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Restović, Ivan

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Ivan Restović
Institute of Philosophy, Zagreb, irestovic@ifzg.hr

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Another Take on the Opposition between Gender Categories

Ivan Restović, Institute of Philosophy, Zagreb

Abstract: The gender spectrum, a continuum ranging from "male" to "female," is a huge improvement over the traditional binary model, according to which one can be either one or the other, and no degrees are allowed. However, the model still suffers from some inadequacies, most notably the inability to represent other genders and agender identities. This is accounted for in the new "spectral" models of gender, which use independent scales to measure the degree to which a person identifies with a given gender category. However, by conceiving the amounts of gender dimensions to be mutually independent, these models invite other difficulties, most notably the inability to account for agender identities in a straightforward fashion. In this paper, I argue that a way to solve the problems with the new models (and not to have the old problems re-appear) is to take a step back, of sorts, towards the initial gender spectrum. I explore from a perspective of philosophical logic the types of relations among gender categories in the spectral models of gender and argue that the initial spectrum construes gender categories to be in the logical opposition of "fuzzy contradiction," while the models with more than one spectrum do not construe gender categories to be in any kind of logical opposition. I propose a weaker opposition (namely, "fuzzy contrariety") between gender categories, as well as the "fuzzy gender hexagon"—an application of a particular abstract logical diagram to gender terms—as a model of gender identity.

Keywords: gender identity, gender spectrum, fuzzy logic, logical hexagon, feminist logic

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1. Introduction

It is probably not an overstatement to say that the idea of the gender spectrum, a continuum ranging from "male" to "female," is quite widespread. This is not to say, unfortunately, that it is also a widely *accepted* idea. But, at least in my experience, the gender spectrum is almost always entertained (if not outright suggested) when considering the limitations of the traditional, binary model. Traditionally (at least in the West), one can either be a man or a woman, and never both. The radical reform the spectrum brings can perhaps be summed up in a single word—*degrees*. "Male" and "female," traditionally, are all-or-nothing, on-or-off, discrete (as opposed to continuous) notions. But as the gender spectrum suggests, it also makes sense to use grades when it comes to expressing gender identity, not unlike in everyday situations in which we discuss a person's height or spiciness of food. Gender, too, is a matter of degree. The gender spectrum—or the *standard gender spectrum*, as I will call it in this paper—is shown in Figure 1. The figure also shows an example of an identification on the spectrum, i.e., an example of a gender identity.

Figure 1: **Standard gender spectrum** with an example of a gender identity

The standard gender spectrum, however, is not the only *spectral* model of gender out there. In this paper, I also consider two—as I call them—*multispectral* models. One is a model similar to that proposed by Magliozzi, Saperstein, and Westbrook (2016), which offers two *independent* continua for femininity and masculinity, while the other is the model by Ho and Mussap (2019), which adds a third (also independent) spectrum labeled “other gender(s).” These models, as I will show, solve almost all difficulties faced by their “monospectral” predecessor, the trispectral model arguably even better than the bispectral one. This being the case, it cannot be denied that the route from the standard gender spectrum to the trispectral model of gender leads towards more inclusion and a better (graphical) representation of the existing diversity of gender identities.

However, as I want to argue, we may want to take a step back. This is because oppositionality—a fairly important feature—was discarded along the way. The new multispectral models are purposefully constructed in such a way as to *not* construe gender categories (like “male” and “female”) to be in opposition *of any kind*. In this paper, I consider different kinds of opposition from a perspective (and in terms) of philosophical logic in order to explore if it is indeed the case that *none* of the available logical oppositions will do when it comes to modeling gender (identity). I argue that there *is* an acceptable logical opposition in this regard, namely “fuzzy contrariety.” This opposition can be found in “fuzzy (or graded) structures of opposition” (Dubois and Prade 2015), a family of abstract diagrams used to represent the logical relations between concepts and/or propositions from various domains. These diagrams, I claim, may as well serve as models of gender identity, when they are applied to predicates referring to gender categories.

It is not my intention in this paper to try to “save” the opposition between genders—in any of its forms—only for that opposition’s sake. What I want instead is to try to show that models in which gender categories are pictured as being in opposition of fuzzy contrariety have considerable advantages; not just over the older, standard gender spectrum, but also over the bispectral and the trispectral model. I believe there are two salient advantages of the proposed approach over the multispectral models. Firstly, fuzzy structures of opposition are able to express agender identities *as explicitly as all other genders*, which the trispectral and the bispectral model fail to do (and cannot be “fixed” in a straightforward way to account for these identities). In this way, the multispectral models graphically misrepresent agender identities. Secondly, the participants’ identifications on multispectral models, I will claim, can have multiple, mutually inconsistent readings. In these models, we often cannot know for certain which gender identity a person wanted to report. If we use fuzzy structures of opposition to model gender identity, the ambiguity is gone. So perhaps instead of discarding the opposition between gender categories, we could reconsider it in another guise.

Here is a brief overview of the paper. In the following section, I discuss Tauchert’s (2002) “fuzzy gender” model, a reinterpretation of the standard gender spectrum. I analyze, from the perspective of philosophical logic, the relation between gender categories in the given model, and discuss the pros and cons of the approach. In Section 3, the same is done for the bispectral (Magliozzi, Saperstein, and Westbrook 2016) and the trispectral (Ho and Mussap 2019) models of gender. In Section 4, I introduce structures of opposition understood by means of classical logic. One such structure, the logical hexagon, is analyzed and applied to the concepts “atheist,” “theist,” and “agnostic.” It is shown how the hexagon contains (and makes visible) all the logical relations between the three concepts, as well as their negations.

