Applying a Fuzzy Model Approach to the Classification of Sexual Differences: Beyond the Male/Female Binary

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Abstract—The idea that sex (the male/female binary) is a clear-cut category distinction is well established in our culture. However, people born with ambiguous genitalia or with a mixture of male and female anatomy have always existed, originally known as hermaphrodites and, later on, as intersex. Along the centuries, human cultures have classified sexual differences in different ways, though the dichotomical model of the two sexes has been the most prevalent. The main objective of this paper is to show how different epistemological models or frameworks have a direct impact on the way of thinking about sexual difference and we claim that a new epistemological model based on fuzzy logic can open the scope to understanding sex in a non-dichotomic and fixed way.

Keywords—Male/Female Binary; Sexual Variability; Intersex; Fuzzy Model; Fuzzy Clusters

I. INTRODUCTION

If there is something that is commonly thought to be a clear binary phenomenon is the distinction between male and female. However, facts are quite different. The medical profession has been dealing with cases of sex ambiguity for many centuries. In the ancient times, people born with ambiguous genitalia or with a mixture of male and female anatomy were known as hermaphrodites. Later on, in the XXth century, the term of “intersex” was introduced. In spite of that, this is not well known by the general population, in part due to the “secrecy” surrounding this phenomenon.

The main objective of this paper is to show how different epistemological models or frameworks could have a direct impact on the thinking of sexual differences, as we will show by depicting the different historical frameworks used in different times to classify sexual differences. Instead we propose a new epistemological model based on fuzzy logic that can open the scope to understanding sex in a non-dichotomic and fixed way.

The order of the paper will be as follows. In section 2 we define the concept of “intersexuality” as it is presented in current researches, and collect the most common types of intersex conditions. In section 3 we analyze different historical approaches to the phenomenon of sexual ambiguity, showing that there has not been a unique way of making sense of sex variability. In section 4 we classify the different variables that are considered to determine the sex of an individual. Section 5 describes the way the medical profession has dealt with intersex people and the protocols they have used in their treatment. Section 6 introduces our proposal of a fuzzy model to analyze and represent sexual variability. In section 7 we present our conclusions and future lines of research.

II. WHAT IS INTERSEXUALITY?

The first thing we have to bear in mind when we use the term “Intersex” is that it is a historical constructed category. Along the centuries, people bearing a mixture of male and female anatomy were called “hermaphrodites”. It was not until the decade of 1950 of the last century that the category of intersex was introduced. However, professional opinions about what should count as “intersex” vary substantially. In what follows, we will use the definition given by the Intersex Society of North America (ISNA).

A. Definition of Intersexuality

The Intersex Society of North America (ISNA) defines “Intersex” as “a general term used for a variety of conditions in which a person is born with a reproductive or sexual anatomy that doesn’t seem to fit the typical definitions of female or male. For example, a person might be born appearing to be female on the outside, but having mostly male-typical anatomy on the inside. Or a person may be born with genitals that seem to be in-between the usual male and female types (...). Or a person may be born with mosaic genetics; so that some of her cells have XX chromosomes and some of them have XY”[1].

B. Frequency of Intersexuality

This is a controversial one since depends of how we define intersex. Following data from ISNA[1], medical centers with specialization in sex differentiation consider that children born with noticeably atypical genitalia (based on their definition of intersex) is about 1 in 1500 to 1 in 2000 births. However, other researchers affirm that a lot more people is born with subtler forms of sex anatomy variations, some of which won’t show up until later in life.
During the last two decades, the historian Thomas Laqueur [3] has claimed that the idea of "sex" as a natural or biological characteristic is a historically constructed concept. In his exhaustive research of Western sexual history, Laqueur identifies different stages in the history of scientific representations of sex. We use here this classification and introduce new ones developed in the last years to identify several different ways in which the concept of sex differentiation has been understood along history.

