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Sexual dimorphism: innate or acquired? A reinterpretation of biological differences

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Abstract

This text argues that the dimorphic interpretation of biological differences in the human species results from an androcentric reading of bodies that have characterized modern science. In contrast to this perspective, the article shows how social practices associated with gender roles can produce biological differences that "adjust" themselves to a dimorphic reading. Based on these facts, we propose that if correlations between genitality and biological differences exists, they are not caused by the processes of sexual differentiation, but by statistical links given by normative gender stereotypes. The behaviors implied in such stereotypes are expressed biologically, and gender roles create many of the biological differences currently assumed as innate and sexually dimorphic.

Keywords: Sex. Gender identity. Sex characteristics.

Resumo

Ética médica nas Faculdades Integradas do Norte de Minas: percepção do estudante

Está cada vez mais evidente que a reflexão sobre ciências humanas e deontologia é necessária para a formação mais abrangente do estudante de medicina, visando preparar não apenas profissionais tecnicamente capacitados, mas também humanizados. Diante disso, e a fim de seguir as diretrizes curriculares nacionais atuais, as Faculdades Integradas do Norte de Minas instituíram módulo no sexto período de medicina chamado "Humanidades, Bioética e Antropologia Médica". Objetivando avaliar a percepção de alunos sobre o ensino de ética nessa instituição, esta pesquisa aplicou questionário a estudantes do sétimo ao décimo períodos do curso de medicina. O instrumento contava com perguntas sobre a estruturação do módulo e o ensino de ética. Os resultados evidenciaram a proposta inovadora do módulo e a importância da ética médica na grade curricular no sentido de contribuir para a formação de médicos mais humanos.

Palavras-chave: Sexo. Identidade de gênero. Caracteres sexuais.

Resumen

Ética médica en las Facultades Integradas del Norte de Minas: percepción de los estudiantes

Cada vez es más evidente que la reflexión sobre humanidades y deontología es necesaria para la formación integral del estudiante de medicina, con el objetivo de preparar no solo profesionales técnicamente calificados, sino también humanizados. Por lo tanto, y con el fin de seguir las actuales directrices curriculares nacionales, las Facultades Integradas del Norte de Minas establecieron un módulo en el sexto período de medicina denominado "Humanidades, Bioética y Antropología Médica". Con el fin de evaluar la percepción de los estudiantes sobre la enseñanza de la ética en esta institución, esta investigación aplicó un cuestionario a estudiantes del séptimo al décimo período de la carrera de medicina. El instrumento tenía preguntas sobre la estructuración del módulo y la enseñanza de la ética. Los resultados mostraron la propuesta innovadora del módulo y la importancia de la ética médica en el plan de estudios para contribuir a la formación de futuros médicos más humanos.

Palabras clave: Sexo. Identidad de género. Caracteres sexuales.

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The androcentric reading of biological differences

The modern scientific method abandoned the theory and world of Platonic abstract forms to consider experimentation and the concrete world as the ideal of knowledge [1]. Feminist epistemology identified that this substantive shift in the way of describing phenomena was functional to the interests of the androcentric subject (the cis, heterosexual, white, proprietary and Western male) in the framework of pre-industrial societies. These interests include the secularization of nature to act upon and dominate it by technical and technological production, and the need to polarize social roles, circumscribing women to reproductive and care tasks [1].

This scenario provided an enabling environment for Newton's ideas: his mechanistic thesis served to reinterpret living nature, which, by exempting it from any divine origin, allowed its manipulation. The human organism also began to be the object of exploration and experimentation, serving as a source of biological arguments to justify confining women to the private sphere. Science developed a dichotomous, essentially hierarchical value system, whose legitimacy was centered on a dimorphic sexual interpretation of biological differences between genders [2]. The reason-emotion, objectivity-subjectivity, universal-particular, abstract-concrete, active-passive, public-private pairs corresponded to the masculine-feminine pair, respectively [3].

