

**Why Males ≠ Corvettes, Females ≠ Volvos, and Scientific Criticism ≠ Ideology:**

**A Response to “Equal ≠ The Same: Sex Differences in the Human Brain”**

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In the recent *Cerebrum* article *Equal ≠ the same: Sex differences in the human brain*, Larry Cahill offers his perspective on the nature of sex differences in brain and behavior, and what he considers to be a “counter-reaction” to such research by “anti-sex difference” investigators operating from the “deeply ingrained, implicit, false assumption that if men and women are equal, then men and women must be the same.”[1] We welcome this opportunity to correct some of the misapprehensions and mischaracterisations in this account, and present a more nuanced view of the relations among sex, brain and gender.

Like Cahill and many others, we welcome more active research on females in basic animal neuroscience. We strongly believe that this is necessary to ensure that basic research is relevant to all humans. We are concerned, though, that one mistake, treating males as the norm, will be replaced with another; namely, treating males and females as two distinct entities. Relatedly, we all believe, like Cahill, that sex matters; that is, that genetic and gonadal sex can influence brain development and function at every level, that useful information may arise from investigating such processes, and that this may be especially critical in understanding pathological development. Indeed, numerous explicit statements to this effect can be found in our work [e.g., 2, 3-5]. Moreover, Joel’s lab empirically investigates such phenomena [6], and Rippon, Jordan-Young, Kaiser and Fine [7] recently made extensive recommendations in *Frontiers in Human Neuroscience* as to best practice methods, analysis, and interpretation in sex/gender neuroscience. We were therefore surprised to find ourselves characterized as “anti-sex difference” researchers. We are neither “for” nor “against” sex differences (or sex similarities, for that matter); focusing only on similarities or differences is misleading. We need to develop a new framework for thinking of the relation between sex, brain, and gender that better fits current knowledge, and that takes into account distributions, changes, overlap, variance, and most of all, context.

Thus, a critical point that is absent in Cahill’s article is that the effects of sex on the brain can be opposite under different conditions. That is, what is typical in one sex under some conditions may be typical in the other sex under other conditions. Moreover, the specific interactions between sex and other factors (environmental, developmental, genetic) are different for different brain regions, and are not necessarily stable over time. As a result, the brains of women and men each comprise a unique, ever-changing ‘mosaic’ of features,

some of which may be more typical in males and some of which may be more typical in females [see 8]. Thus brains, in contrast to genitals, do not come in distinct male or female forms.<sup>1</sup>

In contrast, the metaphor Cahill uses reflects a common assumption [10] that the average differences between women and men in the brain as well as in traits, attitudes, interests, roles, skills, cognitive and emotional abilities and personality characteristics add up to create two distinct systems:

*“claiming that there are no reliable sex differences on the basis of analyzing isolated functions is rather like concluding, upon careful examination of the glass, tires, pistons, brakes, and so forth, that there are few meaningful differences between a Volvo and a Corvette.”*

But sex differences in brain and gender are very different from differences between car brands and between female and male genitals. A car with Corvette tires will almost certainly also have Corvette pistons, brakes and glass (but not Volvo pistons or brakes), just like a person with a womb will almost certainly also have a vagina, clitoris and labia (but no penis or scrotum). By contrast, knowing that a person has a ‘masculine’ mental rotation score, say, tells you very little about whether they will be masculine or feminine in other aspects of gender, because each person has a unique array of gender characteristics. Would we classify cars into Volvos and Corvettes if each car had a unique combination of glass, tires, pistons, brakes, and so on from both the Volvo and the Corvette factories?

Moreover, would we classify glass, tires, pistons, brakes, etc. as being of Volvo or Corvette origin if engines of Volvos changed form to become powerfully Corvette-like under some conditions, and trunks of Corvettes changed to become more spacious, depending on the specific social context in which the car found itself? Or if, in some social contexts and countries, the pistons of Volvos differed quite significantly from those of Corvettes, but in other circumstances or countries they were the same? This clearly never happens with car parts or genitals, but has been repeatedly demonstrated for gendered behaviors [for review see 11] and brain structure [for review see 8].

