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VIII. Captured in terminology: Sex, sex categories, and sex differences

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Abstract

Swayed by the clear distinction between male and female genitalia, the question of how far these categories extend into human biology has attracted humans for centuries. This question is sometimes being framed as whether the effects of sex are restricted to the genital organs or penetrate the entire organism. Here I argue that the two questions are not equivalent and that whereas the answer to the question, how far sex penetrates the body, is – deep down to the level of every cell, the answer to the question, how far the categories, "male" and "female", do, is – probably nowhere beyond the genitals. That the two questions are often used interchangeably reflects the prevailing conceptualization of sex as a dichotomous system or process that exerts profound effects on other systems (e.g., the brain), leading to sexual dimorphism (i.e., two forms, male versus female) also of these systems. Here I discuss the question of whether the effects of sex result in dimorphic systems, focusing on the case of sex effects on the brain. I show that although there are sex/gender differences in brain and behavior, humans and human brains are comprised of highly variable 'mosaics' of features, some more prevalent in females, others more prevalent in males.

Keywords

sex differences, gender differences, male brain, female brain, sexual dimorphism, internal consistency

> Once investigation of the brain structure had begun, it was fully anticipated that visible sex differences would be found: Did not the difference between the sexes pervade every other aspect of physique and physiological function? Because physical

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differences were so obvious in every other organ of the body, it was unthinkable that the brain could have escaped the stamp of sex. (Shields, 1975, p. 741)

Before the introduction

In her 1975 paper, Shields examined ‘‘the psychology of women as it existed prior to its incorporation into psycho-analytic theory’’ (p. 739), focusing on several topics, including the female brain, the biological bases of sex differences, and ‘‘the maternal instinct and its meaning for a psychology of female ‘‘nature’’’’ (p. 740). Throughout her paper, Shields convincingly demonstrated how the study of sex differences in body and mind was designed for and used to justify the subordinate role of the female compared to the male. Here, I would like to discuss the question of sex differences and the ‘‘female’’ (and ‘‘male’’) brain and ‘‘nature’’ from a different perspective, which I have developed on the basis of studies of sex and the brain in animals and humans (Joel, 2011, 2012, 2014; Joel et al., 2015; Joel & Fausto-Sterling, 2016). The essence of my perspective is a distinction between ‘‘sex’’ as a system that affects other systems (e.g., genitalia, brain) in contrast with ‘‘sex’’ as describing a division into two categories (female and male), and relatedly, a distinction between the existence of differences between females and males in brain and behavior and the assertion that there are ‘‘female’’ and ‘‘male’’ brains or natures. I would like to apologize that because I am a neuroscientist and a feminist, but not a feminist scholar, I could not integrate my ideas with the vast literature on feminist theory and feminist science studies. I do hope, however, that my ideas could contribute to the ways sex is thought of in these fields, and look forward to discussions in these fields that would help me develop these ideas.

Introduction

Swayed by the clear distinction between male and female genitalia, the question of how far these categories extend into human biology has attracted humans for centuries. As evident also in the quote from Shields, this question is sometimes being framed as whether the effects of sex are restricted to the genital organs or penetrate the entire organism (reviewed in Schiebinger, 1989). Here, I argue that the two questions are not equivalent and that whereas the answer to the question of how far sex penetrates the body is: deep down to the level of every cell, the answer to the question of how far the categories ‘‘male’’ and ‘‘female’’ do is: probably nowhere beyond the genitals.

The genitalia are also not dimorphic (i.e., exist in only one of two forms, male vs. female). There are people with genital organs whose form is intermediate between the (statistically) typical male and female form as well as individuals who have both male-typical and female-typical genital organs. Yet, the genitalia of most (~99%) humans can be easily categorized as either male or female (this is an estimate on the basis of Blackless et al., 2000). The dimorphic[1] and unchanging (i.e., the form of the genitalia rarely changes from the female form to the male form or vice versa) nature of the genitalia biases how we understand sex itself (Richardson, 2013) and how we conceptualize the relations between sex and all other systems (Joel, 2011, 2012, 2014).[2]

Indeed, the term ''sex'' is used both to describe the division of humans into two categories (females and males) and as the cause of this division (as in ''the effects of sex''). However, this is not a benign confusion in terminology, but a reflection of the deep and prevailing conceptualization of sex as a dichotomous system or process that exerts profound effects on other systems (e.g., the brain), leading to sexual dimorphism also of these systems (e.g., ''female brain'' and ''male brain'').

