstein, 2006; Otto & Nuismer, 2004).

WHY NOT GO WITH HERMAPHRODITIC REPRODUCTION AS A DOMINANT TYPE?

A link between the changeability of the environment and the expansion of the genetic storage of possible phenotypic configurations also explains why there are still species with asexual reproduction: They are more suitable for predictable and stable conditions than sexual species.

A question arose among evolutionary biologists, however: Why did evolution not go with hermaphroditic type of reproduction (when individuals carry both male and female features)? In fact, this type of reproduction emerged in evolution before sex differentiation, and in theory it would double the chances for mating and adaptation in a changing environment. Yet from the 1920s scientists were able to show that, despite the benefits of hermaphroditism, there was a gradual shift in evolution away from it toward sex dimorphism (see Geodakyan, 2012, for review).

There is a coexistence of various reproductive strategies not just in different species but within the same species, but, as an overall tendency, Geodakyan (2012) noted that "roughly speaking, asexual forms are betting on the offspring *quantity*, hermaphrodites—on offspring *assortment*, and dioecious ones (differentiated by sex—I.T.)—on offspring *quality*."

THE ETS: SEX DIFFERENTIATION AS FUNCTIONAL PARTITIONING.

A step toward integration of these findings was offered in the mid-1960s by Geodakyan. He conducted an analysis of sex ratios, dispersion patterns, sex dimorphism in different mutation levels, phenotypic and genotypic diversity of two sexes, feedback control of sex ratios, rates of birth, rates of mortality, and susceptibility to new diseases (Geodakyan, 1985, 1999, 2012).[1] He first proposed the theory of asynchronous evolution, suggesting that genetic changes appear asynchronously in genes in the two sexes: Male genes change first, and after they prove their survival benefits, the reproduction of new characteristics emerges in a female-guarded "bank" of beneficial behaviors. A similar theory was described later by Andersson and Wallander (2004) as the phylogenetic rule of sexual dimorphism. They also suggested that the female sex

follows the changes of the male sex, at least in relation to changes in sizes of the body.

Geodakyan developed this idea further in his *evolutionary theory of sex* (ETS). The ETS suggests that sex differentiation allows a species to use a special (male) partition to try out various genetic changes, including parasitic and cooperative coexistence for possible interspecies coevolution and expansion of ecological niches. In Geodakyan terms, species use males as "experimental animals of evolution" and use another partition (female) to maintain the beneficial features of the species. If, during trial-and-error exploration a species "experiments" with only a part of the population, rather than with the whole aggregation, then another part of the species can continue preserving characteristics that were proven to be beneficial.

Indeed, Geodakyan pointed out,

> There are more males than females produced in each generation, and this pattern is common across species (with the ratio 106:100 for humans, and an even higher ratio for unborn pregnancies). In fact, populations of many birds are often male-skewed, but changes in this sex ratio were linked to a decline of population at a more rapid rate (Grüebler et al., 2008).

> According to the statistics of birth rates during and after World War I and World War II, this asymmetry in birth sex ratio went up (more boys were born than girls), known as the phenomenon of war years. This was the subject of a number of theories (Grant, 2003; Trivers & Willard, 1973) and was observed only under conditions of global mobilization of a population but not in local wars.

> In agriculture it has been noted (since Darwin) that in better conditions more females are born, and with worsening of conditions more males are born, even with artificial insemination from the same donor.

> As a trend across species, males live shorter lives than females, and this difference is not always related to sex differences in lifestyle because mortality at birth is higher for boys than girls (Stinson, 1985; Wells, 2000). Citing Hamilton's study of the sex ratio for death rates of 70 very diverse species (from nematodes to mammals), Geodakyan (2012) found that life expectancy is shorter in males than in females

in 62 species (89%) that he studied. Gavrilov and Gavrilova (1991) analyzed about 16,000 biographic records, including those of centenarians, and also reported consistently higher death rates in males than in females from infancy to the very late stages of life. Interestingly, they described that either improvement or worsening in living conditions was associated with (correspondingly) positive or negative changes in the death rate, but male prevalence in death rate remained (Gavrilov & Gavrilova, 1991).

> According to the records of the World Health Organization (2007), women have stronger immune systems, but it makes them more sensitive to autoimmune diseases. However, a weaker immune system in males results in higher death rates for men from all complications of illnesses (with just a few exceptions), especially from infections. Similar sex differences in immunocompetence and susceptibility to parasites have been found in mammals (see Geodakyan, 2012, for review).

> Women endure various devitalizing conditions (e.g., starvation, exposure, fatigue, shock, illness), better than men, but they are more sensitive to the negative effects of poisons and chemicals, including drugs, because of differences in metabolism.

> There is a strong asymmetry in sex ratio in mental illnesses: Hartung and Widiger (1998) reported that 81% (101) out of 125 disorders reviewed have male prevalence.

Sex differences in longevity and aging (with shorter life span in males) are not just a consequence of higher risks and sensation seeking in male behavior. Shorter life and faster aging in males was indeed linked to differences in chromosomes in various species (Partridge, Gems, & Withers, 2005; Tower & Arbeitman, 2009; Wang et al., 2011). It seems that having a double set of chromosomes prolongs life, but having a heterogametic set shortens it. In fact, in most bird species, where the heterogametic sex is female (ZW sex chromosomes), males tend to live longer than females. When the heterogametic sex (XY sex chromosomes) is male, as in humans and *Drosophila,* females tend to live longer than males. In *Caenorhabditis elegans,* where the hermaphrodite has two X chromosomes (XX) and the male has one (XO), the hermaphrodite tends to live longer.

