Representing Gender in Ontologies: A Dispositional Perspective

Fumiaki Toyoshima [1], Adrien Barton[2,1], Paul Fabry [1] and Jean-François Ethier [1]

[1] GRIIS, Université de Sherbrooke, 2500 Boulevard de l'Université, Sherbrooke, QC, J1K 2R1, Canada
[2] IRIT, CNRS, 118 Route de Narbonne, F-31062 Toulouse Cedex 9, Toulouse, France

Abstract

Like biological sex, gender is a crucial determinant of health. Its representation nonetheless remains underdeveloped in many electronic medical records and health information standards. This paper explores an ontological characterization of gender in compliance with the OBO principles for ontology development and the BFO upper ontology. In particular, we deploy J. McKitrick's dispositional account of gender (identity). Our main proposal is that gender can be analyzed as a behavioral and "extrinsic" disposition, as distinct from the BFO category of disposition. We also briefly discuss the implications of our dispositional approach to gender for so-called "gender roles" and gender-related information entities in existing ontologies.

Keywords

gender, gender role, gender information entity, disposition, extrinsic disposition, role, realizable, Open Biological and Biomedical Ontologies (OBO) Foundry, Basic Formal Ontology (BFO)

1. Introduction

A correct understanding of various attributes (e.g. age) of patients is paramount to appropriate healthcare of patients. Sex and gender are particularly important because their differences will have a profound effect on the development of chronic diseases and health-relevant lifestyle choices [1]. It is nonetheless all too often the case that health records fail to represent accurately sex and gender, or even their distinctness [2]. For instance, Lau et al. [3] report a lack of clarity and inconsistencies in the definition and their implementation of sex and gender in Canadian Electronic Health Records (EHRs) and in international health information standards. They also propose six-level general actions to modernize sex and gender definitions in Canadian EHRs, ranging from the articulation of the need for this work to the demonstration of its benefits in tangible terms.

This paper aims to contribute to Lau et al.'s second-level action to reach consensus on sex/gender-related notions that would help to improve Canadians' health. In particular, we will focus on gender itself. According to the World Health Organization (WHO), gender amounts to characteristics that are largely socially created and sex encompasses those that are biologically determined [4], although sex may have a causal (albeit non-definitive) influence on gender. However, this characterization of sex and gender is too loose to be well implemented in EHRs. Conversely, a very narrow definition of them may yield the socio-ethically undesirable consequence of neglecting underserved sex/gender minorities.

To meet this challenge, we will adopt a methodology to consider the notion of gender in the field of formal ontology. An ontology is an explicit representation of a given domain that is provided in formal language and it is expected to be a powerful tool for enhancing the integration of data that are dispersed in different information systems. An ontological analysis of gender will provide its suitably general and computationally readable representation that can benefit the management of EHRs and have wide implications not only for gender-related notions such as administrative and legal genders, but also for informational entities about sex and gender [2], as they are as important to EHRs as gender itself is.

The paper is organized as follows. Section 2 adumbrates the role of ontologies in the context of medical informatics. Section 3 introduces state-of-the-art philosophical theories of gender, especially its dispositional account elaborated by McKitrick [5]. Section 4 develops our McKitrick-inspired dispositional representation of gender in ontologies. Section 5 is devoted to a brief discussion. Section 6 concludes the paper with some remarks on future work.

2. Ontologies in Medical Informatics

In recent years, considerable effort has been invested to leverage an increasing amount of data and information that are obtained from clinical encounter. However, it remains a thorny issue to ensure the interoperability among different data sources (e.g. databases) that are employed by different medical institutes. One traditional solution to this problem is to build a so-called "data warehouse" into which variegated data sources can be integrated. This approach is nonetheless severely limited by distinct regular and legal frameworks across institutes and countries as well as by its failure to optimize clinical decision support owing to delayed data generation and delivery.

Another recent proposal is to create a "central data model" [6] onto which local data source models can be mapped and which supports query expression. This "mediation approach" [7] to data has the advantage of enabling data transmission only when it is needed and allowed by the local data source curator, so that each data source can preserve its own terminology and structure. One tool that can serve as such a central data model is an ontology: the kind of machine-readable representation of the entities and their relations in a given domain which is formalized in some logical language.

To be utilized as central data models, biomedical ontologies need to be developed in a mutually consistent way. To achieve this goal, for instance, the Open Biological and Biomedical Ontologies (OBO) Foundry [8] provides a set of methodological principles that would be useful for coordinating ontologies to facilitate biomedical data integration: for instance, the Aristotelian method for defining terms [9]. One noteworthy requirement of OBO ontologies (by which we mean ontologies following the OBO principles) is the usage of some upper ontology: an ontology that deals with the most general categories and relations of reality (e.g. time, objects, properties, processes, and the part-whole relation) and that would help to construct intercommunicable domain ontologies. In point of fact, many OBO ontologies are built upon Basic Formal Ontology (BFO) [10]. BFO is an upper ontology motivated by a scientific perspective on what exists in reality [11] and it is recognized by the International Standards Organization (ISO/IEC PRF 21838-2.2). As is illustrated by the fact that upper ontologies are entwined with such philosophical notions as time, an important field called "formal ontology" is an interdisciplinary intersection at which philosophers, linguists, cognitive scientists, and computer scientists collaborate.