In Section 5, I talk about *fuzzy* structures of opposition. The fuzzy logical hexagon is applied to gender categories, this is proposed as a model of gender identity, and the advantages and disadvantages of the "fuzzy gender hexagon" are discussed.

A note about the style of presentation. This paper does not presuppose any previous knowledge in logic, at least to the best of its author's abilities. The logical preliminaries are introduced gradually, most often via separate subsections (and mostly in the following section).

2. Tauchert's "fuzzy gender" model

Tauchert is among the proponents of the standard gender spectrum, shown in Figure 1 (see also Monro 2005, Bittner and Goodyear-Grant 2017). In her 2002 paper, she suggests there be a "gender line" between the notions "male" and "female." Although she is not the first to propose this (see Rothblatt 1995, Feinberg 1996 and Nataf 1996, cited in Monro 2005), there is something unique in her approach. What sets her apart is her framing of the reform that gender categories should undergo. For Tauchert, the change from the traditional, binary model of gender to the spectrum is a change in the underlying *logic* of gender, namely, a change from *classical* to *fuzzy* logic. She thus opens the door to an analysis and critique of gender categories by means of the tools and terms of (formal) logic as a discipline. In this paper, I adopt a similar approach. But before properly introducing Tauchert's, as she named it, "fuzzy gender" model, let me say a few words about logic as a discipline, as well as about the distinction between classical and fuzzy logic.

2.1. Logic, Classical Logic, and Fuzzy Logic

People can mean (at least) two things when they say "logic." Firstly, they can mean the *scientific discipline*. Logic as a discipline studies valid reasoning, or what follows from what. Contemporary logic—as opposed to, say, its medieval counterpart—uses a substantial amount of formal mathematical tools and jargon. However, "mathematicality" is not a prerequisite – one can do logic in a (fairly) natural language. Moreover, logic as a discipline can be seen as a subfield of (analytic) philosophy, but also as that of mathematics or artificial intelligence. Some, like myself, like to distinguish "philosophical" from "mathematical" logic. This is not to say that these are two different kinds of (sub)disciplines. If anything, it points merely to differences in the canonical literature and terminology. Some also distinguish formal from informal logic. But this distinction is beside the point.

On the other hand, "logic" can also mean "*a* logic." There is not only one way to make valid inferences and arguments—some logical systems are *incompatible* with others. This is not to say that all logics are treated equally. Even though many things can be called *logic*, there is still a "regular," default or go-to way of doing logic—classical logic. If you ever took introductory logic courses at school, university, or elsewhere, you were almost certainly taught *classical* logic. And, chances are, you were taught *only* classical logic. In addition to this, however, chances are (excuse me for a possible overgeneralization) that you were not told you were merely learning about valid reasoning and valid arguments in *a* logic, and that a lot of "unquestionable" logical vocabulary and grammar, as well as logical truths and/or axioms, can be put into question. One such "unquestionable" feature of classical logic, relevant for the present purpose, is the dichotomy of truth vs. falsity. Classical logic teaches us how to arrive at true conclusions given true premises. An admirable task, but under the hood, sentences (or "propositions") can only take two "truth values"—*true* and *false*. No sentence is both true and false and every sentence is either of the two.

Now, this may work fine in some contexts—like perhaps that of mathematics, where everything is (supposed to be) well-defined and spelled out (cf. Smith 2008). Consider a triangle. Arguably, a triangle is well-defined and the notion has clearly established boundaries: we know exactly what it means to be a triangle. So, quite uncontroversially, we can claim that every object either is or is not a triangle. Or, to put it in logical parlance, every sentence saying that something is a triangle is either true or false. It is false to say that a pyramid is a triangle, and it is also false to say that a horse is a triangle. So far so good. However, in some situations, the boundaries of a notion are not so well-established and there are cases that are not so clear-cut. Sometimes, the binary semantics[1] of classical logic is simply not nuanced enough to express what we want to talk about. Gender categories are a case in point. If it is true that terms like "woman" and "man" can come in degrees, classical logic is too crude a tool to represent this fact. Degrees will be lost in translation since there are only two values to operate with.

This is where fuzzy logic comes in. According to fuzzy logic, truth is a matter of degree. More precisely, truth values in fuzzy logic lie on a spectrum. In Tauchert's words:

> The shift from Aristotelian or bivalent/binary logic to 'fuzzy logic' takes place when we recognise that black and white are extreme poles of a continuum that overwhelmingly consists of degrees of grey. (Tauchert 2002, 35)

Instead of "Aristotelian," I here use the term "classical"[2] logic. In classical logic, the values "true" and "false" are often represented as numbers 1 and 0, respectively. In fuzzy logic, any number between 0 and 1 will also do. In mathematical jargon, fuzzy truth values are elements of the interval [0,1], as opposed to, like in the classical picture, being elements of the two-membered set {0,1} (Hájek 2013, Zadeh 1975). Instead of numbers in the interval [0,1], in this paper I use *percentages*. The truth value 0.45, for instance, becomes 45%. In fuzzy logic, it makes sense to say that a proposition is 75.59% true, or, if we do not want to be specific, that a proposition is "partly true." Fuzzy logic is one of the more popular non-classical logics. In philosophy, it is used to account for vague expressions and to tackle the sorites paradox (e.g., Smith 2008). In artificial intelligence, it is proposed as a paradigm to achieve human-level (e.g., Zadeh 2008) or human-understandable (e.g., Hagras 2018) machine intelligence.