The ETS explains the links between the emergence of the male sex and improvement of defenses against pathogens by an evolutionary role for the male partition as an immunology lab: If a new genetic combination is so resilient to harmful factors that even phenotypes with a higher susceptibility to diseases can survive, this combination should be used by the whole species. Thus, to be more specific, the ETS supports the idea that the emergence of sex facilitated the fight against pathogens (among other interspecies interactions, such as cooperation between species). However, the ETS does not support the idea that the fight against pathogens was the main function of sex differentiation.

HIGHER MUTATION RATE IN MALES THAN IN FEMALES.

In 1947 Haldane noted that the male germline goes through many more rounds of cell divisions per generation than does the female germline. The higher number of cell divisions in spermatogenesis than in oogenesis means that, statistically speaking, the male germline would potentially have more mutations than the female germline. Haldane therefore hypothesized that the male mutation rate in humans is much higher than the female mutation rate. Over the years studies on various species indeed estimated the male-to-female ratio of mutation rate to be approximately 2 in small rodents, 3–4 for carnivores and birds, and about 4–6 in higher primates (Bartosch-Härlid, Berlin, Smith, Møller, & Ellegren, 2003; Crow, 1997; Ellegren, 2007; Li, Yim, & Makova, 2002; Makova & Li, 2002; Pink et al., 2009) and insignificant in *Drosophila,* the favorite species of experimental genetics (Bauer & Aquadro, 1997). Such differences between species in male bias within the mutation rates suggest that this male bias is a reflection of complexity and uncertainty in interactions between the animal and its environment.

This is consistent with the suggestion that the male sex (i.e., the bisexual system) is the most beneficial in a changing environment. Recently the initial technique assessing the male bias of mutation rate (Miyata, Hayashida, Kuma, Mitsuyasu, & Yasunaga, 1987) was revised and complemented by new methods suggesting that the resulting male-to-female ratios in these rates probably should be even higher than previously reported (Li et al., 2002; Pink et al., 2009). Moreover, it has been shown that in males, variation in gene expression is based on additive interactions of alleles, in contrast to nonadditive (epistatic) interactions between alleles in females (Fox, Czesak, & Wallin, 2004; Wayne et al., 2007), that is, sex differences in mechanisms that rule the germlines that can affect the rate of mutation as well.

MALE VARIABILITY IS IN LINE WITH THE ETS.

One more important and rather universal feature is associated with sex differentiation. Since Darwin it has been noticed that within one species, and among related species, males often differ from each other to a higher degree than females (Brunner et al., 2013; Frasier, 1919; Lehre, Lehre, Laake, & Danbolt, 2009; Pheasant, 1983), creating wider dispersion of phenotypes. The male variability issue triggered hot academic and social debates after it was used from the 1920s as an argument for male superiority. In reality, male variability has nothing to do with superiority. A wider dispersion of male phenotypes from population norms (high male variability) means an overrepresentation of males at the extremes of the phenotypic distribution, that is, that there are more males on both tails of the distribution (e.g., with respect to intelligence, more mentally challenged and more geniuses) than females.

The phenomenon of greater male variability was found in primates and humans with respect to physical characteristics (Lehre et al., 2009; Pheasant, 1983), intelligence (Arden & Plomin, 2006; Deary, Thorpe, Wilson, Starr, & Whalley, 2003; Strand, Deary, & Smith, 2006), personality traits (Borkenau, Hřebíčková, Kuppens, Realo, & Allik, 2013), temperament traits (Rusalov & Trofimova, 2007), semantic perception (Trofimova, 2014), physical aggression (Archer & Mehdikhani, 2003; Pomiankowski & Møller, 1995), and other psychological characteristics (Archer & Mehdikhani, 2003).[2]

This phenomenon coincides with the common understanding that male sex (i.e., sex differentiation) emerged and was used by species in mostly variable environments. Simulations by Williams and Taylor (2006) indeed showed that variability and unpredictable behavior by a part of a group optimize results for the whole group.

In light of these findings, and in light of males' higher birth and mortality rates, the ETS suggestion about the functional role of sex partitioning makes

sense. It is possible that species really use the dispersion of male phenotypes for ecological testing, producing more of them and making them more disposable.

MAINTENANCE OF EXTERNAL STORAGE OF BENEFICIAL BEHAVIORAL ELEMENTS REQUIRES INNATE COMMUNICATIVE DISPOSITIONS.

It is well known that genetic programs that prepare an individual for environmental contingencies provide better chances of survival. Natural selection therefore favored genotypes that managed to store a species' beneficial features in tune with the environment. If the storage of the species' beneficial features expanded from genes to the elements of the environment expected in species' functioning, then genes were needed to encode phenotypic strategies of searching for, identifying, using, protecting, and developing such storage. Tuning behavior to information about the experience of other members of a population, whether past or present, improves a species' protection against errors in otherwise random trial-and-error behavior of individuals.

It is likely that sociability, empathy, and abstract thinking were group selected as preferable traits in several mammalian species, including humans. Similar to sex selection prolonging the survival of specific traits according to the preferences of representatives of the same species, members of the community and families can also change the rates of survival of relatives having desirable (for them) genetic features by helping these relatives survive and reproduce. Group selection remains a matter of much dispute in evolutionary science (Gould, 2002; Luo, 2013; Stearns, 1985; D. S. Wilson, 1983; E. O. Wilson, 2012; Wilson & Wilson 2008),[3] even though, similar to the well-accepted concept of sex selection, it describes the selection conducted by representatives of a species in relation to members of the same species. As noted, we do not discuss here the mechanisms of natural selection, whether sex, group, or individual, but rather the "why," that is, the evolutionary benefits of features associated with sex dimorphism. Here we just note a well-documented fact that the development of the human brain in evolution was most profound for areas related to socialization and abstract thinking, that is, those related to the group activities of humans, not just to their individual physical routines. Similar abilities for social signaling related to the salient environ-

mental information appeared before humans in other species, and their benefits are hard to overestimate, judging by the success in fitness of collective species such as ants, wasps, birds, fish, and, of course, mammals (Sulis, 2009).