We will below explore an ontological representation of gender in alignment with the OBO and BFO frameworks. As a preliminary to this task, we will provide a brief overview of philosophical theories of gender and delineate McKitrick's [5] dispositional account of gender because it is expected to accommodate sexual and gender minorities, who may have special needs of healthcare.

3. Theories of Gender
3.1. A Brief Overview

The notion of gender is traditionally closely associated with sex. For that matter, it is a long-standing practice to lump sex and gender together based on a discrete single binary classification in existing Canadian EHRs [3]. However, it is nowadays an established view that they should be sharply distinguished, and that the words "man" and "woman" should be used to refer to people of a specific gender rather than to people of a specific sex. The categorization must also go beyond the sole man-woman dichotomy, as evidenced by non-binary people who do not identify themselves as women nor as men. Note that, while recognizing that both sex and gender are so complex and multifaceted, we will sometimes appeal to the very rough binary gender distinction (man/woman and masculinity/femininity) merely for expository purposes. But what is gender? A number of different answers to this question have been proposed, especially since de Beauvoir's [12] feminist theorizing upon sex and gender. In

the interests of space, we will briefly present Haslanger's [13] account of gender, as it is arguably one of the most influential theoretical works on gender.

According to Haslanger [13], gender is a socially constructed category. Following Beauvoir's slogan "gender is the social meaning of sex", she defines men and women in a broad social structure of privilege and subordination, respectively:

[A subject/person] S is a woman (resp. man) iff:
(i) S is regularly and for the most part observed or imagined to have certain bodily features presumed to be evidence of a female's (resp. male's) biological role in reproduction;
(ii) that S has these features marks S within the dominant ideology of S's society as someone who ought to occupy certain kinds of social position that are in fact subordinate (resp. privileged) (and so motivates and justifies S's occupying such a position); and
(iii) the fact that S satisfies (i) and (ii) plays a role in S's systematic subordination (resp. privilege), that is, *along some dimension*, S's social position is oppressive (resp. privileged), and S's satisfying (i) and (ii) plays a role in that dimension of subordination (resp. privilege). ([13], p. 234)

At the core of her definition of gender is that "woman" (resp. "man") refers to a category of people who are given a subordinate (resp. privileged) social position owing to the fact that they are *regarded* as having certain bodily features associated with a female (resp. male's) reproductive role.

Leaving examination of Haslanger's theory for the next subsection, we remark that her account of gender has led to a wide variety of contemporary approaches to gender. Being strongly influenced by Haslanger, for instance, Ásta [14] develops a "conferralist framework" for social categories/properties (including gender): a social property of an individual means a property that is conferred on the individual by others in a context, by which she means a social status consisting in constraints on and enablements to the individual's behavior in that context. By conferring social properties, people are attempting to track a "base property" of the individual such that they think the individual possesses it, regardless of the truth. For Ásta, gender is a social property and examples of its related base properties include roles in biological reproduction and in societal organizations of various kinds, sexual engagement, bodily presentation, preparation of goods at family gatherings, and self-identification.

3.2. J. McKitrick's Dispositional Account of Gender

We gave a concise overview of philosophy of gender by presenting Haslanger's [13] and Ásta's [14] theories. It may be admitted that these two accounts are more or less useful for some goals, as Haslanger's project intends to fight for social justice. It is nonetheless questionable whether they provide a suitable theoretical basis for gender representation in clinical practice. To see this, let us take McKitrick's [5] example of gender dysphoria. According to a guideline [15] for standards of care for transgender people, gender dysphoria refers to discomfort or distress that is caused by a discrepancy between a person's gender identity and that person's sex at birth. Imagine that Sam has a biologically male body, plays a masculine social role (e.g. of dressing masculinity-demonstrating clothes in her society), and is long thought to be a man in her society. However, she suffers in silence from this situation and identifies herself inwardly as a woman. It is doubtful whether Sam's inner gender can be accounted for within the scope of Haslanger's and Ásta's very socially oriented accounts of gender.