### TABLE I

<table>
<thead>
<tr>
<th>NAME</th>
<th>CAUSES</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turner Syndrome</td>
<td>Females lacking a second X chromosome (45XO)</td>
<td>Ovaries do not develop. Lack of many feminine secondary sex characteristics.</td>
</tr>
<tr>
<td>Klinefelter Syndrome</td>
<td>Males with an extra X chromosome (47XXY)</td>
<td>Infertility. Breast enlargement after puberty. Lack of many masculine secondary sex characteristics.</td>
</tr>
<tr>
<td>XXX Syndrome (also called superfemale)</td>
<td>Males with an extra X chromosome (47XXX)</td>
<td>They develop as normal males and the vast majority don’t know about their Karyotype</td>
</tr>
<tr>
<td>XYY Syndrome (also called supermale)</td>
<td>Males with an extra Y chromosome (47XYY)</td>
<td></td>
</tr>
<tr>
<td>Gonadal Dysgenesis: Complete (Swer Syndrome) or Mixed</td>
<td>XY/XO mosaics: some cells have XY some XO. (Known as XY Women)</td>
<td>Gonads are not developed properly. Feminine genitalia. Absence of masculine secondary sexual characteristics</td>
</tr>
<tr>
<td>True Hermaphroditism</td>
<td>Various degrees of mosaicism: for example 47XXY, 46XX/46XY, or 46XX/47XYX</td>
<td>There may be an ovary underneath each testicle or an ovotestis. External genitalia are often ambiguous</td>
</tr>
</tbody>
</table>

### III. DIFFERENT HISTORICAL MODELS OF SEX CATEGORIZATION

#### A. Ancient Times: The One Sex Model

This period goes from the Ancient Greeks to the XVIIth century and can be called as the "one sex only" model. In fact this one sex corresponds to the male since the woman’s body was considered to be an imperfect version or “second stage” (not enough developed) of the male body. However, in other non-Western cultures it was believed that everybody has two sexes within (a kind of universal hermaphroditism) which is more in the line of the Buddhist’s logic (everything is formed by a joint of opposites), what we could call “Ying/Yang Logic”.

#### B. Middle Ages: The Three Sexes Model

This period is characterized by the beginning of the establishment of the sexual dimorphism, that is, the belief in the existence of significant differences between women’s and men’s bodies. However, a new in-between category was maintained too to identify a broad and heterogeneous group of people that didn’t fit into this two categories, in which was included not only people with ambiguous sexual characteristics, but also what nowadays are considered homosexuals, transsexuals, travesties, etc. This “third sex” was named in the XIXth century as “inverts”. So we find here a model of three sexes (men, women and inverts) that we can relate with “Three-valued Logic”.

#### C. Modern Period: The Two Sexes Model

Since the end of the XVIIth century, the idea that there exists a binary sexual dimorphism was firmly established. This stage is characterized by the institutionalization of the medical profession and the development of scientific understandings of sex differences that increasingly shaped the (two) sexes as intrinsically different. There are two characteristics of this model that we name as “Monosexuality” (the idea that every person has one -and only one- sex) and “Sexual Duality” (the idea that there exists two -and only two- sexes). These two beliefs have a clear correlation with the two main principles of the classical Aristotelian logic: the Principle of Noncontradiction and the Excluded Middle. That’s why we consider this sexual categorization as related with “Classical Binary Logic”, which is characterized for being dichotomic and crisp.

#### D. The “Five Sexes” Model (Fausto-Sterling)

In 1993 the feminist biologist Anne Fausto-Sterling wrote the article [4] where she stated that “For biologically speaking, there are many gradations running from female to male; and depending on how one calls the shots, one can argue that along that spectrum lie at least five sexes; and perhaps even more” (p. 21). The main variable that Fausto-Sterling considered in this classification was the type of gonads (ovaries or testicles) present in the body. Considering this, she defined five sexes: males, who possess two testes; females, who possess two ovaries; herms (the so-called true hermaphrodites), who possess one testis and one ovary, or an ovotestis; merms (the so-called male pseudohermaphrodites), who have testes and some aspects of the female genitalia but no ovaries; and fems
(female pseudohermaphrodites), who have ovaries and some aspects of the male genitalia but lack testes. Following our argument of linking sex differentiation models with different types of logics we relate this model of the five sexes with “Multi-valued Logic”.

E. Proposal of a new Model: the Continuous Sex with Fuzzy categories

Some years after the “Five Sexes” article [4], Anne Fausto-Sterling published a book [5] where she rejected her first classification and proposed that, rather than several discrete categories, sex differentiation conveys a continuum, being male and female the extremes of it. This idea is also shared by ISNA and other recent researches about intersex. However, none of these authors provide a model for representing and analyzing this continuum.

