Credentialed Fictions and the Sex Binary

Abstract: The sex binary can be a useful idealization in scientific models; a fiction helpful for sorting people into two categories in order to investigate the possible mechanisms driving the differences we observe. However, attempts to say that the sex binary is anything more than that are not only misguided. Alisa Bokulich's account of credentialed fictions will help substantiate this point in order to articulate a more nuanced view of the fictional sex binary in modeling terms. I will argue that, despite often treating it as such, the sex binary is not an approximation of biological sex nor is it explanatory.

§ 1 Introduction

There are things in science that we take to be explanatory and are safe to treat as if they are true for the purposes of inquiry. Bokilich calls these credentialed fictions and outlines the ways in which they can be credentialed. Examples of credentialed fictions in science include gravitational force in the study of the tides, infinite populations in biological models, and perfectly rational agents in economic models. In what follows I will argue that we treat the sex binary as a credentialed fiction but that it cannot be credentialed in the ways in which Bokulich's account requires.

In particular, I will argue that the sex binary is not an approximation of biological sex nor is it explanatory. Though it can be a useful idealization in scientific models, it does not serve a purpose beyond initially sorting people into two categories in order to investigate the possible mechanisms driving differences we observe. To make this argument I will first give Bokulich's account of credentialed fictions. In the second section, I will give an example in bioarchaeology of how the sex binary is treated like a credentialed fiction. The third section we will explore what exactly it is that the sex binary could be approximating. In section four I will give two philosophical accounts of approximation and show that the sex binary does not meet either definition. Section five shows that, even if we could give an account of the sex binary as an approximation, it is not explanatory, and therefore not a credentialed fiction. Section six concludes that the sex binary is not an approximation nor an explanation, and therefore not a credentialed fiction.

§ 2 Credentialed Fictions

Alisa Bokulich argues that credentialed fictions can help us understand truths about the world that would otherwise be hard to grasp without their use. She says that a credentialed fiction is:

> a fiction that the scientific community has examined in relation to a veridical representation and determined that, for certain contexts, it is an adequate representation that can succeed in giving genuine physical insight into, and factive understanding of, a phenomenon of interest; and if it is used properly, it will not lead scientists astray in their inferential reasoning. (Bokulich 2016, 274)

A fiction is compared to an accurate representation of the phenomenon and if it captures the relevant features in a given context, then that fiction is credentialed by a scientific community and is used instead of the accurate representation to make inferences about the phenomenon of interest.

The credentialed fiction that Bokulich uses as her example is gravitational force in the study of tides. Scientists know that there is no such thing as gravitational force; instead the underlying explanation for the tides is curved spacetime. Notice that credentialed fictions are *explanatory*. Gravitational force explains the tides despite the fact that we know the underlying explanation is curved spacetime. Scientists have credentialed the fiction of gravitational force and use it as it is an easier concept to grasp and does not inhibit inferential reasoning. Specifically, it is in virtue of being an adequate approximation and an easier concept to grasp that the fiction does not inhibit inferential reasoning (indeed, improves it), and is therefore credentialed.

She claims that the credentialing process takes place over time, which means that some fictions may be more or less credentialed than others. Additionally, fictions can be credentialed

by the scientific community in three different ways. First, the fiction is an adequate approximation to the phenomenon it represents. Second, the fiction and physical phenomenon are expressed by mathematical equations that share the same form. And third, both the fiction and physical phenomena belong to the same universality class. The second and third ways of credentialing seem implausible as they are well-equipped for mathematized fields like physics, but not for much of biology or the social sciences. While there are certainly aspects of biology that are captured mathematically, such as population dynamics, genetics, and systems biology, there are plenty of other aspects that can only be described qualitatively. Qualitative description and mathematical models can be incorporated together in order to provide an explanation or prediction, but the point is that the biological and social scientific enterprises do not lend themselves to purely mathematical representations. A fiction must only meet one of the three criteria in order for it to be credentialed by the scientific community.