From a medical point of view, the kind of gender formalization that we are seeking should be helpful in providing psychological and clinical care of the person Sam with gender dysphoria, so that she will overcome a variety of difficulties that are associated with her gender identity and expression. Haslanger's and Ásta's definitions of gender may be unfit for this purpose, however, because these definitions conceptualize gender purely in terms of how an individual is observed by others in a certain context and they are lacking in consideration of subjective and psychological aspects of gender. More generally, they may fail to explain the distinctive inward aspect of gender. On Haslanger's account, for instance, we would have no man/woman distinction in a completely gender-equal society.

Accordingly, we will need a more descriptive and less value-laden theory of gender that can be utilized for gender representation in medical data records. Let us now introduce McKitrick's [5] dispositional account of gender because it can be used to satisfy a need for gender representation in the

clinical field. First of all, she argues in favor of the (albeit rough) distinction between a *gender role* and *gender (identity)*, thereby saying that Haslanger's and Ásta's approaches are about gender roles, but not about gender. In our understanding, the difference between gender roles and gender can be illustrated with Sam's masculine social role and her inner feminine gender, respectively. It nonetheless requires close scrutiny how gender is to be distinguished from gender roles in ontologies. We will briefly address this issue in Section 0 by discussing the term "gender role" that is defined in the OBO- and BFO-based Ontology of Medically Related Social Entities (OMRSE) [16].

McKitrick investigates gender, while taking a cue from Butler's [17] "performative account" of gender. For Butler, gender is a matter of a pattern of behaviors in a certain context: for instance, a person's patterns of dress, posture, and speech are not *expressions* of the person's gender, but are instead *constitutive* of being gendered. On the one hand, Butler's theory implies (as with Haslanger's and Ásta's) that gender is socially relative to some extent because it depends partially on social convention whether a pattern of behaviors qualify as masculine or feminine. On the other hand, it explicitly intends to ensure (*pace* Haslanger and Ásta) the possibility that the behaviors that constitutes one's gender can construct one's identity at the same time.

McKitrick's dispositional account of gender can be seen as a further development of Butler's performative one, as McKitrick has some concerns as to Butler's account. For instance, a person does not cease to be gendered even when the person is not behaving in a gender-specific way or is not behaving at all. Furthermore, one could be a woman (resp. a man) while exhibiting patterns of masculine (resp. feminine) behavior for a prolonged period of time, as is illustrated by the transgender person Sam. Taking these possibilities into consideration, she suggests that gender should be a *disposition* to behave in a certain way in a certain context, rather than actually behaving currently in such a way.

To explain dispositions in more detail, she offers "five marks of dispositionality", namely jointly sufficient (but not individually necessary) conditions for dispositionality. That is to say, a property (particular) is a disposition if it:

1. has some characteristic manifestation M [type-level entity];
2. is such that some circumstance C [type-level entity] will trigger manifestation M;
3. can be possessed without manifestation M occurring;
4. is instantiated by things of which a conditional of the form "if it were subject to circumstance C, it would exhibit manifestation M" is generally true; and
5. can be accurately characterized with an expression of the form "the disposition to produce manifestation M in circumstance C". ([18], p. 2)

To take a canonical example, fragility is a disposition because (1) it has a characteristic manifestation of breaking, (2) it will be triggered when its bearer is pressed with force, (3) it can be possessed without the occurrence of breaking, (4) it is borne, for example, by this glass such that "If the fragility is subject to the circumstance in which the glass is pressed with force, then it would exhibit the manifestation of the breaking of the glass" is generally true, and (5) it can be accurately characterized with an expression of the form "the disposition to break when pressed with force".

Based on this understanding of dispositions, she roughly presents her dispositional theory of gender as follows:

[A person] x is gender G [e.g. "feminine", "masculine"] iff:
    x has (sufficiently many, sufficiently strong) [particular] dispositions $D_1 \ldots D_n$ to behave in ways $B_1 \ldots B_n$ [which are particular behaviors] in [particular] situations $S_1 \ldots S_n$, and
    the relevant social group considers behaving in ways $B_1 \ldots B_n$ in situations $S_1 \ldots S_n$ to be G.
([5], p. 2581)

Note that this formulation may at best elucidate the notion of gender instead of defining it explicitly because the term "be gender G" figures in the left and right hands of the formulation. To illustrate this dispositional approach to gender with our driving example, Sam is feminine in virtue of the fact that she has many dispositions that can be realized in her behaviors that are considered feminine by a social group to which she belongs and that are all together strong enough to construct her identity. Examples of such dispositions include Sam's disposition to be manifested in her behavior of wearing a pink silk

dress which her social group takes to be feminine. We will delve into these dispositions to be manifested in gendered behaviors in Section 0.