Even more problematic from our point of view is that this idea assumes sex as a “complete continuum” from male to female, as it it were possible to define a line were all possibilities lay in order from more feminine to more masculine. Though it is recognized in other parts of their researches that there are different variables used to classify sex they don’t realize that there is now to establish a linear order among them. Because of this, a new model should account for the plurality of these variables, some being discrete and some being continuous. Taking into account the complexity of this phenomenon we think that the best tool to represent and analyzing sex variations is the theory of Fuzzy Sets. Because of that, the goal of the paper is to provide a new model that offers a more accurate and rigorous look at real bodies, using “Fuzzy Logic”.

IV. VARIABLES TO DETERMINE BIOLOGICAL SEX

For many centuries, the only way to classify peoples sex at birth was through the observation of the external genitalia. With the advancement of science and medical technologies in the XXth century, several devices such as X-Ray, ultrasound and genetic testing were developed, which allowed doctors to “look” inside the body. These technologies introduced new ways of classifying sex like assessing the chromosomal karyotype of a person, the presence or absence of internal gonads, and the distribution of different hormones in the body.

In this section we are going to collect the different variables that are being used to determine the biological sex in humans. The main goal of this section is to show the plurality of these variables, and, most interesting, the fact that not all of them coincide in determining an individuals sex. As we have seeing in section II, in some people the different variables do not align in the same pole of the binary system, which challenges common assumptions about this dichotomic model.

A. Chromosome Sex

Refers to the karyotype of the 46 chromosome (also called “sexual chromosome”). The most common karyotypes are XX (female) and XY (male). However there are many other sexual karyotypes, for example, an extra X (47XXY or Klinefelter’s Syndrome), a lack of Y chromosome (45XO or Turner’s syndrome), an extra Y (47XYY or Super-male Syndrome), a triple X chromosomes (47XXX or Super-female Syndrome). In these kariotypes all the cells in the body have the same sexual chromosomes. But there are also people with different genetic mosaicisms that is, different cells in the body have different karyotypes (see Table I).

B. Gonadal Sex

Refers to the differentiation of the gonadal tissue. Gonads are the organs that produce gametes (spermatozoon and egg cells). The basic gonads are testicles (testes) and ovaries. However, some people is born with four of them, with one of each, or with a mixed gonad called “ovotestis” that contains both types of tissue.

C. Genital Sex: Primary Sexual Characteristics

Refers to the internal and external reproductive organs. This includes the presence or absence of: penis, scrotum, deferens tubes, uterus, fallopian tromps, clitoris and vagina (including labia majora and minora). As in the sections above, different variations of these organs can occur in different individuals. Because of the way these organs are developed in the embryogenesis, clitoris and penis start from the same tissue and there are cases where it is not possible to differentiate between a micro-penis and a macro-clitoris. (see [5] p. 50). And so is the case with the development of the scrotum and the labia, where exist in-between cases with a “blind vagina” and a “divided scrotum”.

D. Secondary Sexual Characteristics

Refers to the secondary sexual characteristics that are developed in the pre-puberty and puberty stages. The main secondary sexual characteristics are: bodily hair, facial hair, stature, bone structure (mainly shoulders, hips and facial shape), feet and hands size, muscular mass (quantity and distribution), body fat (percentage and distribution), size of breasts, voice pitch and larynx enlargement.

Usually, these have been divided into “masculine sexual characteristics” and “feminine sexual characteristics”. But in reality their presence are distributed in all peoples bodies in different degrees (not only in the case of intersex people but also in so-called “normal” male and females).

E. Hormonal Sex

Refers to the level of hormones present in the body. Hormones are substances segregated by the gonads and perform several functions in the development and well functioning of the body. In the second half of the XXth century endocrinologists developed the theory of “sex hormones”, considering that steroids hormones can be classified in two groups: “masculine hormones” (including testosterone, androsterone and related) and “feminine hormones” (mainly estrogens and progesterone). Much of the research since them has been devoted to explain the differences between these hormones and, so, between male and females bodies. However, there
are more types of hormones than these ones (i.e. FSH, HCG and LH) that are also involved in the development of sexual characteristics, and, contrary to common knowledge, every type of hormones is present in every person’s body (i.e. women also segregate testosterone and men estrogens). Critical studies in the last years [5], [6], [7] have shown that this classification was chosen because it fits perfectly well with the dualist system of sex.