It is this prevailing conceptualization that explains why the discovery of the X and Y chromosomes, which suggests that sex penetrates the body down to the level of every cell, is typically also taken as providing a definitive answer to the question of whether the sex categories penetrate the entire organism. The underlying assumption here is that the effects of sex always lead to sexual dimorphism, and that therefore the fact that cells differ in their genetic material necessarily entails that cells, and the systems they constitute, will differ in their form and function. This is evidenced in phrases such as ''every cell has a sex'' and the belief that whole systems have sex (e.g., ''male'' and ''female'' brains).

In order to avoid the confusion in terminology, I use 'sex categories' when referring to the division into two classes, male and female, and 'sex' when referring to sex as a cause, that is, as a system that affects other systems (e.g., the genitalia, the brain). As a system, it is currently widely accepted that sex includes a genetic and a hormonal component (although there are no accepted definitions of what each of these components includes), through which sex can affect other systems (e.g., Arnold, 2012). Several authors have challenged the idea that sex as a cause/system is dimorphic, pointing, for example, to the fact that the level of hormones secreted by the gonads (the so called ''sex hormones'') overlaps in males and females (e.g., Fausto-Sterling, 2000; Fine, Jordan-Young, Kaiser, & Rippon, 2013; Jordan-Young, 2010; Richardson, 2013; Springer, Mager Stellman, & Jordan-Young, 2011). The question of whether sex as a system is dimorphic has important scientific implications for how we should treat sex in studies of human health and pathology. I deal elsewhere (Joel, in preparation) with this question as well as with evidence that environmental events can affect sex (i.e., the level of ''sex hormones,'' for review see van Anders, Goldey, & Bell, 2014).

Here, I would like to focus on a different question—whether the effects of sex result in dimorphic systems, that is, in systems that can take only one of two forms (e.g., ''male'' vs. ''female'' genitalia, ''male'' vs. ''female'' brains). The reason for this choice is that the question of whether the effects of sex result in dimorphic systems has far reaching social implications, because the myth that they do is used to explain and justify differential treatment of humans with male and female genitalia. It is noteworthy that the question of whether the effects of sex result in dimorphic systems is independent of whether sex as a system/cause is dimorphic. Thus, even if sex is not dimorphic, its effects may lead to dimorphism in other systems, as in the case of sex effects on the genitalia. And vice versa—sex may be dimorphic but its effects need not be, as I demonstrate below for the case of sex effects on the brain.

Sex affects the brain, but are brains "female" or "male"?

There is evidence from *in vitro* and *in vivo* studies that sex can affect the structure and function of brain cells (for review see Arnold & Chen, 2009). But the fact that sex can affect brain cells does not necessarily entail that the form and function of brain cells are either "male" or "female," or that the brains comprised of these cells can be divided into two distinct categories. For these to be true it is not enough that sex can affect every cell; rather, it is necessary that the effects of sex override the effects of all other factors (e.g., genetic variation, environment). This is indeed the case for sex effects on the genital organs, as reflected in two observations: One, that although there is variation within each sex category in the form of the genital organs (reflecting the effects of factors other than sex and possibly the non-dimorphic nature of sex), there is very little overlap between the form of these organs in males and in females; that is, these organs are *sexually dimorphic*. The second observation is that there is *almost always a perfect consistency* between the "sexual" form of the different genital organs within a single individual; that is, most humans are born with either uterus, fallopian tubes, vagina, labia minora and majora, and clitoris, *or* prostate, seminal vesicles, scrotum, and penis. Only a small minority are born with both male-typical and female-typical genital organs (Blackless et al., 2000). Thus, it is not only that each of the genital organs is sexually dimorphic, so is the genital system as a whole (see Joel, 2011, 2012, 2014, for further exposition and discussion).