Quite importantly, this claim implies that dispositions that constitute gender would be extrinsic. It is a prevailing orthodoxy that dispositions are intrinsic. The distinction between intrinsic and extrinsic properties is notoriously difficult to define explicitly, but the basic idea is that a property (instance) is *intrinsic* if it (exists and) inheres in its bearer purely in virtue of the way the bearer is and it is *extrinsic* otherwise, *scilicet* if it (exists and) inheres in its bearer (at least partly) in virtue of the way the world that is external to the bearer is [19]. The fragility of this glass is intrinsic because the glass is fragile under any external circumstances (even when packed in a bubble wrap), for instance. In contrast, an individual's gender is a cluster of behavioral dispositions the nature of whose manifestations (i.e. the bearer's behaviors) is (partly) determined by other members of a social group to which the individual belongs (see Section 0 for more details).

Finally, McKitrick's dispositional view of gender will have some interesting and perhaps also controversial consequences. First of all, it implies that one can have multiple genders (e.g. if one has both dispositions to act in ways deemed as masculine by a certain social group and dispositions to act in ways deemed as feminine by the same social group) and one can have different genders in different contexts (e.g. if one has dispositions to act in ways that are deemed masculine by a social group and feminine by another social group). In addition, a social group can be wrong about a person's gender if its members do not know enough about the person's behavioral dispositions: for example, when the social group makes false assumptions about them based on the person's physical appearances. Therefore, her approach to gender can recognize there being a discrepancy (as exemplified by Sam) between the appearance and the reality of gender.

Moreover, this dispositional account of gender does not exclude the possibility that a person can be wrong about his or her own gender. Interestingly enough, McKitrick says that this possibility is implicitly acknowledged by the aforesaid guideline [15] for standards of care for transgender people. The guideline says that one of the minimum criteria for adolescents with gender dysphoria to receive puberty-suppressing hormones is: "The adolescent has demonstrated a long-lasting and intense pattern of gender nonconformity or gender dysphoria (whether suppressed or expressed)" (ibid., p. 19). McKitrick explains: "The expressed purpose of this measure is to ensure that the individual is correct about their own gender identity before making any irreversible changes to their body" ([5], p. 2582). For according to the guideline: "Health professionals can assist gender dysphoric individuals with *affirming their gender identity* (…) and making decisions about medical treatment options for alleviating gender dysphoria" ([15], p. 9, emphasis added). Table 1 provides a brief comparison between Haslanger's [13] feminist and McKitrick's [5] dispositional approaches to gender.

Table 1
Comparison between Haslanger's [13] and McKitrick's [5] theories of gender

Theory of gender	Haslanger's feminist theory	McKitrick's dispositional theory
Basic idea	Gender is a category of people who are given a social position (e.g. women in subordinate positions)	Having a gender is a matter of having extrinsic dispositions to behave in gendered-considered ways
Characteristics	- Developed with the polico-social aim of fighting for social justice - Focuses primarily on the social import of gender	- Developed taking into account the subjective aspects of gender - Focuses on "gender identity" rather than "gender roles"

4. Representing Gender in Ontologies
4.1. Gender as a Behavioral and "Extrinsic" Disposition

We looked through some contemporary philosophical theories of gender (namely, Haslanger's [13] and Ásta's [14]) and put forward the idea that McKitrick's [5] dispositional account of gender can be

effectively utilized for representing gender in information systems because it has the potential to contribute to appropriate medical care of transgender people, such as our imaginary person Sam with gender dysphoria. We will now consider a way of formalizing this dispositional approach to gender in accordance with the OBO and BFO ontologies. First and foremost, gender *per se* (as well as sex) has been scarcely meticulously analyzed in these frameworks. For instance, the Gender, Sex, and Sexual Orientation (GSSO) ontology [20] is an OBO-compliant ontology designed to collect and organize a large number of existing terms that pertains to gender, sex, and sexual orientation. As Fabry et al. [2] point out, however, the GSSO ontology is only partially aligned with BFO's foundational basis.

To explore an ontological representation of gender, we begin by explaining the basic structure of BFO. BFO has the top-level distinction between continuants and occurrents, the former being further divided into independent continuants and dependent continuants. Among dependent continuants are specifically dependent continuants, which depend (existentially) on at least one independent continuant. As for occurrents, we will focus on one of its subcategories, namely processes: occurrents that exist in time by occurring, have temporal parts, and depend on at least one independent continuant as participant. Two major subtypes of specifically dependent continuants are realizable entities (which will be detailed below) and qualities: specifically dependent continuants (e.g. color, shape, and mass) that do not require any further process in order to be realized.

A realizable entity is a specifically dependent continuant that inheres in some independent continuant and is of a type some instances of which are realized in processes of a correlated type. BFO identifies two direct subtypes of realizable entities, namely dispositions and roles. First of all, a role in BFO is: "a realizable entity that (1) exists because the bearer is in some special physical, social, or institutional set of circumstances in which the bearer does not have to be (optionality), and (2) is not such that, if this realizable entity ceases to exist, then the physical make-up of the bearer is thereby changed (external grounding)" ([10], pp. 99-100). Therefore, a role is an optional and externally grounded realizable entity. Suppose for instance that Mary is a student at the XYZ college. Mary has the role of being a student (which may be realized e.g. in a process of Mary's studying), for she happens to be in the XYZ college (optionality) and she does not undergo physical changes just because she ceases to be a student (externally grounded).

