Neuroscience and Biobehavioral Reviews xxx (xxxx) 1–2

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

Binary thinking about the sex binary: A comment on Joel (2021)

Marco Del Giudice

Department of Psychology, University of New Mexico, Logan Hall, 2001 Redondo Dr. NE, Albuquerque, NM, 87131, USA

In a recent paper, Joel (2021) argued that what she describes as the standard "binary framework" for the study of sex differences in the brain should be replaced by an alternative "non-binary" approach—one in which individual profiles of brain structure and/or function are treated as multivariate "mosaics" of male- and female-typical features, with little underlying coherence and no meaningful axis of male-female typicality. The paper makes a number of valuable points: for example, I fully agree that researchers should pay much more attention to patterns of individual variation within the sexes, and strive to understand those patterns in functional terms. I also agree that training classifiers to categorize people by sex has limited value, because prediction does not equate understanding and can distract researchers from asking deeper theoretical questions about the data.

The paper also has weaknesses, including a selective and at times questionable account of the empirical literature.[1] But here I want to focus on a deeper issue: in spite of the explicit goal of challenging "the binary", the paper is vitiated by its own kind of binary thinking, leading to a series of false dichotomies in which complementary perspectives are treated as mutually exclusive. This problem can be traced to Joel's assumption that brains (or bodies, behavioral profiles, etc.) can be meaningfully placed along a male-female continuum only if the traits of interest show a pattern of strict "internal consistency", so that they are *all* aligned within the profiles of different individuals (i.e., all male-typical, all female-typical, or all intermediate; e.g., p. 166).

Guided by this stark conception of sex differences, Joel advocates the "mosaic analysis" method that she introduced in previous publications. The method aims to distinguish between "internally consistent systems" (i.e., those showing strict consistency across features) and "systems with *no* underlying internal consistency" (p. 170; emphasis mine). However, internal consistency is a matter of degree, not an all-or-none property; among other things, this artificial dichotomy leads Joel to misrepresent the simulation results that my colleagues and I reported in our original critique of the method (Del Giudice et al., 2015). In those simulations, "mosaic" profiles predominated when correlations among features were smaller than about .40–.70 (depending on the size of sex differences on each feature). But when correlations exceeded those values, "internally consistent" profiles became more common than their "mosaic" counterparts, with no other changes to the simulation model.[2] In fact, correlations of .70–.80 (a range singled out by Joel on p. 170) usually yielded more "internally consistent" than "mosaic" profiles. This falsifies Joel's claim that mosaic analysis is uniquely able to differentiate between "mosaicism" and "noise", to the extent that this distinction has a definite meaning. I repeat my advice that researchers should avoid mosaic analysis, which lacks a clear statistical rationale and cannot deliver on its promise (see Del Giudice et al., 2015). However, I do *not* mean to suggest that mosaic-like patterns of sexually differentiated traits are uninteresting or should be ignored. For one, I have argued that the broader cognitive/motivational phenotypes of autism and psychosis can be partly described as contrasting mixtures of male- and female-typical traits (Del Giudice, 2018).

Sex-related traits in many domains show large amounts of overlap and within-sex variation, with a large number of possible combinations. Some of this variation is likely maintained by natural/sexual selection, and alternative adaptive profiles may exist both within and across the sexes. How does this speak to the concept of a male-female continuum, on which individual profiles can be arranged from extremely male-typical to extremely female-typical?[3] Joel's answer is that this concept should be abandoned and replaced by a "mosaic" view, because a male-female continuum fails to account for the

E-mail address: marcodg@unm.edu.

[1] For example, a study by Cheng et al. (2018) is said to have "revealed a 10:9 ratio of mothers to fathers suffering from postpartum depression" (Joel, 2021, p. 174). But this surprising statistic does not refer to clinical diagnoses of depression: Cheng et al. (2018) screened parents using a 3-item anxiety questionnaire, which was validated against a longer screening tool for depression yielding a false positive rate of more than 40% (Kabir et al., 2008), and showed low sensitivity and specificity when tested against actual depression diagnoses (Venkatesh et al., 2014). Moreover, Cheng et al. seemingly loosened the cutoff to include anyone who endorsed even one of the items; to illustrate, a parent who answered in the affirmative to "I have been anxious or worried for no good reason" (and no other items) would have been classified as "positive for depression".

[2] Note that, in Fig. 2 of Del Giudice et al. (2015), the *total* proportion of internally consistent profiles equals twice the male- (or female-) typical proportion (e.g., Fig. 2A) plus the intermediate proportion (e.g., Fig. 2C).

https://doi.org/10.1016/j.neubiorev.2021.04.020
Received 7 March 2021; Received in revised form 15 April 2021; Accepted 17 April 2021
0149-7634/

specifics of individual profiles and does not carry information about sexually monomorphic features (p. 172).