I will argue that the sex binary is often treated as a credentialed fiction, but that it cannot be credentialed. I do not take myself to be criticizing Bokulich's view, but rather using it to articulate a more nuanced view of the fictional sex binary in modeling terms. Since we can eliminate the second two criteria of Bokulich's account of credentialed fictions, we can turn our attention to the first criteria of credentialing which is that the fiction is an approximation of the phenomenon it aims to represent.

§ 3 Treating the Sex Binary as an Approximation

The sex binary is treated as an approximation of biological sex in both public discourse and science. In public discourse, the comment section of a biologist's blog post asserts several times that the sex binary approximates biological sex (Soh 2018). An article in Medium arguing for trans rights calls the sex binary an approximation of biological sex (Hipwell 2021). Even a

blog post dedicated to debunking the sex binary claims that it still approximates biological sex (Cheong 2020). Discussions about the sex binary approximating biological sex abound (Bennie 2023, Singal 2019, Strangio 2016, comments, Kralick 2018, comments).

One area of scientific research where the sex binary is treated like an approximation is in bioarchaeology. Bioarchaeology is the study of human biological materials within the context of archaeology. The sex/gender distinction is especially important in bioarchaeology since sex is determined through skeletal remains and gender determined through artifact analysis. Bioarchaeologists have good reason to treat the sex binary as an approximation to biological sex because it is useful to treat sex and gender as two distinct things. In both everyday language and in some areas of scientific research (Knudson and Stojankowski 2008), sex and gender are used interchangeably or are even sometimes used together (sex/gender) to indicate that the two are so deeply intertwined that it is difficult to make a meaningful distinction between them. Ann Fausto-Sterling, for example, makes a compelling case for the claim that biological sex has been constructed based on Western binary gender norms (Fausto-Sterling 2020). However, the distinction between sex and gender is especially useful for bioarchaeologists because without the distinction between gender and sex, studying gender roles in ancient societies becomes a virtual impossibility (Walker and Cook 1998). They emphasize the importance of distinguishing between the two in the technical language of bioarchaeology, in part to be able to maintain communication between other branches of the discipline. I do not take it that they deny that sex and gender are deeply intertwined. In fact, part of the argument they make for maintaining the distinction between sex and gender is so that there is a precise way to talk about the important ways that the two interact with one another.

One such case in bioarchaeology where we can see how the sex binary is treated as an approximation to biological sex is one that looks at the use of mercury treatment for syphilis in London from the 17th to 19th centuries and how it varied by sex and socioeconomic status. Mercury was a widely-used treatment for syphilis during this time and historical records indicate that, should they become infected, women, and in particular poor women, had little to no access to treatment. Researchers wondered if archaeological remains would support the historical record. Skeletal remains from several London cemeteries were studied in order to interrogate this question. Socio-economic status was determined based on the particular cemetery where the remains were found and, in some cases, based on artifacts buried with the individuals. Skeletons with lesions consistent with syphilis were examined against those without lesions. Sex was estimated for each skeleton based on features of the skull and pelvis, with those not clearly male or female (because of damage) excluded from both the pathological and control groups (Zuckerman, 2017). The results of this study were surprising as mercury levels in skeletal remains were pervasive among those estimated to be poor women which was contrary to historical record.

In this study, the sex binary was treated as an approximation of biological sex by sorting skeletal remains into the binary categories of male and female. Researchers treated the complexity of biological sex as though it can be determined by a binary sorting. It is important to emphasize that bioarchaeologists treated the sex binary as an approximation despite their knowledge that culture and gender both have effects on an individual's bones. Bones are not just biological - they are also cultural and gendered (Fausto-Sterling 2005). Whether or not a particular culture spends a large amount of time inside or outside affects the ways that bones develop within that population and conforming to social norms consistent with gendered ideas of

who does more manual work also affects the ways that bones develop. It is not the case, then, that the size of a bone is purely determined by biology. However, sorting bones into binary categories of male and female based on bone size is used to approximate biological sex in order to make inferences about syphilis treatment. The sex binary is used to explain the actual historical use of mercury treatment for syphilis in women instead of merely relying on accounts in historical records. Since sorting skeletal remains into the binary categories of male and female is used to approximate biological sex and the binary is used to explain historical syphilis treatment, bioarchaeologists treated the sex binary as a credentialed fiction.