F. Neural/Psychological Sex

In the last decades a new body of research in neuroscience called “Brain Organization Theory” have claimed that there are structural brain differences between males and females. According to this theory, the different hormonal exposure in prenatal development affect the activation of different parts of the brain in males and females, which also would explain masculine and feminine patterns of personality, behavior and cognition. Although this theory has gained a great deal of acceptance among neurologists and in the media, other researchers [5], [8], [7] have criticized the binary assumptions in which brain organization theory rests on and the way of linking psychological characteristics to genetics and brain structure without taking into account social and cultural factors.

V. A binary “normativity”: the prevalence of the two sexes model

In spite of the plurality of variables to differentiate sex variations, during the last two centuries the “Two sexes model” was the one that prevailed. This idea was reinforced by the way the medical profession dealt with people born with ambiguous genitalia and other types of intersex conditions. In this section we will expose the characteristics and assumptions underlying this protocols as well as the reactions and critiques to it by feminist scholars and intersex people themselves.

A. The Johns Hopkins’ Protocol

The protocol to deal with intersexuality was developed in Johns Hopkins University in the 1950s and became the rule in the hospitals and clinics of the developed countries until nowadays. This protocol (also called “optimum gender of rearing”) was based on the theories of the psychologist John Money [9], the leader of the team. His thesis was that gender was more about nurture than nature, and therefore a baby can be “made into a real” girl or boy if you make the body look “sexually right” (by which they meant believable and heterosexual) during the first 18 months of life. The decision about sex assignment was considered a “medical emergency” and made unilaterally by the physicians. The parents should accept and raise the baby according to this sex.

So, which was the main factor to decide the sex of the baby? Contrary of what one might think, it was not the specific karyotype or the type of gonads but the external anatomy of the genitalia, and, more concretely, the size of the penis, as can be seen in Figure 1.

After the assignment, then, the main procedure was to perform “genital normalizing surgery” in accordance with the assigned sex and, later on, hormonal therapy and surveillance of the children over her/his life until adolescence, where more hormonal treatment and maybe more surgeries are needed to keep their “sexual normalization”.

B. Critiques to the Johns Hopkins’ Protocol

Paediatric endocrinologists in the Western countries have followed the Johns Hopkins’ protocol to deal with intersex “cases” since the 1950s, with very little variation. However, since the past two decades many scholars, mostly procedent from feminist and queer studies [10], [11], [5], [12], [13] and intersex people organized in associations and patient-support groups [14], [1] have been criticizing this approach.

They strongly criticize the medical procedures performed to intersex people when they are babies and cannot give an informed consent about the treatments. Although in many of the cases the “symptoms” are not painful or life-threatening, surgeries and hormonal treatments that will affect them lifelong are performed (in many cases involving genital mutilations).

Because of that, the Intersex Society of North America (ISNA) gives the following recommendations for the procedure of treating of newborn intersex [15]:

- Perform only the medical procedures necessary to for the physical health of the child. Surgeries done to make the genitals look “more normal” should not be performed until a child is mature enough to make an informed decision for herself/himself.
- Provide parents of intersex –and as soon as possible children themselves– honest and accurate information and counselling by people who is not intersex-phobic. Refer them to other people/organizations dealing with the same issues.
- Intersex children should not be raised without a gender, nor as a “third gender”. They should be given a gender assignment as boy or girl, but this assignment should not involve surgery.

1This is a clear application of the sentence that Zadeh uses in many articles “precision can carry a cost”. It is really a big one in this case!
VI. A FUZZY MODEL APPROACH TO SEXUAL DIFFERENTIATION

The assumption that sex is binary and that there are only two sexes is based on use of a binary logic, where the non-contradiction and excluded-middle principles hold. To change that assumption we propose to use fuzzy logic where the non-contradiction and excluded-middle principles don’t need to hold, and where everything is matter of degree.

To illustrate the feasibility of using a fuzzy model to generate imprecise sex categories we are going to focus in some of the variables used to determine biological sex and their variability among people. Because of this, this model should account for the plurality of these variables, some being discrete and some being continuous, and for the lack of a total order among the variables, although some partial orders could exist. For example, chromosomal karyotypes, though being more than just two, are discrete categories, and genital sex, where there are many continuous variables some them could be partially ordered.