As Thomas Laqueur describes, a new epistemological paradigm displaced the hitherto dominant model of the *anatomy of similarities* for one that assumed *an anatomy and physiology of the incommensurable* [4]. By the end of the 18th century, the idea of opposite and complementary anatomies characterized the interpretation of the differences between men and women [5].

In short, the projection of the dichotomous and hierarchical social order that began to take shape in modernity was justified by a dimorphic sexual interpretation of biological differences. In other words, this perception resulted from the androcentric biases that permeated the scientific discourse on sexual difference. As such, male-female categories became equivalent to man-woman categories: two qualitatively different organisms according to the roles associated with reproduction.

Considering that these roles are the foundation that legitimizes normative gender stereotypes and can explain what are today considered sexually dimorphic differences, this article is structured as follows. The first section shows that the same androcentric biases that characterized the scientific discourse on sexual difference during modernity persists in the biomedical field, but updated to a molecular reading made possible by technical/technological refinement. We will describe the consequences and negative effects that may affect how prevalence and disease development in men and women are interpreted.

The second section presents critiques by feminist epistemologists and empiricist scientists, as well as certain conceptual proposals to support a reinterpretation of biological differences that does not fall back on deterministic and essentialist readings. And the last part highlights the importance of reconceptualizing our biology and undoing the androcentric biases still prevalent in the biomedical field.

The dimorphic sexual interpretation of biological differences in current tenets

During the 20th century, the dimorphic interpretation of biological differences underwent a molecularization process due to two crucial events: the discovery of the SRY gene by French endocrinologist Alfred Jost in 1940, and the consolidation of neuroendocrinology as a scientific discipline in 1959 [6,7]. From these developments emerged the so called "classical dogma and organizational/active (O/A) theory."

Classical dogma broadly describes sexual differentiation in mammals, including humans, in chromosomal terms:

The Y-linked SRY gene is expressed in sexually undifferentiated cells of the primitive genital ridge and commits that tissue to a testicular fate. The testes then secrete hormones: Müllerian-inhibiting hormone, which prevents development of Müllerian ducts; and testosterone, which

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promotes development of masculine structures elsewhere in the body [7].

O/A theory extended the dimorphic interpretation of sexual differentiation to the brain and proposed that from a monomorphic (initially "female") brain a differentiation ("masculinization") caused by testosterone occurs. Such differentiation would permanently organize the brain in a sex-specific manner, being activated in postnatal life and thus explaining the essential differences between males and females. Both the classical dogma and O/A theory suggest that the active differentiation processes would be characteristic only of males [7].

This theory, applied to the human species, assumes "masculinization" as the explanatory cause of brain differences due to "sex": hormonal chemistry and physiological mechanics of reproduction – ovulation cycle, ejaculation and erection – and the so-called "gender behaviors." The predominant scientific discourse tends to assume that these behaviors are not directly related to reproduction, but are linked to cognitive-behavioral abilities [8]. That is, prenatal cerebral dimorphism would imply certain cognitive-behavioral abilities.

According to the androcentric value system, the male brain would be optimized for those skills and behaviors considered the "most valued" – for instance, visual-spatial skills, which involve map reading and navigation (tasks linked to the capacity for abstraction); while the female brain would be optimized for "verbal fluency" (speaking) skills [9]. This brain characterization shows that the word "dimorphism" becomes equivalent to and legitimizes a dichotomous and therefore hierarchical distribution of social roles.

This interpretation of a monomorphic path where "later" occurs a masculinization and de-feminization of the male-man is closely linked to the active-passive dichotomous pair (male-female, respectively). This link was explicitly supported by the various scientific disciplines that emerged during the 19th century, such as embryology and craniology. Without empirical evidence, these disciplines asserted that becoming male required complexification/specialization [10]. In short, the tenets put forth by classical dogma and O/A theory reflect the anachronism of androcentric biases, which entailed interpreting biological differences within the framework of a dichotomous and hierarchical reading of bodies.