I have recently argued that in contrast to the primary role of sex in determining the form of the genitalia, sex is just one of several factors that interact to determine the form of the brain (Joel, 2011, 2012). This is evident at the level of single brain cells, brain regions and the entire brain. The result of these interactions is multimorphic brain cells, brain regions, and brains, neither of which can be grouped into two distinct categories. Note that studies that assess sex effects on the brain typically do so by comparing brains of males to brains of females. Therefore, it is impossible to determine whether a difference between females and males reflects the effects of sex category per se, or the effects of a variable that shows a group-level difference between females and males (e.g., the levels of "sex hormones," body weight, and in humans also psychological and sociocultural factors that correlate with sex, i.e., elements of gender). Yet, the point I would like to make here is that regardless of the cause of the differences between females and males in brain cells, brain regions, and brains, none of these can be grouped into two distinct categories.

The above argument and conclusion have been derived mainly on the basis of animal studies demonstrating that the differences between the two sex categories may be different and even opposite under different environmental conditions[3] and that the interactions between sex category and environment may be different for different brain features and even for different elements of a single cell (reviewed in Joel, 2011, 2012). For example, Shors, Chua, and Falduto (2001) found that a sex difference in the form of the apical dendrites of hippocampal pyramidal neurons was reversed following 15 min of stress. Thus, what was typical in one sex under some conditions (i.e., high density of dendritic spines in nonstressed females and low density of dendritic spines in nonstressed males) was typical in the other sex under other conditions (i.e., following acute stress). A different sex by environment interaction determined the form of the basal dendrites of these same neurons, as the same manipulation (15 min of stress) led to the emergence of a sex difference in these dendrites. It follows that hippocampal pyramidal neurons, which have either XX or XY chromosomal complement and which reside in bodies that are exposed to different levels of ''sex hormones,'' can take at least three forms: apical and basal dendrites with few spines (in nonstressed males and stressed females); apical and basal dendrites with lots of spines (in stressed males); and apical dendrites with lots of spines and basal dendrites with few spines (in nonstressed females).

Similar findings have been reported at the level of brain regions. For example, Reich, Taylor, and McCarthy (2009) found that three weeks of mild stress reversed a sex difference in the density of CB1 receptors in the dorsal hippocampus but eliminated a sex difference in the density of these receptors in the ventral hippocampus. Thus, even when considering only a single characteristic (the density of CB1 receptors) and only two environmental conditions (no stress vs. three weeks of mild stress), the hippocampus can take three forms: low density of CB1 receptors in the dorsal and ventral hippocampus (nonstressed females and stressed males), high receptor density in dorsal and ventral hippocampus (nonstressed males), high receptor density in dorsal hippocampus and low receptor density in ventral hippocampus (stressed females). Given that similar findings have been reported following additional manipulations (e.g., rearing conditions, pharmacological challenges, acute and chronic stress), for additional characteristics of single neurons (e.g., dendritic arborization and axonal branching), brain regions (e.g., size, number of neurons, number of glia cells), and neurotransmitter systems, and for many brain regions (for references and review see Joel, 2011, 2012), it is highly likely that brain cells, brain regions, and brains as a whole, are multimorphic and not dimorphic.

The animal studies described above reveal that brain elements are not sexually dimorphic, that is, there is considerable overlap between males and females in the form of brain features. This is not only because the effects of sex on brain features are quantitatively weaker than its effects on the genital organs (e.g., that sex shifts the distribution of traits of the male population relative to the distribution of the female population (or vice versa) to a lesser extent in brain features compared to genital organs), but also because the effects of sex on brain features are qualitatively different from its effects on the genital organs, in that in brains, but not in genitals, the effects of sex may be opposite under different environmental conditions. The studies reviewed above also reveal that brains are not internally consistent, that is, they are not comprised of only ''male-typical'' or only ''female-typical'' brain features. The lack of sexual dimorphism of brain elements makes a division into two distinct forms (''male brain'' and ''female brain'') impossible. The lack of internal consistency means that brains can also not be aligned on a ''male-brain—female-brain'' continuum (Joel, 2011, 2012, 2014; Joel et al., 2015).