More stable and sophisticated "storage hardware" was invented, as the evolution of human culture and society progressed, to store information that might be beneficial for human activities and for interaction with the environment. With the development of societal structures and informational infrastructure it appeared that genes controlling the abilities for using social storage of beneficial information changed too (Altman, 1978; Brothers, 1990; Dunbar & Schultz, 2007; Leontiev, 1981; Wilson, 2012). Recent studies in neurophysiology showed that specific neurotransmitter systems (mu-opioid receptors and oxytocin), which are part of human neuroanatomy and therefore are encoded in human genes, are the key players in affiliative behavior and social interactions (Bielsky & Young, 2004; Depue & Morrone-Strupinsky, 2005; Donaldson & Young, 2008; Taylor et al., 2006; Trofimova, 2014). Activation of mu-opioid receptors coupled with the oxytocin receptors induces positive emotional experience, and this might be one of the ways our genes provide for positive reinforcement of social interactions.

Both male and female phenotypes benefit from using such externally located but genetically directed storage of beneficial behavioral elements. In this sense both males and females should develop social abilities. At the same time, tuning behavior to some norms that were proven to benefit the species would limit male variability and would interfere with the (suggested by the ETS) role of male sex as a partition for ecological exploration. It is not very hard to imagine that natural selection favored the genetic combinations that coupled the female (childbearing) partition of a species with stronger behavioral orientation toward collectively verified benefits. Males, on the other hand, being a nonchildbearing partition of a species, could have their genes promoted (if they chose mates oriented towards socialization, i.e., species' verified benefits) even when their sex is genetically coupled with higher variability, susceptibility to diseases, and weaker orientation toward social norms and exchanges.

In this context, species with an asymmetric distribution of social and exploratory abilities between

the two partitions have an advantage in natural selection because they can combine two conflicting tendencies: building and maintaining a store of beneficial characteristics and exploring characteristics that were not yet proven to be beneficial. When one partition (female) is tuned to social signaling and norms of actions to a higher degree than another one (males), both partitions (i.e., the species as a system) capitalize on having the normative regulation of its members' behavior. At the same time, the asymmetry in abilities allows the second, variable (male) partition to experiment with alternatives that were neither prescribed by social norms nor encountered by the species before.

This two-partition arrangement increases species' fitness in both stable or favorable and unstable or challenging conditions. In favorable conditions it is more beneficial for a species to follow the accumulated norms and characteristics (i.e., increasing the role of social structures and parental investment). Such investment indeed improves the male/female ratio for survival, as observed in a number of anthropoid primates (Alexander, Hoogland, Howard, Noonan, & Sherman, 1979; Allman, Rosin, Kumar, & Hasenstaub, 1998). In unstable or challenging conditions it is more beneficial for a species to look for alternative routines and characteristics increasing the variation in behavior of its members, and that is what an increase in the male-to-female birth rate during war or unstable or unpredictable conditions might reflect. Wartime also can be interpreted as a time for poor parental investment, but both interpretations suggest lack of normative regulation over the behavior of a species' members.

To summarize, the most consistent findings in evolutionary biology related to the puzzle of what sex differentiation is about suggest that

> Such differentiation emerged as an addition of male sex to asexual (female) reproduction.
>
> Such differentiation went through the stage of hermaphroditism first, with male-only and female-only phenotypes developed on the basis of hermaphroditic species.
>
> Such differentiation is proven to be beneficial for variable environments, suggesting that adding the male sex might be related to management of environmental variability and degrees of freedom.

> Considering that hermaphroditism provides higher gene recombination than sex differentiation, there are additional evolutionary benefits for keeping phenotypes with either male or female features but not both in the same individual.
>
> Higher male (than female) variability was noted in biologically based characteristics.

Moreover, there are roughly two stages in human life that we should consider: first, with more hormonal differences between sexes and, second, with fewer such differences. The sex differences in physical exploratory and verbal communicative abilities are observed to be most significant in the first stage, and the division of labor or social roles takes effect in the second stage. In other words, during the stage when differences in abilities would be the most useful (the second), these differences are leveling, but during the stage when these differences are not needed or reinforced by social or occupational factors, these differences are most significant.

To explain such paradoxes, the ETS considers more systemic tendencies in evolution, not only the factor of reinforcement of the differences in evolution by division of labor or social roles. The ETS pointed to a faster initiation of genetic changes and a wider dispersion from population norms of male phenotypes in comparison to female phenotypes (Figure 2a). Based on these sex differences in the shapes of phenotypic distributions and on birth and mortality rates and susceptibility to new diseases, the ETS assigns the role of a conservation-oriented partition to the female sex, which has slower rates of genotype change and more compact distribution of phenotypes around the norm than males (Figure 2b). The male sex is considered by the ETS as a variational partition.

Psychological Sex Differences in Abilities Coincide With Functionality of Species' Sex Partitions

REVISITING THE NOTION OF SEX DIFFERENCES IN STATISTICAL SENSE.
It is important to emphasize several issues arising with possible wrong interpretations of the arguments in this article.