By contrast, a disposition in BFO is: "A realizable entity (…) that exists because of certain features of the physical makeup [material basis] of the independent continuant that is its bearer" ([10], p. 178). BFO also describes a disposition as an internally grounded realizable entity: if a disposition ceases to exist, then the physical make-up of the bearer is thereby changed. To use a classical example, the fragility of this glass can be realized in a process (realization) of breaking when it is pressed with force, it is based on some structured molecules (material basis) of the glass, and the glass is physically changed when it is no longer fragile (internally grounded).

One *prima facile* plausible way to formalize gender in McKitrick's fashion would be to classify it as a subtype of BFO:disposition, since she endorses its dispositional interpretation. According to Toyoshima et al. [21], however, this straightforward construal may be questionable because McKitrick's conception of dispositions would be wider than their BFO category. On McKitrick's account, gender is a cluster of what she calls "extrinsic dispositions" and she justifies this non-orthodox kind of dispositions on the grounds that they mesh with her five marks of dispositionality. However, BFO says that dispositions are internally grounded realizable entities (in the sense above explained). This stands in marked contrast with McKitrick's extrinsic dispositions because they are borne (at least partly) in connection with the world that is external to its bearer and they can cease to exist when the external world changes, even without the bearer's physical changes. In this sense, extrinsic dispositions can be taken to form a subtype of *externally grounded* realizable entities (just as roles are) in BFO.

To be concrete, consider the following two entities that both qualify as dispositions in McKitrick's flexible sense of the term:

- Sam's disposition d_S^1 to be realized in her behavior of wearing a pink silk dress;
- Sam's disposition d_S^2 to be realized in her behavior of wearing a pink silk dress which is considered to be feminine in Sam's social group.

On the one hand, d_S^1 is intrinsic and it is a disposition in BFO because Sam can wear a pink silk dress independently of circumstances surrounding her. Note that the term "a pink silk dress" refers to *any*

instance of the type *Pink silk dress* (rather than *this particular* pink silk dress) and $\mathbf{d_S}^1$ does not depend on a particular pink silk dress that would be external to Sam (if this were the case, $\mathbf{d_S}^1$ would be extrinsic).

On the other hand, $\mathbf{d_S}^2$ would be arguably better characterized as extrinsic. Consider first visibility, as it is a paradigmatic example of extrinsic dispositions [18]. Something is visible if it is disposed to be seen and the same thing might be visible to some perceivers, but not to others, e.g. when it emits wavelengths of light that can be perceived by certain kinds of creatures. This line of thought could justify the claim that visibility (which is the disposition to be seen) is extrinsic on the grounds that whether something is visible or not depends on who or what is looking at it. Certainly, this argument may not be very strong because the term "visible" would be polysemous. As McKitrick [18] further argues, however, its common usage (e.g. "The Eiffel tower will not be visible today") corresponds to the following rough counterfactual: "If a normal human perceiver looked towards something under *current* conditions, the perceiver would see it." Since the term "current" is indexical, the truth of this counterfactual is context-relative and visibility can be plausibly taken to be an extrinsic disposition (recall the fourth mark of dispositionality in Section 0).

These considerations in favor of the extrinsic view of visibility would serve to understand the present thesis that $\mathbf{d_S}^1$ is intrinsic but $\mathbf{d_S}^2$ is extrinsic. To be sure, $\mathbf{d_S}^1$ and $\mathbf{d_S}^2$ are both behavioral dispositions (namely, dispositions to be realized in behaviors of the bearer) and they are linked in the sense that every realization of $\mathbf{d_S}^2$ is a realization of $\mathbf{d_S}^1$, but not *vice versa*. However, $\mathbf{d_S}^2$ can be realized in Sam's *feminine* behavior of wearing a pink silk dress and it is generally acknowledged that what counts as feminine, or as gendered for that matter, is at least partially socially determined. Just as being seen is relative to perceivers, so a person's gendered behaviors are relative to the social convention of a community a member of which the person is. Thus, just as visibility (which is the disposition to be seen) is extrinsic, so are dispositions (e.g. $\mathbf{d_S}^2$) to behave in ways that are regarded as gendered.