I have said earlier that logic (the discipline) is about valid *reasoning*. So, what makes fuzzy logic a logic in the full sense is the way it reasons—i.e., produces valid arguments—using its unique continuum-valued semantics. To do reasoning, a logic needs more than truth values. It also needs logical "operators" and/or "connectives." In this paper, I focus only on the logical connective (or operator) of *negation*. Most logics (classical included) have negation. This is not surprising: we regularly use and reason with negative sentences, and a good logic should be able to account for this. First, a quick look at *classical* negation. In classical logic, if a proposition (call it *p*) is true, its negation (non-*p*) is false, and vice versa. If it is true that I am married, it is false to say I am not; if I am not married, it is false to say I am. This is intuitive and quite unobjectionable, but remember that in classical logic we are always limited only to two truth values. Everything is fine as long as we consider only non-graded, binary notions (like "married"), but not so much when it comes to properties that can come in degrees.

The way that fuzzy logic sees negation, on the other hand, is less straightforward. Say that we have a proposition *p*, which is 40% true. What about the rest, the remaining 60%? In fuzzy logic, the rest is *false*. If *p* is 40% true, it is also 60% false. And if *p* is 60% false, that means that non-*p* is 60% true. In fuzzy logic, the sum of truth values of a proposition and its negation is always 100% (Łukasiewicz 1970, Zadeh 1975). Some find this concerning (e.g., Williamson 1994). This is because one of the underlying principles of *classical* logic—i.e., the go-to and default logic—is the "principle of non-contradiction." This principle states that no proposition is both true and false, often phrased as "For any proposition *p,* it is not the case that *p* and non-*p*." Fuzzy logic dispenses with this principle, in its own way.[3] There, both a proposition and its negation can be true, *simultaneously*. Admittedly, there are no "full contradictions." Since the values add up to a 100%, it cannot be the case that a proposition and its negation are both *fully* (100%) true. However, we still have "contradictions" of sorts because a proposition that is not fully true is also partially false, and we can even have an "undecided" case where the truth vs. falsity ratio is 50:50. In fact, "contradictions" are almost everywhere! Any time we assign a proposition any other truth value aside from the two "extremes" —i.e., 0% or 100%—we are asserting a "contradiction." For every *p*, if *p* is not fully true, non-*p* is also somewhat true. It would seem that, in order to avoid "contradictions," we should refrain from using the in-between values and keep only 0 and 100. But is this not why fuzzy logic was proposed in the first place, to account for degrees, the "shades of grey"?

I do not think there is anything contradictory about fuzzy logic. First of all, we are talking about a *non-classical* logic. Given that classical logic is the hegemonic logic, it is no wonder other logics may (initially) look unusual or contradictory. But secondly, "contradictions" that appear in fuzzy logic are not unusual or absurd at all. Consider an example. In everyday life, it makes sense to say that "Bob is more tall than not." This sentence is saying that Bob is *both* tall and not, but we do not, I believe, perceive this as a contradiction. The sentence is also saying that Bob is on the taller side, being above average. Fuzzy semantics, in my opinion, accounts for this perfectly. Bob is more tall than not. Say he is 60% tall. (Or, more precisely, say that the sentence "Bob is tall" is 60% true.) According to fuzzy logic, Bob is then 40% non-tall. And since 60 is more than 40, Bob is indeed more tall than not. Nothing contradictory about that, just fuzzy. Another phenomenon that can be modeled by fuzzy negation is ball possession in, say, football. If team A has the ball 51% of the time, team B necessarily has it the remaining 49%. The values add up to a 100%.

In Figure 2, I show a representation of fuzzy truth values for a proposition (denoted as "*p*") in fuzzy logic. Here, truth values are points on a spectrum/continuum ranging from 0 to 100%. The spectrum ranges from non-*p* (representing "full falsity") to *p* (representing "full truth"). The closer a point on the line is to the right-hand pole, the larger the "amount of truth" of a proposition.

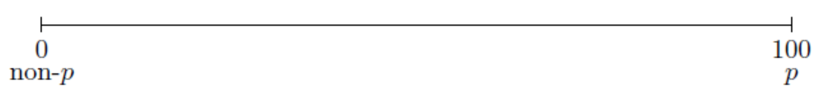

Figure 2: Fuzzy truth values

A final remark, about *double* negation. Non-*p*, of course, is the negation of *p*. But also, *p* is the negation of non-*p*. This is because, in fuzzy logic (as well as in classical logic),[4] double negation cancels itself out. Here is a proof. Take a proposition, call it *q*, and let it be 30% true. According to fuzzy semantics, the remaining 70% of *q* is false, which is to say that non-*q* is 70% true. Now negate non-*q* to get non-non-*q*. Analogously to the above case, if non-*q* is 70% true, the remaining 30% is taken up by the negation of the proposition, so non-non-*q* turns out to be 30% true. Non-non-*q* has the same value as *q*. Nothing happens if you negate a proposition twice (or any even number of times, for that matter). In fuzzy logic, it is of no difference if you say "*p*" or "non-non-*p*" (or non-non-non-non-*p*, etc.). Of course, for brevity's sake, we opt for the former, condensed option. Nevertheless, it follows that, for every proposition *p*, non-*p* is to *p* the same thing as *p* is to non-*p*. The proposition *p* and the proposition non-*p* are *each other's negation*. Negation, in fuzzy and in classical logic, is symmetrical.