> The terms *male* and *female* in this article mean individuals with hormonal and physical characteristics statistically more common for this sex than for the opposite sex.
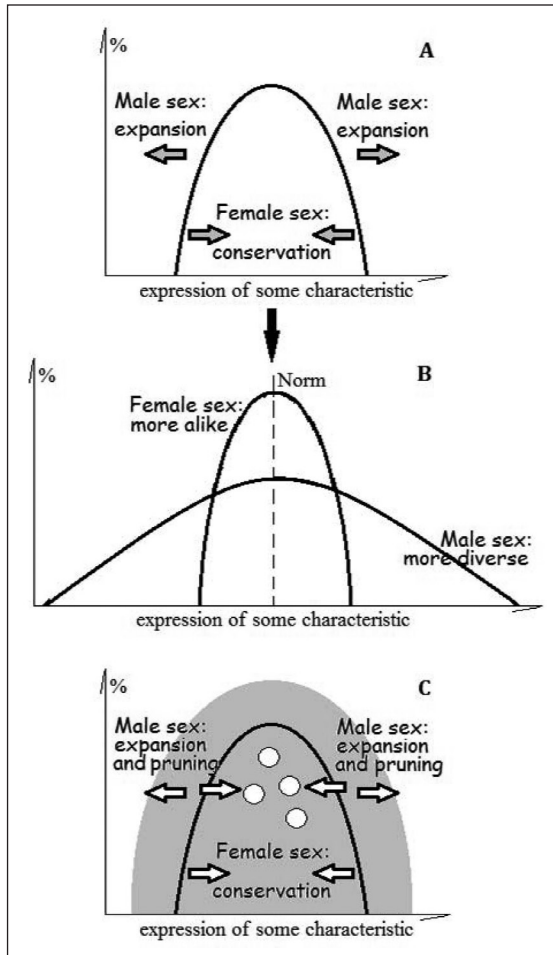
FIGURE 2. Shapes of distribution of phenotypes and functional roles of two sex partitions of species. (a) Evolutionary theory of sex points out to the evolutionary value of the bisexual system (males expand and females conserve the beneficial characteristics of their species), reflected in sex differences in the shape of distribution (b) and sex-specific behavior. (c), The bank of beneficial characteristics would inflate in the course of evolution (gray area) unless there is a tendency to systematically test the relevance of these characteristics and prune them (white holes)

Evolutionary biology gives many examples of how diverse the arrangements of sex attributes can be, as a result of natural evolutionary experiments. If, despite the possibilities of these other arrangements, there is some statistically significant bias in favor of some of them, then this bias probably has evolutionary benefits. This article therefore focuses on statistical tendencies for sex differences in a few human psychological abilities and disabilities, and especially shapes of distributions, as a source for new insights.

As noted, the psychological sex differences discussed in this article do not have as clear sex dimorphism as physical characteristics: Male and female distributions of scores on most traits overlap to a large degree. The arguments in this article relate to sex differences only in the statistical sense and are brought up only for discussion of evolutionary tendencies. There are males and females who have very high and very low abilities described in Table 1. Both males and females also were diagnosed with disabilities listed in Table 2. This article uses statistical arguments (i.e., means and shape of distributions) and does not label all men as dyslexic impulsive sensation seekers and all women as rule-following extroverts.

Greater male variability means that there are males who are more superior in verbal abilities, or more obedient and social, or have higher discriminatory sensory abilities than even the most gifted females in these aspects. Also, there are males who have more severe depression, obsessive–compulsive disorder and borderline personality disorders than females diagnosed with these disorders. Despite the occurrence of such cases, statistically speaking there are tendencies as described in Tables 1 and 2.

Finally, the described sex differences in physical and communicative abilities are more profound from birth to the mid-20s and might be less significant in later life. Therefore, this article focuses on the evolutionary coupling of hormonal systems with specific psychological sex differences and does not insist that these differences remain in later adulthood. The fact that several meta-analytic studies did not find profound sex differences in these two types of abilities (here we do not mention other abilities, e.g., olfactory, spatial, intellectual, musical) might have something to do with overlooking such a leveling phenomenon in these abilities. Moreover, meta-analysis is prone to negativity bias when variations in methods in different studies wipes out the effects (Borenstein et al., 2009).

SEX DIFFERENCES IN COMMUNICATIVE AND EXPLORATORY ABILITIES IN THE ETS PERSPECTIVE.

It is a big stretch to expect that the same factors that were involved in differentiation of two sexes in biology could penetrate into largely socially driven human psychology. Still, in our opinion such penetration happened in human behavior and abilities via

interaction between the genetic and environmental factors.

It appears that the ETS, despite some controversial comments of its authors, explains the pattern of sex differences much better than the HGT or the SRT, by attributing these differences to the roles of two functional partitions of a species. Of a few consistent sex differences found in abilities and mental disabilities, most relate to the differentiation between two behavioral directions: behavior directed toward synchronization of group activities around some norms, which were proven to be beneficial (e.g., verbal activities, socialization, compliance, agreeableness, rule monitoring, rules promotion) with preferred conservatism (low risks, high choosiness, and perceptive discrimination), and behavior directed away from norms and safety and toward exploration of behavioral degrees of freedom (e.g., risk taking, sensation seeking, substance abuse, disobedience, impulsivity, lower perceptual sensitivity). Sex differences in mental illnesses also differentiate along the axis towards versus away from the norm.

Young males are superior in physical, speed-related capacities and spatial tasks, and this superiority is coupled with their higher rates of risk and sensation seeking, ADHD, aggressiveness, and psychopathy. This combination is in line with the ETS's presentation of the male sex as a species' partition designed for exploration of new ecological behavior and expansion of established boundaries. In addition, practically all mental disorders with male prevalence are related to a compromised ability to follow social norms and expectations. Such combination facilitates devaluation or lower responsiveness to social messages and provides individual comfort in deviant, extreme, and socially disapproved actions, which is consistent with a variational (expanding of degrees of freedom) role of the male partition of species.

Young females are superior in verbal, empathic socialization abilities and have higher responsiveness to rules and social approval than males. This combination of behavioral aspects promotes the synchronization of group behavior around social values, thereby conserving elements of social establishments that were proven to be beneficial. Similar reasoning about the applicability of the ETS to psychological sex differences was offered by Rusalov (1993) in his analysis of sex differences in temperament. He found that females scored significantly higher on temperament scales measuring verbal–social endurance and tempo, and males scores higher on physical endurance and tempo scales. Rusalov suggested that the verbal superiority of females is in line with Geodakyan's view about the function of the female partition of a species as designed to synchronize the norms and values of the community.