McKitrick [18] makes a further point to strengthen the argument that dispositions to behave in gendered ways (which we will call "gendered behavioral dispositions" for simplicity) are extrinsic. First, the fact that certain behaviors count as gendered can causally impact the way people are disposed to engage in them. For example, some people in Sam's social group may avoid wearing a pink silk dress because they do not want to be considered feminine. This could imply that gendered behavioral dispositions are *bona fide* dispositions. For dispositions in McKitrick's broad sense of the term and realizable entities in BFO largely overlap each other and they are both generally characterized by their causal relevance to their realizations (see Toyoshima et al.'s [21] detailed discussion), gendered behaviors have the sort of causal import that does emanate from being considered gendered, and the causal import of gendered behavioral dispositions is determined in connection with that of gendered behaviors. We will henceforth employ the term "gendered behavioral disposition" to refer to a subtype of extrinsic dispositions.

At the same time, it will be important to articulate the relationship between gendered behavioral dispositions (e.g. $\mathbf{d_S}^2$) which are extrinsic and ordinary behavioral dispositions (e.g. $\mathbf{d_S}^1$) which are intrinsic. We will call the latter dispositions "intrinsic behavioral dispositions". Following Williams [22], we can think that an extrinsic disposition of something *relies* (existentially) *on* [21] some intrinsic disposition ("intrinsic dependee") of the bearer in the sense that without the latter, the former would cease to exist. To illustrate this, $\mathbf{d_S}^1$ is an intrinsic dependee of $\mathbf{d_S}^2$ and this entails that every realization of $\mathbf{d_S}^2$ is a realization of $\mathbf{d_S}^1$, but not *vice versa*. Generally speaking, every gendered behavioral disposition has as intrinsic dependee some intrinsic behavioral disposition.

To recapitulate, we propose the following textual definition of gender in alignment with McKitrick's [5] formulation of gender (see Section 0) and the OBO principle about definition creation:

> gender $=_{\text{def.}}$ An extrinsic disposition (i) to be realized in behaviors of the bearer that are considered gendered by a social group to which the bearer belongs and (ii) that is strong enough to construct the bearer's identity.

It should be underlined that, when located within the BFO framework, extrinsic dispositions (including gendered behavioral ones) would belong to a subtype of realizable entities that is disjoint from the BFO category of disposition (see Section 0 for a brief discussion on the subtle relationship between extrinsic dispositions and roles in BFO, especially between gendered behavioral dispositions and gender roles in the OMRSE).

One may suspect that this definition of gender is uninformative, for it seems to be circular because its definiens includes the term "gendered". First of all, even if circular definitions tend to be regarded as vicious, some of them can be appropriately benign. To take a canonical example, upper-level entity terms (e.g. "continuant" and "occurrent" in BFO) are hardly definable without circularity and they can be at best *elucidated* together with the examples to illustrate the entities to which they can apply (cf. [10], p. 89). This line of reasoning can also go for the definitions of some domain-specific entity terms such as "occurrent belief" [23][24] (a mental process of "taking something to be the case", which might be synonymous with "believing") and presumably "gender" because the significant socio-historical element of gender might possibly justify accounting for being gendered by being considered gendered.

In addition, it may be socio-ethically concerning to over-specify "gendered" in the definiens so as to avoid circularity. For instance, it may render the definition more informative to replace "gendered" by another term "masculine or feminine". As we said in Section 0, however, this binary categorization of gender is nowadays subject to criticism, as is witnessed by contemporary (e.g. feminism-inspired) social and political movements. Moreover, an "accurate" understanding of gender may change dramatically in the future. All these points being considered, we would have good reason to preserve the term "gendered" in the definition of "gender" that should ideally remain long unaltered in ontologies.

4.2. Formal Representation

We will provide a formal representation of gender in ontologies, especially the one in the Web Ontology Language (OWL) based on the Manchester Syntax [25]. To forestall confusion, we will write terms for instances and relations in bold and terms for classes in italic, respectively. Figure 1 provides an *is-a* hierarchy of important classes which are not necessarily mutually exclusive, including the ones extracted from existing ontologies such as BFO and the OMRSE (where a class *A* being a subclass of a class *B* implies all instances of *A* being instances of *B*). Table 2 lists predicates that represent binary relations with their informal explanation:

BFO:*Independent continuant*
    BFO:*Object*
        NCIBTaxon:*Homo sapiens* (http://purl.obolibrary.org/obo/NCBITaxon_9606)
           Gender bearer
    BFO:*Object aggregate*
        Social group[2]
BFO:*Specifically dependent continuant*
    BFO:*Realizable entity*
        BFO:*Disposition*
           Intrinsic disposition
               Intrinsic behavioral disposition
        BFO:*Role*
           OMRSE:*Gender role*
        Extrinsic disposition
           Gender
           Gendered behavioral disposition
BFO:*Process*
    GO:*Behavior* (http://purl.obolibrary.org/obo/GO_0007610)
        Gendered-considered behavior

Figure 1: An *is-a* hierarchy of relevant classes

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[2] The NCI Thesaurus OBO Edition (NCIT) has the class *Social group*, but it does not adhere strictly to the BFO framework and it is defined very narrowly as: "Individuals with whom time is shared outside of employment activities" (http://purl.obolibrary.org/obo/NCIT_C18230). By the class *Social group*, we instead mean a subclass of the BFO class *Object aggregate* and leave its rigorous characterization (e.g. group agency [26]) for future work.