2.2. Tauchert's use of fuzzy logic for gender categories

Back to Tauchert's (re)interpretation of the standard gender spectrum. Compare Figure 1 and Figure 2. They have the same underlying form—a spectrum ranging from 0 to 100. The same form can be instantiated by two different phenomena—gender categories and fuzzy truth values. In the standard gender spectrum, "male" is to "female" what in fuzzy logic non-*p* is to *p* (and vice versa). And what *p* and non-*p* are to each other is—negation, more precisely, *fuzzy* negation. In Tauchert's model, a person's gender identity is composed in the same way as the truth value of a proposition in fuzzy logic. Just like a proposition can, in fuzzy logic, have a true and a false part, so can a person's gender identity have a male and a female part. If *p* is 80% true, non-*p* is 20% true. If John is 80% male, they are 20% female. The notions "male" and "female" are, according to Tauchert's (2002) model, each other's fuzzy negation.

The use of fuzzy negation to represent the relation between gender categories "male" and "female" allows for an infinitely more inclusive and expressive picture than the traditional, black-or-white, binary model. There is an infinite number of points on the spectrum: one can be 63% female, but also 63.5847% female.

Let us look back at the traditional, non-fuzzy model of gender. As it turns out, in the traditional model, the relationship between the terms "male" and "female" is that of *classical* negation, i.e., the negation of classical logic. As noted earlier, in classical logic, propositions can only be (fully) true or (fully) false, and always only one of the two. The same goes for "male" and "female" in the traditional model of gender (identity). In the traditional model, "male" is to "female" what in classical logic non-*p* is to *p* (and vice versa).

With this in mind, we can express Tauchert's proposed reform of gender categories not only in terms of logic but also in more precise terms of logical negation. Yes, she proposes that we, when modeling gender categories, use fuzzy logic instead of classical logic. But also, in more detail, she proposes that we *replace classical negation with fuzzy negation* when conceptualizing gender (identity). Traditionally, "male" means "non-female" and female means "non-male." And the same goes for Tauchert's (2002) model (or the standard gender spectrum). The notable difference is that the negation is understood in accordance with different logical semantics.

Tauchert's intervention into negation falls closely in line with Plumwood's (1993) "feminist logic" program. Plumwood proposes a feminist reform of classical logic, particularly of classical negation. She lists some features of "oppressive conceptual oppositions," which are, in her opinion, enabled by the classical understanding of negation. Fuzzy negation does a better job in this regard, as shown in Subsection 2.5. Before that, however, a few more logical preliminaries.

2.3. Negation and opposition

Negation and contradiction.

Merriam-Webster offers five different meanings of the word "opposition." The definition relevant to our purposes is the following. An opposition is "the relation between two propositions having the same subject and predicate but differing in quantity or quality or both." Negation, both classical and fuzzy, fits this definition. If you take a proposition, call it *p*, and negate it to get non-*p*, you will certainly get two propositions that differ in quantity or quality. Negation, it follows, is an opposition.

However, logic (the discipline) uses different terminology to express this. Strictly speaking, negation is not an opposition. Rather, it is an *operator* (or a "connective") that you put in front of a proposition in order to get another, negative proposition. In logic, a proposition and its negation (which are each other's negation) are said to be in an opposition called "contradiction." I talked about contradiction before (in Subsection 2.1), but there it meant something else. Let me briefly disentangle this ambiguity of the term. If I said that I am married and not married, then I would say something contradictory, I would utter a *contradiction*—something absurd or meaningless. In classical logic, this is against one of the basic principles, that of non-contradiction, so we cannot have contradictions of this sort. Call this the "contradiction-as-absurdity" meaning of the term "contradiction." On the other hand, "contradiction" can mean the relation between two propositions that are contradictory. In this meaning, we are talking not about the state of affairs, but about relations between sentences. In a sense, we *can* have this sort of contradictions. I cannot say that I am married and not married since that would be absurd; but I *can* say that the two sentences—one saying I am married and the other saying I am not—are in contradiction. In this sense of the word "contradiction," I do not have to decide which of the two propositions is the fact of the matter. I am merely saying how a proposition and its negation relate to each other. And they are related, i.e., opposed, by contradiction. Call this the "contradiction-as-opposition" meaning of the term "contradiction." From this point on, I use the term "contradiction" only in the latter sense.

There is more than one kind of opposition. In this paper, I use the distinction between oppositions dating back to Aristotle (*An. Pr.* B15 63b 24–27). Today, these oppositions are called *contradiction*, *contrariety*, and *subcontrariety*, and are among the crucial notions in logic (the discipline). They were initially proposed in the two-valued setting. In Aristotle's logic (as well as in classical logic developed in modern times), propositions can only be true or false. For now, I consider only the opposition of contradiction.

The opposition of contradiction in classical logic.