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<sup>1</sup> This is true for about 98-99% of humans who are born with either uterus, fallopian tubes, vagina, labia minora and majora, and clitoris, or prostate, seminal vesicles, scrotum and penis. About 1% of the human population does not fit into one of these two categories because of either having an intermediate form for one or more organs, or having both male and female organs. 9. Blackless, M., et al., *How sexually dimorphic are we? Review and synthesis*. American Journal of Human Biology, 2000. **12**(2): p. 151-166.

Carothers and Reis's taxonomic analysis of gender, which Cahill cites, demonstrated exactly this distinction [12]. Thus, they did indeed find categorical differences between the sexes for highly sex-stereotyped activities (like playing golf and wearing make-up). Yet, these were specifically selected to demonstrate the validity of their taxonomic methods.<sup>2</sup> What Cahill fails to mention, however, is that for virtually all of the other gendered characteristics analyzed (covering such domains as sexual attitudes and behaviors, care orientation, science inclination, and Big Five personality traits), the researchers drew precisely the opposite conclusion. "[A]lthough there are average differences between men and women, these differences do not support the idea that 'men are like this, women are like that.'" Rather:

*[T]hese sex differences are better understood as individual differences that vary in magnitude from one attribute to another rather than as a suite of common differences that follow from a person's sex."* [13, p. 23]

So human brains and behaviors do not come in two distinct forms. What about the relations between the two? Can we relate behavioral differences to structural differences, as Ingahlhalikar and colleagues [14] did in the PNAS paper Cahill cites? This study reported average sex differences in brain connectivity and speculated that these connectivity differences were related to average differences found in another study on the same participants in several behavioral measures (e.g., executive control, memory, reasoning, spatial processing, sensorimotor skills, and social cognition). Yet the researchers did not use their data to directly test their hypothesis that sex differences in brain connectivity were related to behavioral sex differences. An alternative possibility is that the observed connectivity differences have no functional implications, perhaps, for example, serving to offset average brain size differences between the sexes [15]. Indeed, this alternative hypothesis arises directly from de Vries' claim, cited by Cahill, that sex differences in the

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<sup>2</sup> To be precise, heterosexual, Midwestern U.S. undergraduates were asked to identify things that women versus men "typically enjoyed during their free time". Validity testing in a second similar group winnowed the list of 129 items down to 28. In the larger sample – again heterosexual, Midwestern U.S. college students - 10 of these 28 showed large sex differences ( $d > 1$ ), confirming that "taxometric procedures can effectively detect taxa in gender-related constructs" 12. Carothers, B.J. and H.T. Reis, *Men and women are from Earth: Examining the latent structure of gender*. Journal of Personality and Social Psychology, 2013. **104**(2): p. 385-407.

brain sometimes serve to compensate for other differences (rather than to create further differences), thus making the two sexes more similar [16].

It matters that women and men are not like Volvos and Corvettes. It matters scientifically, with respect to research models, methods, analysis, and interpretation. The elucidation of these issues has been a primary goal of our work: for example, in relation to functional neuroimaging [4, 7, 17-19], brain structure [8], prenatal hormonal influences on the brain [2] and sex differences in psychopathology [5, 20]. But it is also a matter of importance to the general public that women and men are not like Volvos and Corvettes. There is growing evidence that thinking about the brains and behavior of males and females in this inappropriately categorical way has psychosocial effects that serve to sustain the gender status quo [for review see 21, see also 22 for an analysis of media and social media commentary arising from Ingalhalikar et al.'s PNAS article and press release]. People look to Volvos for a safe car for the family, and to Corvettes for status and power. Categorical thinking about gender reinforces the idea that similar divisions in social roles for women and men are appropriate, fixed, natural, and inevitable. We are therefore grateful for this opportunity to indicate just how misleading this is as a metaphor.

We appreciate fears on the part of neuroscientists that blanket antipathy towards the investigation of sex influences on the brain could stifle research opportunities. As we hope is now clear, we are all for investigating sex, gender, and their interlacements. However, the research models neuroscientists (and others) use should be appropriate to the phenomena in question.

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