Consequences of a dimorphic interpretation of biological differences in the biomedical field

The hierarchical reading that underlies the dimorphic sexual interpretation of biological differences is reflected in the omission of females and women in basic, preclinical and clinical research protocols [11]. As a result, the National Institutes of Health (NIH), the European Commission and the Canadian Institute for Health Research begun requiring that research funded by them include both males and females (in animal, tissue and/or cell studies) in their experimental designs, and that sex be considered a biological variable in their analyses, with few exceptions [12].

Some studies prove the biases that result from omitting the female and interpreting the processes of genital and cerebral differentiation, taking the male as the main reference and complete material that "contains" the female. In this sense, although it has been found that the SRY gene initiates testicular differentiation in males, we also have genes responsible for initiating ovarian differentiation in females. In other words, females undergo active genital differentiation. This fact was observed not only in mammals, but also in birds and even in turtles, in which sex determination depends on temperature [13].

Regarding the brain, although the process of masculinization and defeminization was corroborated in male mice [14], this is not equivalent to legitimizing the idea of a monomorphic brain from which masculinization occurs. In contrast, a study performed with female mice found a process of feminization and de-masculinization [15]. In other words, the results obtained suggest the existence of a "dual" brain, with the simultaneous presence of male and female circuits in each organism, also implying the presence of active sexual expression patterns, both with respect to male lumbar shape and female lordosis (curvature of the spine) [15].

By suggesting parallel processes of genital and cerebral differentiation between males and

females, rather than a "complexification" to become a male, these two studies [14,15] expose the nineteenth-century androcentric biases when interpreting genital and cerebral differentiation. This opens a fissure to begin to reinterpret such processes in the biomedical field.

The dimorphic interpretation of biological differences is itself the fruit of the dichotomous social order in modernity; that is, androcentric biases are not diluted just by validating the existence of parallel processes in the differentiation mechanisms. Instead, structurally destabilizing such biases implies questioning the supposedly rigid and dimorphic nature of differentiation processes.

Including females and women in research protocols is a necessary condition to overcome the androcentric biases that characterize biomedical knowledge production. But this is not enough; we also need to consider the way this inclusion is interpreted and the results obtained from a study that incorporates "both sexes." Regarding the form of inclusion, we must analyze how the male category is characterized as an experimental model.

In this sense, it is curious that the justification for selecting only males in experimental studies is to avoid the hormonal fluctuations of females. In other words, reporting the hormonal status of females becomes an obstacle that only complicates data analysis (and, therefore, obtaining publishable results in the short term), if it is not specifically the objective of the study in question [10]. Paradoxically, most studies that are not reproducible are so due to misreporting of the hormonal status of males: testosterone also fluctuates, exhibiting, for example, seasonal and circadian rhythms [16].

By extrapolating non-human animal physiology to discuss the human species, the history of endocrinology has established the idea of a causal link between the hormonal fluctuation of females-women and "their" emotional instability [17]. Even the research questions aimed at linking the notion of "fluctuation" with the hormone testosterone do not reveal the strong roots of an androcentric – and therefore biologist – reading of the differences: the supposed "emotional stability of men" is justified by the "hormonal stability" of the male. Stability, in turn, is associated with the innate predisposition to exercise "objectivity" and "neutrality." This is another example of how the dimorphic description of biological differences conforms to a social-dichotomous and hierarchical organization of bodies.

Regarding the results, we must question what is interpreted from the male and female categories established in a given study. As the dimorphic interpretation implies two qualitatively different categories that are at the same time homogeneous "inwards" each other, it is considered that incorporating males and females is equivalent to introducing a biological variable. First, they are compared; second, it is assumed that the possible differences found reflect innate, fixed and immutable biological differences. This fact is also extrapolated to the human species, as Janine Clayton discuss:

To appreciate the consideration of sex as a biological variable, it is necessary to define and distinguish sex from gender. "Sex" originates from an organism's sex chromosome complement – XX or XY chromosomes in humans, and is reflected in the reproductive organs. Each cell has a sex. One's sex affects all aspects of physiological functioning, not just hormonal secretions. Although one's sex can also affect one's behavior, other factors, social and cultural, can also influence behavior. Thus, the term "gender" pertains to social, cultural, and psychological traits linked to human males and females through social context [18].