We have recently assessed sexual dimorphism and internal consistency in the human brain, by analyzing several data sets obtained from magnetic resonance imaging of over 1400 individuals (Joel et al., 2015). Consistent with previous findings (for review see Eliot, 2011; Lenroot & Giedd, 2009; McCarthy & Konkle, 2005), our analysis, which covered most regions of grey and white matter as well as measures of connectivity, revealed extensive overlap between the distributions of females and males for all brain regions and connections, irrespective of the type of sample, analysis, or measure. Further analyses, involving only the brain regions showing the largest sex/gender[4] differences (i.e., least overlap between females and males), tested whether brains are internally consistent in the ''sexual'' form of the different regions, that is, whether individuals are consistently at one end of the ''femaleness-maleness'' continuum across brain regions, or show *substantial variability*, being at the one end of the continuum on some traits, and at the other end on other traits.

We found that internal consistency is rare and that most brains are comprised of highly variable combinations of features, some more common in females compared to males, some more common in males compared to females, and some common in both females and males. These findings were robust across sample, age (18–78 or 18–26), type of magnetic resonance imaging (T1-weighted images or diffusion tensor imaging), and method of analysis (volume-based, surface-based, connectivity). These findings provide the first demonstration that human brains are comprised of highly variable mosaics that cannot be classified into two types, ''male'' and ''female,'' nor aligned on a ''male-brain–female-brain'' continuum (Joel et al., 2015).

Using the same approach, we have analyzed data of personality traits, attitudes, interests, and behaviors of over 5000 individuals, and found that substantial variability is highly prevalent in humans whereas internal consistency is extremely rare (Joel et al., 2015). This finding is in line with previous studies that concluded that humans possess an array of masculine and feminine traits that cannot be captured using a uni-dimensional (masculinity–femininity) or a bi-dimensional (masculinity $\times$ femininity) model (Egan & Perry, 2001; Koestner & Aube, 1995; Spence, 1993). These demonstrations of lack of internal consistency within humans' personality traits, attitudes, interests, behaviors, and other psychological variables that show sex/gender differences, add to the high degree of overlap between females and males in most of these variables (see Hyde, 2005, 2014 for review and references). The high overlap together with the lack of internal consistency undermines the belief that humans can be categorized into two distinct gender groups, woman and man.

Taken together, our studies and the studies of others demonstrate that regardless of the cause of observed sex/gender differences in brain and behavior, humans and human brains cannot be categorized into two distinct classes.

Mosaic and prediction

That humans and human brains are comprised of highly variable mosaics that do not belong to one of two distinct categories means that we cannot predict one's unique brain mosaic or gender mosaic on the basis of one's sex category (for further discussion see Joel, 2011). Yet, in most societies, sex categories are treated as valid predictors of one's personality traits, cognitive abilities, attitudes, interests, and behaviors. Moreover, the assumption that they are valid predictors provides the basis and justification for differential treatment of humans on the basis of the form of their genitals (e.g., the single-sex education movement in the USA, which was founded on claims of the different educational needs of distinctively different ''male'' and ''female'' brains and psychologies, http://www.singlesexschools.org). Thus, I add to the long-standing objections to the use of the categories men/women and male brains/female brains the objection that, even in our gendered world, these categories are scientifically invalid.

Mosaic and the current dogma: Sex, sex categories, sex differences

The currently dominant paradigm assumes that males and females belong to two distinct categories, not only in their genitalia, and views sex almost exclusively through the lens of ''sex differences'' (see also in the opening quote from Shields, 1975). Consequently, studies of sex are conceptualized as a search for sex differences, and findings of sex differences are presented and understood as evidence that the sex categories penetrate every organ of the human body. As explained here, although findings of sex differences provide evidence for a relation (direct or indirect, e.g., through gender) between sex and the system in which sex differences were found, they do not provide evidence that the system in question is sexually dimorphic. To reach the latter conclusion, one has to demonstrate that the sex differences are dimorphic and internally consistent (Joel, 2012, 2014; Joel et al., 2015; Joel & Fausto-Sterling, 2016). To date, the only system for which this has been demonstrated is the genital system (i.e., there are few people who have both male and female genital organs). Moreover, current data demonstrate that these two conditions are not met regarding sex differences in brain and behavior. Hopefully, future studies looking at the relations between sex and other systems in which sex differences have been documented (e.g., the immune system, the gastrointestinal system) will assess both internal consistency and degree of overlap, to reveal whether the relations between sex and other systems are more similar to the relations between sex and the brain or to the relations between sex and the genitalia.