Let me start with "regular," two-valued logic. In classical logic, the opposition of contradiction can be defined in the following way. Two propositions are contradictory if they cannot both be true at the same time nor both be false at the same time. In other words, out of two contradictory propositions, one—and only one—must be true. This also applies to predicates or concepts (gender categories included). If two predicates are contradictory, they cannot both simultaneously apply nor can they both simultaneously fail to apply to something. And, analogously, of two contradictory predicates, one—and only one—must apply. This definition is perhaps not so informative. It is analogous to the description of the relation between a proposition/predicate and its *negation,* since two contradictory items are, at the end of the day, each other's negation.

However, there is another, more interesting definition of contradiction, which I adopt here. Two propositions or predicates, the definition goes, are contradictory if they are (i) mutually exclusive and (ii) jointly exhaustive (Béziau 2016). The first feature is not surprising, at least in the classical setting, where we have only two truth values that never mix. But the latter may not be so straightforward. Two contradictory properties—say, blue vs. non-blue, exhaust between themselves everything there is in the universe of discourse, i.e., in the domain of things we are considering. Every object is either blue or non-blue, and no object is neither blue nor non-blue. Again, this is also how things are with "male" and "female" in the traditional model of gender.

The opposition of contradiction in fuzzy logic.

But how does all of this work in fuzzy logic? Importantly, fuzzy logic has its own version of the opposition of contradiction, just like (or, more precisely, *because*) it has its own version of negation. That means that we can distinguish between *classical* contradiction and *fuzzy* contradiction. The definition of the latter is, interestingly, the same as that of the former. Two "fuzzy contradictory" predicates, too, are jointly exhaustive and mutually exclusive. However, these two features need to be read in accordance with fuzzy semantics. A similar thing goes for the proposition "Male equals non-female." This is claimed by both the traditional model of gender *and* the standard gender spectrum. But they mean vastly different things by the word "not" (classical vs. fuzzy negation). In the present case, the fuzzy and the classical logician mean different things by "mutually exclusive" and "jointly exhaustive."

Let me start with "fuzzy mutual exclusivity" of the two items in the relation of fuzzy contradiction. In my opinion, this one is quite unintuitive. (The reason may lie in the hegemony of classical logic.) If two propositions or predicates are fuzzy contradictory, they are, by definition, "fuzzy mutually exclusive." And, as seen earlier, two contradictory propositions/predicates are each other's *negation*. So, it follows that, in fuzzy logic, *p* and non-*p* are mutually exclusive, in the fuzzy sense. Say that *p* is 40% true. By the semantics of fuzzy logic, this means that that non-*p* is 60% true. (Since the values of a proposition and its negation in fuzzy logic always add up to a 100%.) But how can *p* and non-*p* be mutually exclusive if they are *both* true (albeit both only partly)? In which sense can the two opposing propositions be considered "mutually exclusive"? The catch is in seeing how the truth values of the opposed propositions (or predicates) relate. Say again that *p* is 40% true. So, non-*p* is 60% true. But if *p* were to become 41% true, the value of non-*p* would fall to 59%. This is simply a corollary of the fact that the values of *p* and non-*p* need to add up to a 100%. The two propositions *do* exclude each other, in the sense that the truth value of one grows only *at the expense* of the other. A proposition (or a predicate) and its negation compete for space, so to say – but this doesn't mean that the two opposed items cannot mix. In fuzzy logic, mutual exclusivity and the possibility of "mixture" are disentangled. This nuance, on the other hand, is lost on classical logic. Classically, being mutually exclusive merely means that the two properties can never co-occur.

The second property of the opposition of fuzzy contradiction is fuzzy joint exhaustivity. This is another corollary of the fact that the value of *p* and the value of non-*p* added together give a 100%, namely, the fact that they add up *all the way* to a 100%. And in fuzzy logic, a 100% is "the whole truth" or "the full truth." Not only do *p* and non-*p* compete for space (mutual exclusivity), but they also compete for *all* the space. In other words, the *whole* spectrum of fuzzy truth values lies exactly between non-*p* and *p*, the two propositions in a fuzzy contradiction. There are no other truth values outside this boundary. In yet other words, truth-wise, a proposition can have only the true part and the false part—there are no other options.

2.4. Standard gender spectrum understood in terms of fuzzy contradiction

In Subsection 2.2, I said that the reform Tauchert (2002) proposes is, to put it more precisely, the fuzzification of *negation* between the gender categories, i.e., a switch from the classical to the fuzzy understanding of *negation* in the description of the logical relation between the categories "male and "female." At this point, this can be made even more precise. Tauchert proposes that the gender categories (in logical terms, *predicates*) "male" and "female" be in the opposition of fuzzy contradiction, as opposed to the opposition of classical contradiction. This means, further, that the two gender terms should be understood as *fuzzy* mutually exclusive and *fuzzy* jointly exhaustive (and not *classically*, like in the traditional model). Both of these features can be read from the standard gender spectrum (see Figure 1). Look at the gender identity shown in Figure 1. A point is drawn at 70 (out of 100). In Tauchertian terms, this means that the person in question is 70% male and 30% female. The point divides the line into two parts, in such a way that one part becomes larger only at the expense of the other. If the person's level of maleness were to be reduced, this would automatically and unavoidably increase their amount of femaleness by the exact same amount. The one excludes the other. Secondly, the standard gender spectrum makes “male” and “female” jointly exhaustive since these notions make up the poles of the spectrum. Joint exhaustivity adds a proviso that the amount of maleness and the amount of femaleness have to add up to a 100%. There can be no space left for other categories. As I will argue, fuzzy mutual exclusivity between the notions “male and “female” is an asset for Tauchert’s model (i.e., the standard gender spectrum), while fuzzy joint exhaustivity is a burden.