§ 4 What is the Sex Binary Capturing?

Recall that the matter of judging its credentials is just a matter of figuring out whether it adequately approximates the phenomenon it represents. If the sex binary is treated like a credentialed fiction in both public discourse and in certain scientific contexts, it will be helpful to figure out exactly what it is approximating. At first glance, it may seem like there is a fairly straightforward answer to what it is that the sex binary is approximating. We might think that the sex binary is approximating something at the population level since we generally live our lives in such a way that we can divide people into two categories. (This of course isn't true, but we often *act* like there are just two categories of people.) We fill out medical forms, use bathrooms, and announce the birth of a baby as one of two sexes.

If that is the case, then what the sex binary is approximating is our preconceived ideas of sex based on a Western idea of gender. It is certainly the case that there is a long history of thinking of biological sex as a binary, particularly in white, Western cultures where its original use in 18th century Europe was used to enforce hierarchies of gender and race (Wilson 2004). The very fact that we have come to think of biological sex as either male or female is a historical

contingency, rooted in the fact that people went looking for a biological basis for perceived gender differences in order to maintain power. What we are approximating, then, are Western binary categories of gender that have been enforced for hundreds of years. However, I take it that if the sex binary is to be explanatory in biology and related sciences, we want it to be approximating something biological, not something socially contingent.

Indeed, sex is defined by gamete size at the most basic biological level. If the gametes of a species are different sizes, called anisogamy, individuals that produce larger gametes are females and individuals that produce smaller gametes are males (Ritz and Greaves 2022). Stacey Ritz reminds us, though, that "the binary of the gametes (ova and sperm) required for sexual reproduction does not translate directly into a binary at higher levels of organization" (Ritz 2017, 314). The sex binary cannot be approximating claims at the population level because those statements are usually about the mean differences between two groups of people that we have labeled as male and female. For example, "men have higher testosterone levels than women" is making an assertion about the difference between the mean of two groups categorized as male and female. In reality, some men have lower testosterone levels than some women while some women have higher testosterone levels than some men. The graph depicting the original statement forms an overlapping bell curve of the two groups, where the mean of the group of men is greater than the mean of the group of women.

Instead, what the sex binary is approximating are the underlying processes and mechanisms that are driving the difference between the mean of the two groups. The labels male and female are categories useful for initial sorting but the differences in these categories need to be investigated further in order to find the mechanism underlying the difference. Once found, it

may be the case that the line drawn between the groups would be moved such that there would be a mix of men and women on either side.

Further, since there are multiple sex-related variables that exist at multiple levels of biological description, the research context determines what the sex binary is approximating, which can and will be different in various contexts. Sarah Richardson argues that *sex contextualism* ought to guide biomedical research and claims that sex and sex-related variables are determined within a research context. She says:

> This research context may include pragmatic interests, observational constraints, interacting or mediating environmental variables, characters of the species or strain, developmental stage of the research organism or materials, and level of biological analysis—for example, cell, tissue, organism, and community. (Richardson 2022, 9)

Two examples should help illuminate this point.

First, researchers at the University of Alabama studying wound infection found that female mice were able to avoid wound sepsis without any treatment interventions. They were, however, unable to replicate the study. Upon further investigation, they found that the female mice happened to be at different phases of their estrous cycle during the two different experiments, with all having high levels of estrogen in the first experiment and all having low levels in the second. In this context then, estrogen is the sex-related biological variable (Richardson 2022). Sorting the mice into male and female was a useful starting point, but the actual sex-related mechanism was at the hormonal level.