In addition to being misleading, it is questionable whether the practice of listing sex differences is scientifically useful. This is because sex differences may be non-existing or even opposite under different genetic, developmental, and environmental conditions. Therefore listing sex differences in brain or behavior is mainly futile, as different lists will be obtained under different conditions (see also Jordan-Young & Rumiati, 2011). This is true for animals (for a recent review of the dependence of sex differences in behavior on genetic and environmental factors, see Joel & Yankelevitch-Yahav, 2014) as well as for humans. For example, if one aims to list sex/gender differences in human brain and behavior, whose brain and whose behavior should one analyze? Consider, for example, the different sex/gender differences in brain structure that are found at different time points throughout development (e.g., Garcia-Falgueras, Ligtenberg, Kruijver, & Swaab, 2011; Lenroot & Giedd, 2009; McCarthy & Konkle, 2005) or in different samples (Joel et al., 2015), or the opposite sex/gender differences found in different countries in mathematics achievement measured from international exams, such as the TIMSS (http://timss.bc.edu/timss2011/downloads/T11_IR_M_Chapter1.pdf).

If looking for sex differences may not be useful, how could we study the relations between sex and the brain? I want to start by acknowledging that this is a major challenge for those studying sex, and that I do not yet have an answer. But I can point to a few directions. One is to use direct measures of sex (e.g., levels of "sex hormones") instead of using sex category as a proxy. Another is to acknowledge that the effects of sex may be different under different conditions, and therefore study sex effects in context, that is, under different genetic, developmental, and environmental conditions (Joel & Fausto-Sterling, 2016). A third is to measure psychological and social variables that correlate with sex category (Joel & Fausto-Sterling, 2016). And last, given that brains are mosaics of features, develop or adopt analytical methods that take into account both the variability in the human brain (rather than treat it as noise) and individual differences in the specific composition of the brain mosaic (Joel et al., 2015; Joel & Fausto-Sterling, 2016). For further discussion of how the relations between sex and the brain could be studied in humans and animals, see Joel & Fausto-Sterling (2016).

A comment on sex and gender

Whether we follow Unger's (1979) definition of gender as the characteristics and traits that are considered appropriate to males and females, or describe gender as the characteristics and traits that are statistically more prevalent in males and in females, the above analyses and discussion reveal that there is probably no human male or female who has only "masculine" or only "feminine" characteristics. This is quite surprising given that most humans do have either male or female genitalia and that gender clearly exists as a social system that attributes meaning to the type of genitalia one has. Because most people have a mosaic of both "masculine" and "feminine" characteristics, I believe it may be wrong to prefer the use of the terms "man"/"boy" and "woman"/"girl" over "male" and "female," as is often done for *cis*-genders. Although the terms "man"/"boy" and "woman"/"girl" have the advantage of acknowledging that observed differences between males and females may be the result of nurture rather than nature, in using them as synonyms to "male"/"female" we are reinforcing the idea that gender is dichotomous, when we already know that this is not true.

I also think that we should not aim to replace sex with gender as a factor analyzed in studies of brain and behavior. This is because gender has several meanings (a social system, a set of psychological characteristics, a type of performance), each multilayered and probably un-measurable. For example, how can we measure the forces exerted on an individual by her/his gendered society? How can we measure one's gender characteristics when we already know that gender characteristics are not correlated and that each person has a unique mosaic of gender characteristics that cannot be aligned on a masculine-feminine continuum? How can we measure gender performance in view of the fact that behavior is highly dependent on the situation? Thus, although it would be wise to consider psychological and social variables (e.g., socioeconomic status, stress, education, personality characteristics) in studies of brain and behavior, we should not attempt to integrate these variables into a ''gender'' variable, even if some of these variables show sex/gender differences (Joel & Fausto-Sterling, 2016).