A role proposed by the ETS for the female sex as a guardian of verified benefits is in line with the behavioral observations of lower risk, more hygienic and conservative behavior in females in comparison to males. These behavioral observations coincide with sex differences in intrinsic meaning attribution. In the psychosemantic experimental studies of Trofimova (2012a, 2012b, 2013) on Canadian, Chinese, and Russian cultures, participants were asked to give estimations to very general, neutral concepts using common bipolar scales. The results showed that women favored more predictable objects, including rules and routines (such as reality and work related), whereas men favored more exceptional objects (social and physical attractors).

These findings are in line with anthropological studies suggesting that males were occasional and optimal foragers targeting exceptionally nutritious food (Krasnow et al., 2011; Marlowe, 2007). It is possible that the role of males as a variational and exploratory partition of a species makes their attention and perception tuned more to sensational and variable elements, regardless of their functional significance. It is also possible that the role of females as a conservational partition of a species makes their attention and perception tuned more to the most pragmatic features of objects (e.g., resource allocation, protection and selection of valuables, establishing the rules and regulations of the community, discrimination against pathogens). Such features of female perception are beneficial for the community's survival, and, considering the consistency of sex differences in these features across cultures, they are probably genetically encoded. Statistically speaking, women were found to have more sensitive discrimination in taste, colors, and odors (Table 1) and they are choosier than men when it comes to many aspects of their functioning, such as dating (Buss & Schmitt, 1993; Clark & Hatfield, 1989), dressing, shopping, choosing words and clarifying what was said during conversations,

furnishing their houses, and taking care of children and of their health (Woodwell, 1997).

SST, HGT, SRT, and ETS—all these theories converge on the idea that verbal abilities, obedience, and higher sensory discrimination in females were reinforced in evolution by the nurturing role of females among early humans. These theories also agree that these sex differences make women better gatherers and nurses or educators and men better hunters and mechanics. The debates arise about the sequence of events. What was there first: abilities or division of labor? Researchers working in the HGT and SRT paradigms would argue that the prevalence of females in gathering and social activities was the factor for sex differences in perceptive, attentive, and social–verbal abilities, in other words, that the differences in early employment led to the differences in abilities. Researchers in the ETS paradigm would argue that differences in abilities were there first, leading to a division of labor between the two sexes and corresponding social roles, reinforcing these differences.

Interestingly, Stoet (2011) showed in his experiments that males were faster in finding target objects and made fewer mistakes than women, and this might look like a contradiction to the HGT and ETS. To resolve this contradiction, we have to keep in mind the difference between the speed of search, perceptual sensitivity, and perceptual endurance. Trofimova (2010, 2014; Trofimova & Sulis, 2011; Trofimova & Robbins, 2015) argued that endurance, behavioral sensitivity to specific reinforcers, and the speed of actions are three different aspects of arousal and are regulated by different neurochemical and neuroanatomic systems. It is well established that men are superior to women in physical speed and reactivity (as seen in Olympic records), and their higher scores in impulsivity suggest that in general the dynamic of their responses is faster than for women (which makes them better hunters but also fast gatherers when needed). However, this does not mean that they could identify more targets (i.e., that they have superior sensitivity) or stay longer on the task (i.e., that they have superior endurance) than women. Indeed, studies show that females are able to stay focused on gathering activities, whereas males gather more opportunistically, often in the course of pursuing their primary foraging activities (Krasnow et al., 2011; Pacheco-Cobos, Rosetti, Cuatianquiz, & Hudson, 2010).

NEOTENY AND MALE VARIABILITY AS FACTORS IN SCHIZOPHRENIA.

As noted earlier, higher male variability expresses itself as an overrepresentation of males at the extremes of distributions of characteristics. Recently special attention was given to the evolutionary benefits of other phenomena, such as neoteny, as a delayed maturation of the brain in humans (Brüne, 2000; Montagu, 1962). In general, extending the juvenile period and delaying maturation reduces reproductive fitness, so the paradoxical spread of such a seemingly disadvantageous tendency in primates, especially humans, became a focus of attention of evolutionary theorists. There is good consensus between biologists and psychologists that a delayed maturation of the brain makes the brain more plastic in terms of learning specific behavioral elements that are most appropriate for environment, instead of having innate behavioral strategies. Such an increase in learning abilities based on neoteny was used to explain human verbal and mental abilities (Crow, 1995, 1997; Gould, 2002; Montagu, 1962).

In the light of higher male variability, we could expect that neoteny could be extended longer (including a delay in verbal development or maturation of impulse control) or be shorter in men, in comparison to the population norm. Several authors suggested that a shortening of neoteny as a result of genetic dysregulation not only impairs learning capacities and decreases playfulness and curiosity but also emerges as schizophrenia (Bemporad, 1991; Brüne, 2000; Burns, 2004; Crow, 1997). As Crow put it, schizophrenia might be the price humans pay for having language.

In the context of this article, higher rates of schizoid and schizotypal personality disorders in men might reflect a possible shortening of neoteny in patients with these disorders, and weaker impulse control (as in ADHD) and sensation seeking might reflect a possible extension of neoteny. In this sense greater male variability in neoteny might emerge in sex differences in mental disorders, as described in Table 2. Overall these observations support the idea that psychological phenomena could be based on global evolutionary tendencies. More specifically, these observations are in line with the ETS idea about male sex as a species' variational partition.

ADHD ARGUMENT.

SST, HGT, and RST cannot explain sex differences in mental disorders, such as autism or ADHD. It is

hard to imagine that females chose males with such disorders or that the everyday division of labor somehow required such disabilities in early humans.

Hartmann (1993) and Jensen and colleagues (1997) suggested that ADHD was a beneficial condition for early hunters, because impulsivity means faster reaction and faster shifts of attention between multiple targets. These suggestions were criticized in a literature confronted with nonsupportive anthropological arguments (Shelley-Tremblay & Rosen, 1996). Another evolutionary explanation in regard to sex differences in autism and ADHD was offered by Baron-Cohen (2003, pp. 118–130).