The mechanism driving the result was estrogen levels, not sex itself.

The second case is an example of where sex contextualism would have helped in research. Canadian researchers did a study that examined ferritin levels in individuals who were

frequent blood donors and found that females were more likely to have ferritin depletion after donation. This led to a policy whereby women had to wait longer between donation times than did men. The mechanism driving the result was ferritin levels, not sex itself. The sex binary was not representing a division between males and females, but was rather representing the mechanism responsible for ferritin levels which will vary between individuals. The actual sex-related variable was at the cellular level, not the population level.

The previous cases show us that what the sex binary is *capturing* is not actually a sex binary but a bunch of mechanisms that underlie the differences between the mean of two populations. What we need to know now is whether or not the sex binary as an idealization can be an *approximation* of a sex binary in a real population. Recall that one way a fiction can be credentialed is for it to be an approximation of a phenomenon. The next section gives two accounts of approximation and shows that the sex binary is not an approximation of the phenomenon it is aiming to capture.

§ 5 Approximation

On the first account of approximation, John Norton draws a distinction between approximation and idealization, arguing that the difference between the two is referential. Approximations are propositional and refer to the target system inexactly while idealizations refer to new systems, like a model, and may or may not contain approximations that refer to the target system inexactly. Idealizations contain novel information not included in the target system as they refer to a model, not the target system itself. He says that there is no single approximation relation between proposition and target system; the context will determine what counts as an approximation as some descriptions of an approximation may be rather close to or very far away from the target system.

On Noton's view, the sex binary is an idealization, not an approximation. What it is referencing is the difference of the mean between the two groups, it is not the relevant mechanism in the actual target system. The sex binary is correlated with the phenomenon of interest, but is not approximating it. If we look at the wound sepsis example from above, we can see why this is the case. Remember that initially, researchers concluded that female mice were able to avoid wound sepsis without any intervention while male mice were not. When they were not able to replicate their findings, they realized that the relevant mechanism driving the difference was estrogen levels, not sex itself. Here, the sex binary is referring to the difference of the mean between male and female mice in a statistical model, which is an idealization. The sex binary is not referring to the target system itself, but rather to an idealization in a statistical model. If it were referring to the target system the sex binary would have referred to estrogen levels. But we know estrogen levels vary during different phases of estrous cycles. That means that some female mice will in fact require medical intervention to avoid wound sepsis at certain times of their cycle and will not require medical intervention at other times of their cycle. Since the sex binary is referencing the difference of the mean between the two groups, it is not referencing the relevant mechanism in the actual target system. In other words, the sex binary is correlated with the phenomenon of interest, but is not approximating the phenomenon. It is the mechanism correlated with sex, in this case estrogen, not sex itself. Therefore, the sex binary is not an approximation on Norton's view.

On the second account, Demetris Portides argues that approximations and idealizations are both characteristic features of scientific models which are theoretical entities that provide a link between theory and experiment. Scientific models are both an idealization and an approximation of the target system it represents. He claims that the two are connected to one

another in important ways, arguing that idealized models can be progressively deidealized into an approximation of the target system. He says that:

> the approximation relation refers to the closeness of theoretical predictions to experimental measurements, and this closeness has been traditionally interpreted by (realistically inclined) philosophers and scientists alike as closeness to truth, or truthlikeness of scientific theories. (Portides 2007, 703-4)

On Portides' view, the sex binary is, again, plausibly an idealization, not an approximation. If we look at the blood donation example from above, we can see why this is the case. Remember that researchers found that female blood donors were more likely to have ferritin depletion after blood donation and therefore issued a policy whereby female donors were required to wait longer between donation times than male donors. Since the most common mechanism driving ferritin depletion is blood loss, it makes sense that some female donors during certain phases of the estrus cycle would attempt to donate blood during a time where their ferritin levels are lower than is safe to donate. But not all female donors would fall into this category. Additionally, blood loss can happen for any number of reasons to all people, meaning that some male donors may not be able to safely donate as frequently as other male donors. Therefore, the relevant mechanism driving the difference between groups was not sex itself. We are not getting closer to the truth about sex, but rather closer to the truth about ferritin levels. The sex binary is correlated with ferritin levels, but is not approximating them.