2.5. Advantages of Tauchert’s approach

A *prima facie* advantage of Tauchert’s account is the fact that it is infinitely more expressive than the traditional model of gender. Instead of only two, there is now an infinite number of possibilities. This alone seems liberating and more permissive. Also, more specifically, Tauchert’s logic-oriented reform of gender categories is in keeping with Plumwood’s (1993) proposal for a feminist reform of classical logic. Plumwood, like many other feminist philosophers (e.g., Butler 1990, de Beauvoir 1956, Lloyd 1984), wants to tackle “oppressive dualisms”—the conceptual contrasts that shape and inform Western philosophical thought and canon. Among these dualisms are, for example, reason/emotion, subject/object, mind/body, nature/culture, universal/particular, and male/female (Plumwood 1993). They are called oppressive because, as many feminist analyses warn, of the two concepts, one is regularly considered inferior. Furthermore, the inferior pole is regularly associated with the (stereotypically) feminine. Plumwood believes, much like Tauchert, that the problem is in the underlying logic of these dualisms, particularly in negation. According to Plumwood, “accounts of negation can be seen as providing, at a very abstract level, certain structures and principles for conceiving and treating otherness [. . .], the other which is not self, whatever self may be” (1993, 441). “If negation is interpreted as otherness, then how negation is treated in a system, together with other features of the system, provides an account of how otherness is conceived in that system” (1993, 454). The hegemonic, go-to logic, as discussed earlier, is classical logic. This means, according to Plumwood, that the inferiorized, otherized notions in the prevailing dualism are understood as *classical* negations of their corresponding upper sides. Emotion, for instance, is understood as the classical negation of reason, and female is the classical negation of male. Plumwood’s overall view is very similar to Tauchert’s, the salient difference being that the former doesn’t consider gender categories in particular but engages in an analysis and critique of classical logic at a more abstract level. Plumwood (1993) offers five features of oppressive conceptual differentiation, three of which (in my understanding) can be directly attributed to classical negation, without reference to “other features of the system” (Plumwood 1993, 454). These are relational definition (incorporation), homogenization (stereotyping), and radical exclusion (hyperseparation).

Tauchert’s (2002) model takes care of the latter feature. According to Plumwood, “[c]onceptual structures stressing polarisation allow the erection of rigid barriers to contact which protect and isolate dominant groups” (Plumwood 1993, 448). In different words, those in power use conceptual structures that are far more oppositional, i.e., *hyperseparated*, than it is necessary (or acceptable), and they do that to promote their rule. On the other hand, “[a] nonhierarchical concept of difference will affirm continuity [. . .], reconceive relata in more integrated ways, and reclaim the denied area of overlap” (Plumwood 1993, 456). I think Tauchert follows Plumwood’s advice quite explicitly. Her model of gender uses fuzzy, *continuum*-valued semantics of fuzzy logic. Or, in terms of the standard gender spectrum (which is equivalent to Tauchert’s model), there is a *continuum* (or spectrum) of values in-between the terms “male” and “female.” Further, by modeling the two genders as being in opposition of fuzzy contradiction, Tauchert’s account enables the two terms to mix or *overlap*, which can be understood as a way of conceiving them in a *more integrated* way. There is no longer a chasm between the two genders.

Now, I said earlier that I consider fuzzy mutual exclusivity to be an asset for the standard gender spectrum. However, at this point in the paper, I cannot argue for this. All I can claim for now is that it is good that genders are able to mix, which happens if (but not *only* if) they are fuzzy mutually exclusive. But I cannot yet explain why they should be fuzzy *mutually exclusive*, i.e., why the value of one notion should grow only at the expense of the other. I will do this only after I consider the multispectral models, in which gender categories *can* mix but are at the same time *not* considered mutually exclusive (or opposed in any way). I now turn to the downsides of Tauchert's "fuzzy gender" model.

2.6. Disadvantages of Tauchert's approach

I think the core problem of Tauchert's account is expressed in the following quote from Biana and Joaquin (2020):

> [I]n maintaining that the hegemonic opposites of heterosexual male and heterosexual female are at the polar extremes of the gender line, Tauchert's model implies that the gender categories in between the heterosexual binaries are still defined by the norm. (Biana and Joaquin 2020, 362)

Introducing degrees is well and good, but one can look at the reform as merely drawing a line between two *hegemonic* poles—which may not do much for disrupting the binary. There is movement only between the two "extremes."

In response to this problem, Biana and Joaquin suggest "clearing the fuzziness." Instead of using degrees, they opt for a "model that reimagines the gender categories as discrete categories" (2020, 363). I don't have anything to say against their concrete solution (the "gender galaxies" model), which I do not discuss here. I do, however, disagree with them that clearing the fuzziness should be the solution to the problem cited above. We can, I will suggest later, solve the problem as well as keep the fuzziness. The problem, in my opinion, lies not in degrees themselves, but in fuzzy joint exhaustivity, the other, independent feature of fuzzy contradiction, which in Tauchert's model holds between the terms "male" and "female."