Here are some important distinctions to keep in mind:

> Speed of action versus impulsivity. One of the main characteristics of ADHD is impulsivity (involuntary behavioral reactivity). Speed of action in hunting differs from ADHD-type reactivity by having a component of preselection and anticipation of a target, the component that is missing in ADHD. For example, let us compare squirrels (gatherers) and lions (hunters). If lions acted as squirrels, they would apply their speed to attacking a prey animal as soon as they see one. That is what squirrels do: Once they smell or suspect the location of a nut, they immediately start digging. They do not stare at it for long (as lions do with potential prey); they use all of their speed to get it right away. In contrast, a lion (more precisely, lioness, because mostly females hunt in this species) does not immediately react to (attack) prey. As group hunters, lionesses coordinate their position in relation to each other and to their prey. This process, similarly to other life situations, requires capacities for planning and focusing on specific features of situations rather than reactivity to the immediate presence of suitable food. In other words, good hunting requires good impulse control, that is, the voluntary suppression of responsiveness to a large number of stimuli and the suppression of multiple potential reactions to them. Such stimuli include present but untargeted members of the prey group, other animals that can be potentially eaten but have less nutritional value than the chosen victims, potential sex partners, and unknown and complex objects that members of the same species approach to satisfy their curiosity when they are not hungry and not in a rush. In short, if we consider hunt-

ing tasks, impulsivity as a reactivity to situational distractions (as in ADHD) would bring more disadvantage than benefit to a hunter.

Divided attention versus ADHD. Another main characteristic of ADHD is attentional distractibility (involuntary switching of attention to new situational targets). In contrast, the main demand in hunting is voluntary control of perception and action, including voluntary (and not involuntary) switches between multiple sources of information, such as monitoring what a hunter's partners are doing and what their prey is doing. Both gathering and hunting require a voluntary division of attention for several sources of stimuli, but ADHD would compromise a hunter's activities much more than those of a gatherer. After all, gatherers can repeat a search in the same area and find missing targets, whereas prey will not wait for hunters once they have been attacked. In this sense ADHD would be detrimental for hunting, not beneficial. The higher rates of ADHD in males contradict the idea that functional activities influenced sex differences: Early human hunters faced high demands for attention, accuracy, and impulse control, and therefore males should have higher or at least as high attentional capacities as females, not lower.

Strong attention-related arousal versus hyperarousal in ADHD. That strong cognitive arousal enables hunters to pay attention to various stimuli simultaneously should not be confused with the symptoms of hyperarousal in ADHD. The first type of arousal, attention, or mental endurance, is linked to the ability of neocortex (frontal lobes) to suppress, differentiate, and regulate otherwise immediate impulses to act. In contrast, impulsivity is linked to a deficiency in the same neocortical areas. In this sense attention-related arousal and hyperarousal in ADHD are opposite cases of the capacities (high vs. low) regulated by the frontal lobes. ADHD in early humans can be viewed (similarly to the direct reactivity in animals) as immature impulse control, which improved as human evolution progressed with the development of the neocortex. Evolution probably did not develop ADHD in response to the hunting functions of early humans, as it was inherited from our animal ancestors.

Variability of behavior and ADHD. Williams and Taylor (2006) reported from computer

simulations of the ADHD trait within a sub-group of a population that it might be beneficial for the whole group. A closer look at their definitions shows that they used the parameter of unpredictability (or variability) as a main characteristic of this subgroup. This characteristic is not among the clinical symptoms of the ADHD, so assigning it to this disorder is a big stretch; however, variability, as described in the ETS, is a characteristic of one sex partition. Importantly, the results of Williams and Taylor (2006) showed that unpredictable behavior by a minority optimizes results of the food management behavior for the group. These results are in line with the ETS.

Sensation seeking and hunting. There is no doubt that exploratory capacities make men better hunters. The question is about the confusion between cause and effect. The HGT suggests that the division of labor in functional activities (hunting in males) was the initial factor that developed the sensation-seeking behavior. From the SST perspective, however, it is not clear why females would want such risky investment of their personal genotypes and prefer sensation seekers. More importantly, this implies that there were times when males were no riskier than females and that human evolution created the sex gap in risky behavior. The ETS argues that this gap is the cause, not the effect of division of labor: Men were capable of activities requiring risk and sensation seeking, and therefore they were more willing to engage in such activities.

SUMMARY.

Sex differences in abilities related to communicative and exploratory aspects of behavior might be influenced by a global evolutionary tendency within species to form two functional partitions and are not just an accidental result of sexual selection or labor distribution in early humans. Overall functional differentiation (i.e., the partitioning of a system into parts that play different functional roles) is a common evolutionary phenomenon (Arnellos & Moreno, 2012; Neander, 1991; Trofimova, 2000). It illustrates that something beneficial for a whole species can arise when it is not necessarily adaptive at an individual level, contradicting the opinions of many evolutionary psychologists that evolution happens only at the level of individuals (based on arguments about

genetic change). Similar to collective modes of action or the use of environmental infrastructures to pass knowledge on to further generations, functional differentiation systemically allows species to survive competition and natural selection. It is therefore possible that sex differentiation was very beneficial in accelerating the evolution of species because it provided species with a specific partition for an ecological exploration.

Contradictory Allocation of the Drive for Social Control (in Males) and Higher Socializing Abilities (in Females)

It is suggested here that the ETS explains the specifics of sex differences in some abilities and disabilities of young humans better than the SRT and the HGT. However, the ETS does not explain the allocation of the drive for group control and social status commonly noted more in males than females. It is well documented that males in a majority of social mammal species, including humans, have consistently higher drive and behavioral tendencies to acquire social status and power than females (Pratto et al., 2000; Pratto, Sidanus, & Levin, 2006; Madsen, 1985; Tremblay, 2000).