More generally, I suggest that instead of replacing sex with gender, we stop treating humans as belonging to two distinct categories (whether of sex or of gender) and start treating humans (socially and scientifically) as belonging to a single highly heterogeneous population.

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Notes

1. I treat the genitalia here as dimorphic, ignoring the fact that they are not truly so, as a background against which it is easier to appreciate how a dimorphic framework is completely wrong for describing the relations between sex and the brain.
2. I use the term 'system' rather loosely here. It may refer to a single cell (see the example on pyramidal neurons below), to anatomically defined regions, such as the hippocampus (see the example below), to anatomical organs, such as the brain, or sets of organs, such as the genitalia (i.e., the uterus, fallopian tubes, vagina, labia minora and majora, and clitoris, or, prostate, seminal vesicles, scrotum, and penis), as well as to functional systems, such as the immune system. I claim that the existence of sex/gender differences in a system is not sufficient to conclude that this system may take one of two distinct forms or types. Rather, such a conclusion requires that the form of the elements that show sex/gender differences should be dimorphic (i.e., with little overlap between the forms of the elements in males and females) and there should be a high degree of internal consistency in the form of the different elements of a single system (e.g., all elements have the ''female'' form) (Joel, 2012, 2014; Joel et al., 2015; Joel & Fausto-Sterling, 2016).
3. That the effects of sex may be different under different conditions is not unique to sex, and is probably true of any other biological system or process (e.g., stress), whose effects may change if the conditions are changed. What does seem to be different, though, is that when considering sex effects, we are more likely to understand them as essential and fixed, as are sex effects on the genitals, and less likely to acknowledge that context matters.
4. I follow the suggestion of Kaiser (2012) and use the term sex/gender to indicate that studies typically assess subjects' sex (i.e., whether one is male or female, assuming cis-genderism) but observed differences may reflect the effects of both sex and gender (that is, the social construction of sex). I would like to note that I ignore here the

important issue of the probable effects of gender on observed differences between females and males in brain and behavior, which has been dealt with brilliantly by others (e.g., Fausto-Sterling, 2000; Fine, 2010; Jordan-Young, 2010), because I want to emphasize here two additional and related points. One, that our conceptualization of the relations between sex and the brain, even in animals, is wrong. Two, that regardless of the cause of observed differences between females and males (sex, gender, their interactions), humans and human brains cannot be divided into two distinct categories, man/woman, male brain/female brain. Note that I reserve the terms *man* and *woman* to describe individuals with the characteristics and traits that are considered appropriate to males and females or that are statistically more prevalent in males or in females, and therefore refer to humans in this paper as males and females and not as men and women.

References

Arnold, A. P. (2012). The end of gonad-centric sex determination in mammals. *Trends in Genetics*, *28*, 55–61.

Arnold, A. P., & Chen, X. (2009). What does the ''four core genotypes'' mouse model tell us about sex differences in the brain and other tissues? *Frontiers in Neuroendocrinology*, *30*, 1–9.

Blackless, M., Charuvastra, A., Derryck, A., Fausto-Sterling, A., Lauzanne, K., & Lee, E. (2000). How sexually dimorphic are we? Review and synthesis. *American Journal of Human Biology*, *12*, 151–166.

Egan, S. K., & Perry, D. G. (2001). Gender identity: A multidimensional analysis with implications for psychosocial adjustment. *Developmental Psychology*, *37*, 451–463.

Eliot, L. (2011). The trouble with sex differences. *Neuron*, *72*, 895–898.

Fausto-Sterling, A. (2000). *Sexing the body*. New York: Basic Books.

Fine, C. (2010). *Delusions of gender*. London: Icon Books Ltd.

Fine, C., Jordan-Young, R., Kaiser, A., & Rippon, G. (2013). Plasticity, plasticity, plasticity and the rigid problem of sex. *Trends in Cognitive Sciences*, *17*, 550–551.