Table 2

Predicates for binary relations and their informal explanation

Relational predicate	Informal explanation
bearer_of (x,y) [10]	x (independent continuant) is a bearer of y (specifically dependent continuant)
has_mod-part (x,y) [27]	x (realizable entity) has as mod-part y (realizable entity)
member-part_of (x,y) [10]	x (object) is a member part of y (object aggregate)
realized_in (x,y) [28][29]	x (realizable entity) can be realized in y (process)
relies_on (x,y) [21]	x (extrinsic disposition) relies existentially on y (intrinsic disposition)

(Note: The references therein mean prior work from which relations are imported, although the **has_mod-part** and **realized_in** relations are reinterpreted in our context.)

We begin by considering gendered behavioral dispositions because gender is roughly an aggregate of them, on our McKitrick-style view. We can define a gendered behavioral disposition as follows:

> gendered behavioral disposition =$_{def.}$ An extrinsic disposition to be realized in behaviors of the bearer that are considered gendered by a social group to which the bearer belongs.

This definition can be formalized by introducing the class *Gendered considered behavior*:

> *Gendered behavioral disposition* subClassOf [*Extrinsic disposition* and (**realized_in** only *Gendered-considered behavior*)][3]

Furthermore, we argued that every gendered behavioral disposition has as intrinsic dependee some intrinsic behavioral disposition. We first give the following textual and logical definitions of an intrinsic behavioral disposition:

> intrinsic behavioral disposition =$_{def.}$ An intrinsic disposition to be realized in behaviors of the bearer.

> *Intrinsic behavioral disposition* subClassOf [*Intrinsic disposition* and (**realized_in** only *Behavior*)]

Then, gendered behavioral dispositions can be linked with intrinsic behavioral dispositions through the **relies_on** relation [21] as follows (e.g. d_S^2 **relies_on** d_S^1):

> *Gendered behavioral disposition* subClassOf (**relies_on** some *Intrinsic Behavioral Disposition*)

Let us move onto gender. For example, Sam's gender (say g_S) is an aggregate of many gendered behavioral dispositions (e.g. d_S^2) that construct together her feminine identity. We can specify the relationship between g_S and d_S^2 in such a way that g_S **has_mod-part** d_S^2. This claim can be supported by the observation that g_S and d_S^2 satisfy the three axioms characterizing mod-parthood [27]:

- The bearer (i.e. Sam) of g_S is an improper part of the bearer (i.e. Sam) of d_S^2.
- g_S is realized if and only if at least one of its mod-parts (e.g. d_S^2) is realized in this process.
- g_S is triggered if and only if at least one of its mod-parts (e.g. d_S^2) is triggered by this process.

We can generalize the finding that "g_S **has_mod-part** d_S^2" to the following axiom about gender:

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[3] In this paper we utilize Röhl & Jansen's [28] account of the identity of dispositions, partly because it has the practical virtue of being representable in the OWL, where the universal restriction ("only") on classes is available. See, however, Barton et al.'s [29] criticism that this "ONLY theory" of dispositions would encounter the theoretical problem of "disposition multiplicativism" (by which they mean the arbitrary proliferation of dispositions) and their alternative "PARTHOOD framework" for dispositions, which can avoid disposition multiplicativism.

> *Gender* subClassOf [*Extrinsic disposition* and (**has_mod-part** some *Gendered behavioral disposition*)]

Note that, while being subclasses of BFO:*Realizable entity*, both classes *Gendered behavioral disposition* and *Gender* are disjoint from BFO:*Disposition*.

Finally, we propose the class *Gender bearer* because it is useful for biomedical ontologies. For example, data about patients' gender can be managed in ontologies by creating this class. On our account, a gender bearer would be a human being that bears a gender and also a member part of a social group. These claims can be formally represented as follows:

> *Gender bearer* subClassOf [*Homo sapiens* and (**bearer_of** some *Gender*)]
> *Gender bearer* subClassOf (**member-part_of** some *Social group*)

5. Discussion
5.1. Gender Identity and Gender Roles

The Ontology of Medically Related Social Entities (OMRSE) [16] defines the term "gender role" as follows:

> gender role $=_{\text{def.}}$ A human social role borne by a human being realized in behaviour which is considered socially appropriate for individuals of a specific sex in the context of a specific culture. (http://purl.obolibrary.org/obo/OMRSE_00000007)

To illustrate this with our motivating example, Sam has a male sex and her gender role can be realized in a process of Sam going around in clothes that are considered as manly in her social group.