Several biosocial theories describe evolutionary mechanisms supporting men's drive for power and social status. These theories describe how hormonal and neurotransmitter regulation, sex selection, functional activities, the benefits for cheaters as observed in game theory, social expectations, and peer pressure led to an increase of sex differences in this drive throughout human evolution (Barkow, 1989; Huesmann et al., 1984; Madsen, 1985; Schultheiss et al., 1999; Wilson & Daly, 1985). For example, SST suggests that "status signals competence," and therefore females prefer high-status males for reproduction (Barkow, 1989; Huberman, Loch, & Önçüler, 2004), and such preference eventually couples with male sex hormonal patterns. According to cross-cultural studies, potential access to resources (which social status and power deliver) indeed universally attracts females more than males during mating (Buss, 1989; Clutton-Brock, 2009). However, if sex differences in the drive for power are just the consequence of females' choices of males to get to more resources in evolution, then it is not clear what are the evolutionary benefits of forcing females to search for a middle (literally) man standing between them and resources

instead of developing a drive in females for getting the resources directly. In theory, it still would be a functional arrangement if males were physically strong, performing their hunting and other physical jobs, having their extremes in behavior, but not wanting social status any more than females.

The mechanisms of "how" do not explain the evolutionary benefits of "why" it was advantageous for our species to develop a stronger drive for social power in males and not in females, or to have such differences at all. If males in primate species are physically stronger than females anyway, why do they need additional sensitivity to their social status if they can routinely exercise their physical power?

Fischer and Rodriguez Mosquera (2001) argued that males show aggression to secure social status and respect primarily in the eyes of their fellow males, not so much in the eyes of females. However, aggression is not the necessary component of the drive for social status; it is just a behavioral element that can be easily noticed. A significantly more positive evaluation of the concept of power was found in educated, well-behaved men, in comparison to women, not only in observable behavior but also in fundamental semantic perception (Trofimova, 2012b, 2013).

Another argument on this matter is that it is the frustration in males caused by their limited communicative abilities that leads to a more aggressive choice of behavior out of a need to control the group. Such a shortcut to influence over the group makes sense only if in evolution there were no chances for males to be equal with females in terms of communicative abilities or there were no chances for females to be equal with males in access to resources. However, such chances were there in evolution, as they were used by other species. In ants and hyenas females have both communicative superiority and power. In many fish and birds species there is an opposite arrangement: Males have brighter appearance and rich communicative and demonstrative behavior (through songs and motions) to attract the attention of rather pale females, and also higher aggressive and competing behavior. In this sense sex differences in humans in terms of a drive for status and power might have some evolutionary advantages if, after a long course of evolutionary experiments, natural selection settled with the given arrangement in humans.

Why do women not have a similar drive for social status, whether within the group or just in the eyes of their fellow women? If females have higher tuning to social activities and group benefits than males, then they have all the reasons to want a high social status; it would give them a shortcut to group resources to feed their children and to manage the male workforce (as in hyenas). It is hard to judge how competitive women were for social status during periods of human matriarchy, but this period was associated with slower social evolution than patriarchy. Why do women not want status as much as men? What are the evolutionary benefits of having sex differences in the drive for power? Why can humans not be equal in this regard?

Moreover, there is a mismatch between the drive for social status and capacities. The drive for a social control is stronger in males, but it is females who dominate in the abilities for social interaction. At first glance it would make more sense to match the drive for group control with abilities related to group interaction, similar to the correspondence between physical capacities and functional needs in hunting. It would make more sense if females, supposedly in charge of preserving the species' bank of beneficial characteristics and better equipped for social interactions, used their abilities to get higher social status and control resources.

This means that there were evolutionary benefits for creating a significantly higher motivation for power and social control in the "wrong" sex, that is, in males, whose rates of communicative disabilities were only increasing.

A Possible "Redundancy Pruning" Role for Male Partition of a Species

To upgrade the ETS, it might be useful to consider that the "variational" role of the male sex among two conjugate sex subdivisions does not end with testing the boundaries of a species' normative behavior. This role also includes the provision of "irrelevance pruning," or "redundancy pruning," of previously efficacious but potentially out-of-date characteristics, established in genotypes, phenotypes, and memotypes.

It is natural to suggest that if the female sex were developed to conserve the species' behavior, then it would not be females who would revise and make changes to established characteristics. With the accumulation of useful behavioral elements in a normative

bank over time, a species risks having too complex and potentially contradictory a system of these elements, which would compromise their adaptation. The accumulated behavioral strategies can still guarantee a desired outcome, but it is possible that in new circumstances these strategies could be substituted with shortcuts, or some upgrade of these strategies, which would simplify the achievement of the goals. In this sense the species needs a party that would systematically try out such shortcuts, eliminating an excess of accumulated behavioral rituals, and it seems that this is what males do. This means that the male partition of a species is in charge of both increasing and decreasing degrees of freedom of the species' system, whereas the female partition is in charge of keeping the obtained, tested (using males), and accepted degrees of freedom (Figure 2c).

The combination of male-prevalent characteristics might reflect an evolutionary role of the male partition in searching for shortcuts in activities of the human species and challenging those that become less relevant:

> Use of prohibited (socially disapproved) but less energy-consuming ways to receive gratification (such as deception and theft) are reflected in higher rates of conduct disorder, psychopathy, and sociopathy in males.
>
> Stronger abilities and drive for technology (since early age) and superiority in mechanical reasoning emerge in intrinsic meaning attribution. These sex differences cannot be explained by HGT, SRT and SST: Complex mechanical components of cooking, sewing, and other household activities typically attributed to women should develop at least equal abilities in both sexes.
>
> Ability to simplify and to generalize new information is stronger in men than in women.
>
> Search for novelty and low tolerance for repetition and boredom are confirmed by higher male preference for sensational objects.
>
> Higher rates of impulsivity and impatience facilitate a search for shortcuts in time-consuming activities.
>
> Higher physical strength and aggressiveness help males obtain power without following social preferences.
>
> Lower verbal abilities in males than in females signal low probability of success in social estab-

lishments, forcing males to search for alternative ways to get resources.