If we assume that the sex binary is an idealization in this statistical model, Portides claims that we can deidealize it into an approximation. Idealizations are a distortion of a feature or features of the target system and so deidealization is usually taken to be the reversal of this idealization process, usually by adding back in features from the target system in order to correct

the distortion. We might be able to deidealize the sex binary to an approximation, but it will not be an approximation to sex itself, but rather the approximation to the truth we get is to the relevant ferritin level.

There are those who advocate for the position that 'every cell has a sex' (Bradbury 2017), meaning that sex penetrates the whole organism, right down to the cellular level. We describe humans as male and female and then assume that that division holds throughout the individual. If that were the case, perhaps the sex binary could be deidealized. Instead, biological processes associated with sex are non-additive, exist at various levels of biological description, and usually form a bimodal distribution of traits, not a binary (Ritz and Greaves 2022). Biological sex is a complex system of social behaviors and biological processes without a clear referent. For all of these reasons, the sex binary cannot be deidealized into anything approximating the truth about a population or an organism.

The sex binary cannot be an approximation on either account of approximation. On Norton's view, the sex binary is not an approximation because its referent is in the model, not the target system. On Portides' view, the sex binary is not an approximation because it is not close to the truth of the target system or scientific theory.

§ 6 Explanation

One might object that we only went through two accounts of approximation and that while they seem plausible, maybe there is an account of approximation that we would view as accurately describing the sex binary. This section will argue that, even then, it would not be credentialed because it is not explanatory. One important feature of Bokulich's account of credentialed fictions is that the fiction explains the observed phenomenon. Remember her claim that the credentialed fiction gravitational force *explains* the movement of the tides. Therefore if

the sex binary is a credentialed fiction, it must be explanatory. Broadly, explanations aim to answer why things happen, whether that thing is a particular event or something more general like a repeated pattern or regularity (Woodward and Ross 2021). This leads to the natural question of what exactly the sex binary is aiming to explain. I think the answer to that question is that we are seeking to explain observed differences at the population level. But as we saw with the two examples from the previous section of wound sepsis and blood donation, the sex binary does not explain any of those observed differences. If it were an explanation, it would give us some answer regarding why we observe that females tend to need less intervention to treat wound sepsis. The binary is merely reporting the fact that there is a difference between the mean of two groups classified as men and women. It is also merely reporting an observed difference between the mean of two groups classified as men and women regarding the difference observed in ferritin depletion of blood donors. It is certainly useful information and in fact, an invitation to investigate further to find the mechanism or mechanisms driving the observed differences. It is not, however, an explanation. Importantly, those we group as "males" are not identical to one another and those we group as "females" are also not identical to one another (Low 2004). Because of this, it is not enough to say that there are differences between the two groups.[1] The explanation for the difference will be some underlying mechanism or mechanisms. We are looking to explain observed differences at the population level - the sex binary is not explaining those differences. Because the sex binary is not explanatory, it cannot be a credentialed fiction.

[1] Presumably, even if all males were identical to one another and all females were identical to one another, merely pointing out a difference between the two groups would not count as an explanation for observed differences. There is still a further question regarding *why* it is the case that there are observed differences.

§ 7 Conclusion

People elevate the sex binary to a status that it does not deserve - as I've argued, they treat it as a credentialed fiction. The sex binary can be a useful idealization in scientific models; a fiction helpful for initially sorting people into two categories in order to investigate the possible mechanisms driving the differences we observe. But the sex binary is not an approximation of biological sex nor is it explanatory. Therefore, despite often treating it as one, the sex binary is not a credentialed fiction.

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