Garcia-Falgueras, A., Ligtenberg, L., Kruijver, F. P., & Swaab, D. F. (2011). Galanin neurons in the intermediate nucleus (InM) of the human hypothalamus in relation to sex, age, and gender identity. *Journal of Comparative Neurology*, *519*, 3061–3084.

Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist*, *60*, 581–592.

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology*, *65*, 373–398.

Joel, D. (2011). Male or female? Brains are intersex. *Frontiers in Integrative Neuroscience*, *5*, 57.

Joel, D. (2012). Genetic-gonadal-genitals sex (3G-sex) and the misconception of brain and gender, or, why 3G-males and 3G-females have intersex brain and intersex gender. *Biology of Sex Differences*, *3*, 27.

Joel, D. (2014). Sex, gender, and brain—A problem of conceptualization. In S. Schmitz, & G. Höppner (Eds.), *Gendered neurocultures. Feminist and queer perspectives on current brain discourses*. Vienna: Zaglossus. e.U.

Joel, D., Berman, Z., Tavor, I., Wexler, N., Gaber, O., & Stein, Y., et al. (2015). Sex beyond the genitalia: The human brain mosaic. *Proceedings of the National Academy of Sciences of United States of America*, *112*, 15468–15473.

Joel, D., & Fausto-Sterling, A. (2016). Beyond sex differences: New approaches for thinking about variation in brain structure and function. *Philosophical Transactions of the Royal Society B* 371: 20150451.

Joel, D., & Yankelevitch-Yahav, R. (2014). Reconceptualizing sex, brain and psychopathology: Interaction, interaction, interaction. *British Journal of Pharmacology*, *171*, 4620–4635.

Jordan-Young, R. M. (2010). *Brain storm: The flaws in the science of sex differences*. Cambridge, MA: Harvard University Press.

Jordan-Young, R. M., & Rumiati, R. I. (2011). Hardwired for sexism? Approaches to sex/gender in neuroscience. *Neuroethics*, *5*, 305–315.

Kaiser, A. (2012). Re-conceptualizing "sex" and "gender" in the human brain. *Zeitschrift fu ür Psychologie*, *220*, 130–136.

Koestner, R., & Aube, J. (1995). A multifactorial approach to the study of gender characteristics. *Journal of Personality*, *63*, 681–710.

Lenroot, R. K., & Giedd, J. N. (2009). Sex differences in the adolescent brain. *Brain and Cognition*, *72*, 46–55.

McCarthy, M. M., & Konkle, A. T. (2005). When is a sex difference not a sex difference? *Frontiers in Neuroendocrinology*, *26*, 85–102.

Reich, C. G., Taylor, M. E., & McCarthy, M. M. (2009). Differential effects of chronic unpredictable stress on hippocampal CB1 receptors in male and female rats. *Behavioural Brain Research*, *203*, 264–269.

Richardson, S. S. (2013). *Sex itself: The search for male and female in the human genome*. Chicago: University of Chicago Press.

Schiebinger, L. (1989). *The mind has no sex? Women in the origins of modern science*. Cambridge: Harvard University Press.

Shields, S. A. (1975). Functionalism, Darwinism, and the psychology of women: A study in social myth. *American Psychologist*, *30*, 739–754.

Shors, T. J., Chua, C., & Falduto, J. (2001). Sex differences and opposite effects of stress on dendritic spine density in the male versus female hippocampus. *Journal of Neuroscience*, *21*, 6292–6297.

Spence, J. T. (1993). Gender-related traits and gender ideology: Evidence for a multifactorial theory. *Journal of Personality and Social Psychology*, *64*, 624–635.

Springer, K. W., Mager Stellman, J., & Jordan-Young, R. M. (2011). Beyond a catalogue of differences: A theoretical frame and good practice guidelines for researching sex/gender in human health. *Social Science & Medicine*, *74*, 1817–1824.

Unger, R. K. (1979). Toward a redefinition of sex and gender. *American Psychologist*, *34*, 1085–1094.

van Anders, S. M., Goldey, K. L., & Bell, S. N. (2014). Measurement of testosterone in human sexuality research: Methodological considerations. *Archives of Sexual Behavior*, *43*, 231–250.

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