For Clayton [19], director of NIH's Office of Research on Women's Health, dimorphic sexual characterization is a fact and, therefore, sex is understood as a fundamental biological variable. From this perspective, any experimental design for biomedical purposes should start from the criterion of man-woman grouping, reflecting the male-female categories, respectively, to search for essential biological differences.

As the author [19] states, it is often assumed that the hormonal secretions of the rightly labeled "sex hormones" (estradiol, progesterone, and testosterone) present sexually dimorphic differences. And although all people have "sex hormones," studies were conducted only on estradiol and progesterone in women, and testosterone in men [20].

It is only in recent years that studies on "sex hormones" in women and men have emerged. The results suggest that the average levels of estradiol and progesterone are similar between men and women, which dilutes the idea of sexual dimorphism for these hormones. Although we still find, on average, a higher testosterone level in men compared to women, this difference is much smaller than assumed and there are large overlaps [21]. Testosterone concentrations are variable and differences may or may not exist, depending on the sample under study.

In short, a dimorphic sexual interpretation of biological differences leads to biases both in how experimental models are characterized (the male as the "ideal biology") and in experimental designs (omission of females or their inclusion by conceptualizing them as a biological variable). This has direct repercussions on how illness is interpreted: it is fundamentally associated with sex, while gender (that is, social practices according to genitality) is considered peripheral.

Conceptual categories to make our biology more flexible

The need to distinguish between the concepts of "sex" and "gender," which are often used interchangeably in biomedical literature, motivated the NIH to provide an online course on the topic. This use of "sex" and "gender" as synonyms is not only because in English the terms are literally synonymous; it is also because for the predominant scientific discourse gender results from sex. This discourse understands that there is a causal link between biology (sex) and behavior (gender), and thus sex and gender are translated as synonyms in biological language.

The idea of gender promoted by the NIH, however, suggests that our body is a finished system that is ultimately affected, in additive terms, by our gendered social practices. As Shattuck-Heidorn and Richardson point out, the example often used to show how gender can affect our biology *is the simplistic and highly stereotyped scenario of the effects of wearing high heels on knee joints* [22].

From this perspective, gender stereotypes do not seem to be embodied, but rather represent superficial, "measurable" and "observable" disguises in a linear fashion. In turn, sex would represent the "deep" differences between men and women, interpreted as a precise and constant dimorphic biological variable. The idea of depth is applied here to show that this reading is supported by the assumption that behind the man there is a male, and behind the woman a female.

In contrast to this rigid and dimorphic conceptualization to characterize biological differences, the studies from NeuroGenderings Network, an interdisciplinary network of renowned researchers that criticize the predominant neuroscientific discourse, complexify the way in which sex is interpreted. Many of them make explicit that, although it is advisable that females and women be included into any study that is currently conducted only in males and men, such inclusion does not necessarily imply introducing sex as a biological variable. Instead, the aim is to be more representative of the species than would be the case if only males or females were studied [23].

They also raise the need to consider other factors that vary with sex. In this sense, in contrast to the idea of gender suggested by the NIH, NeuroGenderings emphasizes that the high plasticity that characterizes our species makes gender more than a superficial factor. Thus, the idea of a flexible biology that dialogues with and feeds back into our gender practices appears. To make this dialogue visible, two authors, among others, introduced key concepts [24,25].

The first is Nancy Krieger [24], who develops the idea of biological expression within the framework of social epidemiology and refers to how gendered social practices, which imply economic inequality, can affect our health. By characterizing socioeconomic inequality as a key factor for the differentiated expression of a disease, Krieger speaks of a gendered biological expression. In the next section, the scope of this concept will be further elaborated.