As we said in Section 0, McKitrick's [5] dispositional account of gender is motivated by her rough distinction between gender (identity) and gender roles. However, it may not be straightforward to distinguish sharply between gender in our proposal and gender roles in the OMRSE. Given the hypothesis that some roles in BFO can be seen as extrinsic dispositions [21], for example, it would be possible to think that (just as with gender) some gender roles are extrinsic dispositions that have as mod-part some gendered behavioral disposition(s), insofar as being "considered gendered" can involve being "considered socially appropriate for individuals of a specific sex" (despite potentially problematic socio-ethical implications of this assumption). This means that there is room for improvement of our characterization of gender, in particular regarding how to formalize the (ii) part of our definition of gender (see Section 0). It would nevertheless also imply that our idea of gendered behavioral dispositions may contribute to further clarification of the OMRSE notion of gender roles.

5.2. Linking Gender with Gender Information Entities

We have so far focused on the very notion of gender. To optimally use the information in the medical records to support healthcare delivery, however, it is equally important to offer an ontological representation of informational entities that refer to sex and gender, such as the piece of information that is involved in the value "Man" filled in the field "gender" of a clinical document [2].

For instance, the OMRSE possesses the class *Gender identity information content entity* with the definition: "A social identity information content entity that is about whether some person identifies as some gender" (http://purl.obolibrary.org/obo/OMRSE_00000209). At present, the OMRSE does not assert a specific axiom about this class. It is a subclass of the class *Information content entity* of the OBO-compliant Information Artifact Ontology (IAO) [30] and this IAO class is in turn a subclass of the BFO class *Generically dependent continuant*. Quite importantly, information content entities are defined as bearing the IAO:**is_about** relation towards a portion of reality, although the notion of aboutness will warrant further clarification (see, for thoughts, Biccheri et al.'s [31] analysis of aboutness and Sanfilippo's [32] discussion on a general ontology of information entities).

Since we propose the textual and logical definitions of the class *Gender*, the following axiom can be provided with regard to the aforementioned OMRSE class:

Gender identity information content entity subClassOf (**is_about** some *Gender*)

Note that we are interpretating the OMRSE term "gender identity" rigorously, but existing healthcare information systems may not distinguish sharply gender identity from gender roles and this could motivate the pragmatic creation of the class, say, *Gender identity or gender role information content entity* to deal with informational entities concerning gender identity and/or gender roles. Relatedly, it is interesting to remark that, taking into account the fact that many medical records do not distinguish between sex and gender, Fabry et al. [2] propose the class *Biological sex or gender identity information content entity* as a catch-all label that encompasses sex/gender-related information entities, and this class will be further clarified by our axiom because it is partially defined in terms of the OMRSE class *Gender identity information content entity*.

Moreover, our schema for representing gender can be extended to other social identities. McKitrick [5] considers an objection to her dispositional account of gender: it fails to explicate well what is special about gendered behaviors. She responds that this apparently problematic feature is an acceptable outcome partly because it arises in many other theories of gender, including Ásta's [14] and Butler's [17]. On the contrary, this discussion would indicate the interesting possibility that we may be able to analyze other social identity entities than gender in the same fashion. In the OMRSE, the parent class of the class *Gender identity information content entity* is *Social identity information content entity* (http://purl.obolibrary.org/obo/OMRSE_00000204) and it has other subclasses such as *Ethnic identity information content entity*, *Racial identity information content entity,* and *Sexual orientation identity information content entity*. It will be a noteworthy line of inquiry to explore ethnic, racial and sexual orientation identities in a McKitrick-style dispositional way and to enrich a representation of related information content entities as found in the OMRSE.

6. Conclusion

Sex and gender are prominent determinants of health and their accurate representation in medical records is vital to appropriate clinical decisions. In this paper, we adopted a methodology to provide a BFO/OBO-based analysis of gender and proposed the McKitrick[5]-style view that gender is a behavioral and extrinsic disposition, as distinct from the BFO category of disposition. We also brief discussed the term "gender role" in the OMRSE and gender-related informational entities.

In the future we plan to further our ontological representation of gender. To take one example, its elaboration will demand a systematic study of realizable entities in BFO [21], so that our notion of gender and the OMRSE class *Gender role* can be well demarcated. This task can comprise, for instance, the reconceptualization of the BFO categories of disposition and role *vis-à-vis* extrinsic dispositions. Careful consideration will be also required of what we exactly mean by the term "gendered" and various possible socio-ethical ramifications of the sex/gender-based classification of people. For pointers to this work, we allude to a direction of study (as touched upon by McKitrick [5]) to combine a dispositional account of gender with some elements of Haslanger[13]-style feminist theories and an endeavor to locate our proposal in a broader framework of social ontology [33]. [4]

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