> Higher rates of autism and lack of empathy help males disengage from the feelings of others and from social expectations.
>
> Finally, higher drive for status and power, based on strong biological factors, increases probability for males to get an easy access to their goals by exploiting other people.

In this sense power and social status are just types of "Easy buttons" to enable males to obtain the resources of the community. The male-prevalent tendency for "social deafness" makes it more comfortable for males to do something against the community's establishments using these very resources.

Not all males with high determination for leadership have selfish and psychopathic motivation, judging from the altruistic political leaders in our history; however, a drive for power is coupled in males with psychopathy more often than not (Dugatkin, 1992; Hare, 1999; Huberman et al., 2004).[4] When sex differences in semantic processing of verbal material were studied, it was shown that men probably know very well what is good and what is bad from the society's point of view, but they have selective preference for sensational and power-related social values (Trofimova, 2012b, 2013). This speaks against the idea of a global deficiency in male semantic processing of social cues and in favor of their selective acceptance of social values. An evolutionary role of the male sex for "redundancy pruning" might justify the opinions that ADHD, communicative disorders, and a drive for social status in males, and their coupling with the male sex during human evolution, might be beneficial for a human society but not for an individual (Baron-Cohen, 2011; Hartmann, 1993; Shelley-Tremblay & Rosen, 1996; Williams & Taylor, 2006).

In humans the normative bank of beneficial behavioral characteristics is expressed and regulated by sociocultural and verbal means much more strongly than in other species. At the same time, it was noted that humans are capable of much more extreme cruelty to members of their own species within or without confrontations (i.e., extreme sociopathy), in comparison to other species. It is likely that these phenomena are an example of the evolutionary balancing interaction (or adjustments) between social, psychological, and biological levels of behavioral regulation, which

eventually affected the genetic norm of reaction. In such evolutionary adjustments, the stronger control (via societal establishments) from a conservational partition, the more opposition to it emerges in the variational partition via genetic and phenotypic searches for additional degrees of freedom. From this perspective higher rates of attention deficit and communicative disorders (ability to perceive messages from other members) in males in comparison to females might be influenced by a self-regulatory tendency of the human species to facilitate a disengagement from a growing social control.

The interactions between biochemical (hormones, neurotransmitters), biological (body systems, genes), psychological (abilities, behavior), and social factors in human evolution (cultural regulation, socialization) suggest that we should use information from different sciences, and not just biology, in the analysis of evolutionary processes.

Conclusions

In summary, the SRT and HGT look at sex differences in abilities from the perspective of what early humans were doing, whereas the ETS takes into consideration the role of the shapes of phenotypic distributions, that is, the genetically encoded range of phenotypic diversity. In addition to these aspects, it might be useful to look at these differences from the perspective of what sex division is about in a systemic sense (i.e., from evolutionary interests of the species and not phenotypes). It is likely that the directionality of sexual selection and the division of labor between sexes were the consequence and the mechanisms, and not the cause, of the sex differences in human behavioral abilities. As a result, psychological sex differences might be influenced by a global tendency within a species to expand its norm of reaction but at the same time to preserve the beneficial properties of the species.

This article suggested that

> A pattern of consistent sex differences in physical, verbal, and social abilities corresponds to the idea of ETS considering sex dimorphism as a functional specialization of a species into two partitions: conservational and variational. In our opinion, female superiority in verbal abilities, rule obedience, socialization, empathy, and agreeableness reflects the systemic conserva-

tional function of the female sex. Male superiority in risk and sensation seeking and physical abilities; higher rates of psychopathy, dyslexia, autism, and schizophrenia; and higher birth and accidental death rates reflect the systemic variational function (testing the boundaries of beneficial characteristics) of the male sex.

It is likely that the variational function of "male partition" also provides irrelevance and redundancy pruning of an excess in a bank of beneficial characteristics of a species, despite resistance from the norm-driven conservational partition of species. This might explain contradictory sex differences, allocating a high drive for social status or power in the sex with the least skill in social interaction. The higher the rates of communicative disorders and psychopathy in males, the easier it is for them to disengage from normative expectations and to act under social disapproval.

1. *The Evolutionary Theory of Sex* (Geodakyan, 2012) was extensively published but initially only in Russian. It became available in English only in the 1980s, when the author had more academic freedom at the beginning of perestroika.

2. Archer and Mehdikhani (2003) described sexual selection mechanisms that reinforce male variability in a number of psychological characteristics. Here we focus not on the mechanisms of reinforcement but on the benefits for the species to have such reinforcement at all.

3. This article does not discuss group selection theory, but those who would like to see a recent analysis of this theory can benefit from the discussion by the father of sociobiology, E. O. Wilson (2012, pp. 172–180) or by Gould (2002).

4. The psychopathic style of ruling by men in power is often described as a tendency to cut corners, as exhibited by CEOs and politicians (Dugatkin, 1992; Hare, 1999). An explanation of the evolutionary "promotion" of psychopathy in power does not excuse the psychopathic actions of men in power, which have caused an enormous loss of life and destruction, at least in the past two centuries. This explanation also does not excuse the higher rates of pay for "jobs in power" and the devaluation of female-prevalent jobs, which usually entail coping with more repetitive tasks requiring a lot

of attention and plasticity. Historically, the payment system was set by males, according to male preferences. In terms of importance and responsibility for other people, a CEO does not work any harder than a school teacher, a nurse, or a social worker.

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