Fuzzy joint exhaustivity adds a proviso stating that the two contrasted concepts amount to all there can be, i.e., the two values add up to a 100%, leaving no space for more options. The hegemonic opposites exhaust all the options. However, using the analogy with colors, one can ask: yes, "black and white are extreme poles of a continuum that overwhelmingly consists of degrees of grey" (Tauchert 2002, 35), but why do we get only two "primary" colors to work with? Yes, you can get infinite shades of grey by mixing black and white, but aren't there more colors? In fuzzy logic, propositions *p* and non-*p* are in the opposition of fuzzy contradiction, which means that they are (also) fuzzy joint exhaustive. At this level of abstraction, this is not problematic. It is not problematic that the *truth value*s move only between the *two* poles, non-*p* and *p*, or, put differently, that a proposition can have only two parts, the true part and the false part. In fuzzy logic, (abstract) propositions *p* and non-*p* are genuinely and acceptably fuzzy jointly exhaustive. The problem arises when we map *p* and non-*p* to "male" and "female." And as the apparent diversity of gender identities suggests, these two do not jointly exhaust all gender categories.

For this purpose, I want to differentiate between three (connected) problems for Tauchert's (2002) model of gender (as well as the standard gender spectrum, see Figure 1), all of which result from the fuzzy joint exhaustivity between the gender categories.

1. It doesn't allow for (partly or fully) agender identities.
2. It doesn't allow for other genders except "male" and "female."
3. It suffers from *overdetermination* between gender categories.

Regarding the first two items, every point is on the *gender* line, so one cannot escape being *gendered*. And the two hegemonic genders are the only two colors that come into the mix on the continuum of shades of grey. Paradoxically, the infinite number of possibilities provided by Tauchert's model is not large enough to account for all gender identities.

The third problem is perhaps more subtle. What I mean by "overdetermination" is the following phenomenon. Why would someone tell you they are 80% male and 20% female? That would be redundant. The sum is, according to the spectrum, always a 100%, so one can be inferred from the other. There is no need to list both features. However, from a feminist perspective, this presents a problem. According to Plumwood (1993), oppressive conceptual oppositions use a "relational definition" in order to *incorporate* the lesser terms. And since "female" is the one that is devalued in the hegemonic opposition between male and female, we can expect the default way of presentation, if not challenged, to become the one where we omit the amount of *femininity*. The standard gender spectrum under patriarchy may result in people expressing only how *male* they are. Every other identity falls under that. Aside from incorporation, the given arrangement of values can be accused of "homogenization" or "stereotyping" (Plumwood 1993). In the dualistic West, there is the male and the non-male part. And there is nothing more to say about the non-male part. It is not further divided into categories, developed, or discussed. The plurality of being (partly) gendered in ways other than male or being (partly) not gendered is being lumped into a single, homogenous category.

None of the problems considered in this subsection arise in the models of gender (identity) proposed by Magliozzi, Saperstein, and Westbrook (2016) and by Ho and Mussap (2019), which I consider next. These, as I call them, "multispectral models," keep the degrees (fuzziness), but dispense with mutual exclusivity. They do so by providing separate, *mutually independent* scales for masculinity and femininity (and other gender(s), in the case of Ho and Mussap). These models fully account for the existing diversity of gender identities. However, as I will argue, by choosing to portray the values across the scales as *mutually independent*, they invite different kinds of difficulties.

3. Multispectral models of gender

3.1. Bispectral model of gender

Magliozzi, Saperstein, and Westbrook (2016) call for an improvement of gender representation in national surveys, which either conflate it with sex or offer only two discrete, traditional options. They welcome the calls to improve the measurement of gender by adding to the list more options than the two traditional genders but warn that "adding more categories alone cannot solve all the dilemmas of representing population diversity" (2016, 2; see also Westbrook and Saperstein 2015). Some such dilemmas are the impossibility of measuring/representing variation within the same category, as well as the possibility that the list of options is not complete (i.e., exhaustive). Instead, they argue that "a more thorough retooling of the use of gender in surveys should include using femininity and masculinity scales as measures of gender identification" (Magliozzi, Saperstein, and Westbrook 2016, 2). An important feature of the model of gender they propose is "measuring femininity and masculinity separately, ensuring that two concepts are *neither treated as mutually exclusive nor operationalized as opposites*" (2, italics added).

In the survey by Magliozzi, Saperstein, and Westbrook (2016), the respondents were given a task to indicate how much on a scale from zero ("not at all") to six ("very") they felt themselves to be feminine, and the same for masculine. All pairs of possible answers across the two scales are valid. One can be, for example, maximally female and maximally male at the same time. In this paper, I re-imagine the scales as *sliding*-scales, i.e., two continua ranging from 0 to 100%. I do this in order for Magliozzi, Saperstein, and Westbrook's (2016) model to be more easily comparable to the standard gender spectrum as well as to the trispectral model I consider next. However, everything that will be said in favor and against the bispectral model can also be said in favor and against the original model. I call this reinterpretation the "bispectral model of gender." Figure 3 shows the bispectral model, along with an example of an identification on the spectra, i.e., an example of gender identity.