The second author is Anelis Kaiser [25], a founding member of the NeuroGenderings Network, who proposed incorporating the notion of sex/gender into the field of neuroscience to show that it is impossible to "disaggregate" purely biological factors in the brain from factors associated

with our gendered social experience. The author recommends that brain studies aimed at finding differences between men and women should not refer to "sex differences," but rather to "sex/gender differences" [25]. Of course, this idea can be extended to our whole organism.

Gendered biological expression: the brain as a starting point

Israeli researcher Daphna Joel and collaborators [26] showed the invalidity of characterizing brains according to man-woman categories because the high variability between women's brains, on the one hand, and between men's brains, on the other, would be equal to the high variability between both brains. Joel and collaborators [26] propose then the mosaic brain hypothesis, which would be equivalent to conceptualizing each brain as a unique combination of factors. This type of hypothesis raises the question of whether grouping according to man-woman categories to look for "differences" would not result in false positives.

Whereas both female and male participants should be used in every study of the structure and function of the human brain to better represent the entire variability of our species, the use of sex category as a variable in analyzing the results of such studies should not be the default. (...) [It would lead] *to the detection of chance differences between the groups of females and males in the study* [27].

Likewise, if differences between men and women for a given brain parameter (in terms of structure and/or function) were found, and were valid, they should not be interpreted with the weight of causality. Instead, the contribution our social practices bring to such differences should be evaluated. Due to its high plasticity, the brain is the paradigmatic organ to understand how social practices can modify our organism:

It is now clear that the functional and even structural organization of the human nervous system is a continuous and dynamic process that persists throughout one's life. "Experience-dependent plasticity" has been demonstrated time and again in the acquisition of skills as wide ranging as musical performance, basketball, dancing, taxi driving, and juggling [28].

The studies of the NeuroGenderings researchers show that the dimorphic characterization of the brains is invalid, highlighting the need to develop new grouping criteria.

From this, it can be characterized that gender practices are trained, they become exercises we embody through habits that we learn, memorize, produce and reproduce on a daily basis. Therefore, they propose to define the connection between genitality and gender as statistical – a statistical connection is explained more by normative gender stereotypes than by a biological determination.

Thus, the idea of a gendered biological expression is applied, which can be used to describe a statistical link between genitality and certain biological differences observed today between men and women – a statistical link between our genitality and our gendered biological expression, not only in a sociological sense as proposed by Krieger [24], but also in an ontological one. In other words, the normative correlation between our genitality and the gender assigned to us at birth implies the embodiment of our gendered practices, which end up being expressed biologically.

Beyond brains

The idea of a statistical link to interpret correlations between genitality and biological expression can be extended to other organs and physiological processes. In the pharmacological field, for example, reducing the requirements to the mere inclusion of sex as a biological variable in experimental designs has been a source of criticism because it makes invisible, or treats as peripheral, factors capable of affecting the metabolization or clearance of drugs. Such factors are related to gendered habits: physical activity, diet and the consumption of bioactive components, such as tobacco, coffee or alcohol, among others [29]. Body weight also affects the elimination rate of certain drugs, as was found for the hypnotic zolpidem [30]. Since all these factors have central effects on pharmacokinetics, they become critical variables.

In this sense, we must generate tools to investigate which genetic and social factors – or how social factors can affect genetic

factors – contribute to the metabolism of a given drug. Thus, if a study were to look for differences between women and men in the speed of metabolization of a drug, and it were observed, for example, that the speed is slower in women than in men, this does not mean that there are differences linked ultimately to sex. Instead, they could be explained by certain gendered habits that affect the speed of metabolization. In this case, the correlation between genitality and drug metabolization should be understood as a statistical, and not causal, link, and other characteristics and cultural habits of the study participants should be contextualized.

Clayton's [19] idea that hormone concentrations are dimorphic is not only contested by those overlaps, but findings in the field of social neuroendocrinology directly challenge the belief (dominant in the biomedical field) that sex defines hormone concentrations. Instead of starting from hormone concentrations and then associating them with certain behaviors, the classic methodology of behavioral neuroendocrinology, this discipline studies the effects that the environment/social context has on hormone regulation. Thus, studies observed that social rejection increases progesterone levels [31], and that dominance contexts increase both estradiol and progesterone [32]. In other words, hormone concentrations vary as a consequence of our social practices.