It is obviously true that, in most domains of interest to psychologists and neuroscientists, the multivariate space of individual differences “cannot meaningfully be *reduced* to a male-female continuum or to a binary variable” (p. 165, emphasis mine). But this does not make such a continuum useless or irrelevant, even when it happens to account for a minority of the variance (conventionally “small” effects can still have important functional implications; and see Del Giudice, 2021a for a discussion of how the proportion of explained variance can seriously distort the real-world magnitude of effects). Instead, different components of individual variation provide *complementary* information about a given domain, and there is no need to choose one over the other. To illustrate, human faces can be categorized as male or female with high accuracy, and placed on a continuum of femaleness-maleness that is intuitively salient to observers—even though people’s faces show combinations of male- and female-typical features that fall short of Joel’s binary criteria for consistency (see Del Giudice, 2021b). Should we insist that faces are “mosaics”, and hence cannot be meaningfully ranked in terms of their maleness-femaleness? In the high-dimensional space of facial features, a clear male-female continuum coexists with enough within-sex variation that individual faces serve as highly distinctive markers of personal identity, independent of sex. It is also the case that individual differences in the maleness (i.e., male-typicality) of men’s faces are only partially correlated with their perceived masculinity, which is also influenced by cues to height and body size (e.g., Holzleitner et al., 2014). Clearly, the maleness-femaleness continuum does not exhaust the range of meaningful sex-related variation in human faces, but this is not grounds to reject it as useless.

The analogy with faces illuminates another finding discussed by Joel, namely that unsupervised clustering of brain structure data failed to identify clusters of mostly male vs. female brains. As it turns out, when face pictures are subjected to unsupervised clustering, the resulting clusters *also* tend to contain both males and females—even if sex differences in facial anatomy are larger than those in brain structure. The same happens with cluster analyses of personality profiles (for details and references see Del Giudice, 2021b). In other words, multivariate domains may contain patterns of sex differences that are both large and functionally important, and yet fail to be picked up by algorithms that are blind to their existence. Part of the reason is that high-dimensional spaces have a counterintuitive geometry: when a domain includes more than a handful of traits, almost *all* the data points are located in the sparse periphery, while the central region becomes virtually empty. Hence, most individual profiles are going to be highly distinctive, and “unusual” relative to the distribution average; and even when there is a large distance between the sexes, the scale of distances between individuals can be much larger (see Del Giudice, 2021b). In the vastness of high-dimensional spaces, meaningful patterns of sex differences can easily coexist with massive amounts of individual variation. Our methods should make room for both, and we should resist the temptation to reduce the complexity of sex differences research to a binary choice between the “right” and “wrong” approach.

[3] One could argue (e.g., p.172 in Joel’s paper) that combinations of extremely sex-typical traits are in fact not “typical”, because they constitute a minority of the profiles of each sex (e.g., only a small proportion of men show hyper-masculine interests and behaviors in *all* areas of their lives). However, such combinations are disproportionately *more* typical of one sex than the other (e.g., hyper-masculine interest profiles are uncommon in men, but virtually non-existent in women), which justifies using the adjective “typical” in a comparative sense. Finding different terms for these two meanings of “typical” would probably reduce confusion on this point.

References

Cheng, E.R., Downs, S.M., Carroll, A.E., 2018. Prevalence of depression among fathers at the pediatric well-child care visit. JAMA Pediatr. 172, 882–883. https://doi.org/10.1001/jamapediatrics.2018.1505.

Del Giudice, M., 2018. Evolutionary Psychopathology: A Unified Approach. Oxford University Press.

Del Giudice, M., 2021a. Are We Comparing Apples or Squared Apples? The Proportion of Explained Variance Exaggerates Differences Between Effects. PsyArXiv. https://doi.org/10.31234/osf.io/bgh54.

Del Giudice, M., 2021b. Individual and Group Differences in Multivariate Domains: What Happens When the Number of Traits Increases?. PsyArXiv. https://doi.org/10.31234/osf.io/rgzd2.

M. Del Giudice R.A. Lippa D.A. Puts D.H. Bailey J.M. Bailey D.P. Schmitt Mosaic Brains? A Methodological Critique of Joel et al. (2015) Cogprints http://cogprints.org/10046/ 2015

Holzleitner, I.J., Hunter, D.W., Tiddeman, B.P., Seck, A., Re, D.E., Perrett, D.I., 2014. Men’s facial masculinity: when (body) size matters. Perception 43, 1191–1202. https://doi.org/10.1068/p7673.

Joel, D., 2021. Beyond the binary: rethinking sex and the brain. Neurosci. Biobehav. Rev. 122, 165–175. https://doi.org/10.1016/j.neubiorev.2020.11.018.

Kabir, K., Sheeder, J., Kelly, L.S., 2008. Identifying postpartum depression: are 3 questions as good as 10?. Pediatrics 122, e696–e702. https://doi.org/10.1542/peds.2007-1759.

Venkatesh, K.K., Zlotnick, C., Triche, E.W., Ware, C., Phipps, M.G., 2014. Accuracy of brief screening tools for identifying postpartum depression among adolescent mothers. Pediatrics 133, e45–e53. https://doi.org/10.1542/peds.2013-1628.