Firstly, we will focus on variable of genital sex, and more concretely, on the length of clitoris-penis, since it was the main variable used in Johns Hopkins’ protocol to assign one sex or another. Given the lack of statistics about the length of them at birth we will use the length of them in adults extracted from [16], [17], [18]. In Figure 2 can be seen a plot of the distributions of length of clitoris-penis in people from US identified as female, intersex, or males.

As we can see in Figure 2 there is a clear continuum of lengths from flaccid clitoris to erect penis, although it is usually divided in three different and mutually exclusive categories: below 3.5cms it is considered a normal clitoris, above 7cms it is considered a normal penis, and in-between are considered macro-clitoris or micro-penis. Although we don’t know the exact correlation between length at birth and length in adults, we could consider that clitoris below 3.5cms in adults correspond to longer that 2.5cms at birth, and in-between 3.5cms and 7cms corresponds to the “unacceptable” region in the Johns Hopkins’ protocol for babys (see Figure 1). This last category represents those cases were surgery was usually recommended at birth, in an attempt to dichotomize what in reality is a continuous variable.

Secondly, we are going to model several sex variables together: the kariotype from the chromosomal sex and two secondary sexual characteristics (height and shoe size). Although height and shoe size are not usually used to classify the sex of people they are considered somehow correlated with chromosomal and hormonal variables. Given the lack of statistics for other secondary sexual characteristics we will use these two to illustrate how a multidimensional fuzzy model of sex could look like.

Using data of height of US adults provided by 2000 CDC Growth Charts for the United States [19] and data of shoe sizes from Footwear 1998 sales on US [20], we have built a graphic with the estimated height and shoe sizes for different kariotypes (46XX, 46XY, 45X, 47XXY, 47XXX, 47XYY). Based on the linguistic descriptions of the secondary sexual characteristics of the different kariotypes (see Table I) we have estimated the height and shoe size for each kariotype. For example, 47XXX are taller than average females, and 47XYY develops as normal 46XY males.

As we can see in Figure 3 the distributions of height and shoe size varies depending on the kariotype, but also within each kariotype, due to the intrinsic variability of sexual characteristics. If we tried to classify all these variability in only two groups we will get an unrealistic forced division, as we can see in the graph resulting of a crisp clustering process according to their height and shoe size (see Figure 4). Although in reality no one divide people according to this fictitious clusters, the figure illustrates the idea that any rigid division will force an artificial discretization on a phenomenon that is not (as it is done in the Johns Hopkins’ protocol).

However, a more natural model could be done using fuzzy clusters, where each individual belong to all the clusters with different degrees, as can be seen in figure 5. In this case
one cannot classify each individual as belonging to only one cluster. The model captures the notion that there is variability within each cluster and an overlapping between the clusters. Although we know this example is a bit artificial, we think it illustrates how a fuzzy model could be used to represent the variability among individuals and the necessary overlapping between any clusters one could made.

Fig. 4. 2 Rigid Clusters

Fig. 5. 3 Fuzzy Clusters

VII. CONCLUSIONS AND FUTURE WORK

The main objective of this paper has been to show how different epistemological models or frameworks have a direct impact on the thinking about sexual difference. As we have shown by depicting the different historical frameworks that have been used to classify sexual differences, classical binary logic has been the main model used for decades. The fact that genital ambiguity is considered a medical emergency evidences the discomfort about bodies that do not fit into a dualist sex system. And it is very impressive that, in order to maintain our dichotomic cultural beliefs, it has been more feasible to change peoples bodies than to change our own assumptions.

To challenge this view we have proposed a new epistemological model based on fuzzy logic to represent sexual variability in humans. Though we do not claim that this approach can be directly translated into medical management of intersexuality nor should be adopted or preferred by intersex people themselves, we believe that this approach can open the scope to a more fluid and plural understanding of sexual variability in a non-dichotomic and fixed way. And, in the long term, that can be beneficial for people that do not fit in traditional sex categories.

In the future we plan to extend this research to include more variables of sex classification using the fuzzy-logic approach.

REFERENCES