In the same vein, Van Anders [20] showed that non-genetic factors strongly influence testosterone concentrations. Besides seasonal and circadian rhythms, certain strongly gendered social roles can affect these concentrations. For example, regardless of whether men or women are involved, competitive contexts increase testosterone levels, while activities associated with caregiving reduces testosterone levels [20]. In light of these findings, the following question arises: why is there a small average difference in testosterone concentration between men and women?

The studies described in this section show that the idea of sex as dimorphic is invalid in cerebral terms and in relation, "at least," to pharmacokinetic processes and "sex hormones." We must analyze what other biological parameters, which continue to be considered solid legitimizers of a dimorphic sexual interpretation of biological differences, do not in fact result from a biosocial regulation controlled by gender stereotypes.

Such a scenario suggests that in the biomedical field, man-woman categories should refer to biological expressions that materialize a normative statistical link. In other words, gender stereotypes can explain many of the biological differences currently observed between men and women.

Although outside the scope of this article, it is worth suggesting that social practices are not only gendered, but also crossed by other normative categories, such as those associated with racialization processes. Such categories intersect and coexist in the same body. Consequently, understanding how social experience affects our bodies requires an intersectional perspective.

In this respect, an illustrative case is the recent work of Krieger, Jahn and Waterman [33], who found an association between the incidence of a type of breast cancer and Jim Crow laws – the legal racial segregation practiced in 21 U.S. states until 1964. The authors found a higher incidence of this type of cancer in black women born before 1964 compared to those born after, while this difference was not observed in white women [33].

Final considerations

Since modernity, the hierarchical and dichotomous social order has been biologically justified based on a dimorphic sexual interpretation. Although the current predominant scientific discourse upholds this interpretation, molecular biology, far from reaffirming it, shows its anachronism. Thus, evaluating the differences between men and women assuming a sexual dimorphism can lead to biased results, which hinder a true understanding of the mechanisms that explain the prevalence and development of diseases. The unique plasticity that characterizes us as a species, structurally conditioned by the roles associated with gender, implies a great impact of our social practices on our biological expression.

From a sex-gender perspective, to assess this impact we need to replace the idea of a causal link between sex and gender with the notion of a statistical link. If there are biological differences

for a certain parameter between men and women, this notion enables us to conceptualize them within the framework of social practices embedded in gender stereotypes.

As Van Anders [20] showed, gendered habits can increase or decrease testosterone levels. In this sense, it is essential to evaluate the extent to which our gendered practices affect our biological expression. For example, how do our gendered practices affect gene expression related to chromosomes that, like hormones, are also labeled "sexual"?

As the dimorphic sexual interpretation of biological differences results from a modern androcentric reading of bodies, we must revise and analyze the assumptions and hypotheses that guide biomedical studies focused on searching for sexual differences. Moreover, such a reading feeds the idea of a rigid, determined and binary biology, which does not conform to our biological realities: from chromosomal expression, through genital expression, to brain expression, our biological diversity and dynamism transcends the reductionist dichotomy.

To not overestimate the contribution of genetic factors in our biological expression, we must begin to develop methods that make visible and complex the social variables that, in turn, can affect genetic factors. Likewise, our biological expression must be placed within the framework of current gender stereotypes. Such stereotypes, however, should not be universalized, but rather made more complex from a geopolitical perspective. In other words, female gender stereotypes in the Anglo-Saxon world, where most of the studies cited here come from, are different from those in Latin America. We need to produce knowledge in this direction bearing in mind local structural conditions.

When biological differences between men and women are observed, we are not analyzing a causal, non-historical and atemporal link between genitality and these differences; rather, we are developing new epistemic and methodological strategies to understand how our organism functions and the processes of differentiation associated with it, as well as developing other preventive tools and for treating diseases.

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