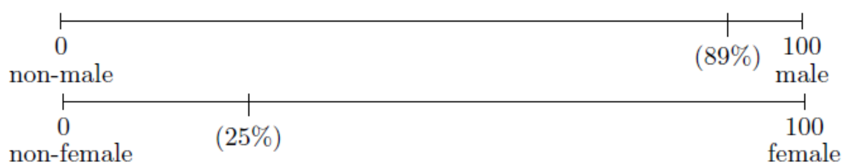

Figure 3: **Bispectral model of gender** with an example of a gender identity

As the example of a gender identity shows, the percentage of a person's femininity and the percentage of their masculinity don't have to add up to a 100%, as they do in the standard gender spectrum or Tauchert's (2002) "fuzzy gender" model. Any combination between the two values is legitimate. The values can even both be 0%, or both be a 100%. The two are independent, affecting each other in no way. This also means that they cannot be mutually exclusive: the value of one does not grow at the expense of the other.

A note about how the poles of the continua are named in Figure 3, which also applies to Figures 4 and 5 (below). The two spectra in Figure 3 are labeled according to fuzzy logic, where the truth value of a proposition, call it *p*, ranges from non-*p* (standing for 0%) to *p* (standing for a 100%). That is why the left-hand poles of the continua are labeled *non*-male and *non*-female. I choose this presentation in order to be able to more closely compare the multispectral models with the fuzzy approach. However, the more usual (and intuitive) way of representing the continua (used by Magliozzi, Saperstein, and Westbrook's (2016) and Ho and Mussap (2019) themselves) is to put a label (name) only on the right-hand pole. For instance, the more transparent way to represent the femininity scale is to merely offer a continuum ranging from 0 to 100, and to ask the respondent to indicate on the continuum the extent to which they identify with the gender category "female." And this category stands on the right-hand pole of the continuum, since the closer one is to a 100, the more they are female. Femaleness is what is measured. No terms like "non-female" need to appear. So, a recipe for making the multispectral models (Figures 3, 4, and 5) more readable is to disregard the negated gender terms on the left-hand sides of the spectra.

3.2. Trispectral model of gender

Ho and Mussap (2019) found inspiration for their model in popular infographics used to describe gender identity. They provide "an evaluation of the Gender Unicorn as a measure of gender" (219), this being the last update among a string of progressively more expressive/inclusive infographics. They stress that "[t]he most respectful way of measuring gender would [...] be to use materials that the trans and gender diverse community as a group has reviewed and accepted as the best way to conceptualize their gender diversity" (218).

Ho and Mussap trace the development of gender representation in the infographics starting from the "Genderbread Person" by Lawson (2011), through the two successive iterations of the Genderbread Person by Killermann (2012a, 2012b), to, finally, the "Gender Unicorn" (Trans Student Educational Resources 2015). These models take into account (and provide sliding-scales for) four different dimensions of a person: sex, gender identity, sexual orientation, and gender expression. Ho and Mussap adopt the measurement of gender identity found in the last iteration, the Gender Unicorn, and call their model the Gender Identity Scale (GIS). GIS offers three separate continua for expressing gender identity, each ranging from 0 ("not at all") to 100 ("very strongly"). Along with measuring the amounts of femininity and masculinity (as the bispectral model does), it also adds a third continuum for, as Ho and Mussap put it, "other gender(s)." In this paper, I call this the "trispectral" model of gender, shown in Figure 4. Each spectrum measures the extent to which a person identifies with the corresponding gender. Like in the previous figure, I label the continua in a less common way (they range from non-*p* to *p*), so they can be more closely associated with fuzzy truth values (see Figure 2). This is why the (not so usual) notion of "non-other-gender(s)" is applied as a pole on the last continuum. In a more common (and straightforward) representation, the third spectrum would range simply from 0 to 100 and would be titled "the extent of identification with other gender(s)."

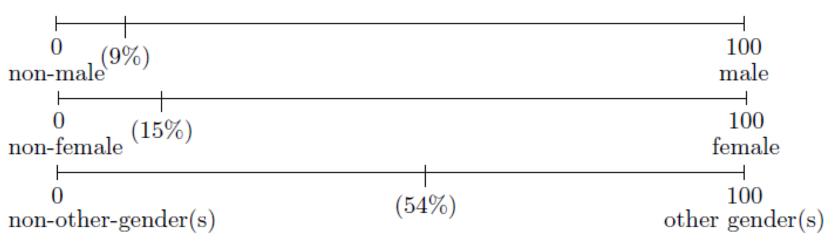

Figure 4: **Trispectral model of gender** with an example of a gender identity

The person shown in Figure 4 is 9% male (and 91% non-male), 15% female (and 85% non-female), and 54% of some other gender(s). In GIS, Ho and Mussap do not use percentages, but I believe they are, in a sense, implied. I believe "54 out of a 100" means the same as "54%." And since there are percentages, GIS can be analyzed in terms of fuzzy logic. Like in the bispectral model, the percentages of each gender are mutually independent—all combinations are possible. Like Magliozzi, Saperstein, and Westbrook (2016), Ho and Mussap (2019) purposefully avoid considering values as mutually exclusive or opposed in any other way. They reiterate this when interpreting the results of their survey. Looking at particular identifications of GIS, Ho and Mussap consider the possibility that some of the participants may have interpreted the numbers from 0 to 100 as "overall percentages [. . .], and therefore adjusted their overall identity such that all their responses added up to 100" (2019, 10). But the authors stress that they want to avoid such an interpretation, concluding that "[i]t would be advisable, in the future, to utilize a straightforward numbering scheme with a different number of points, such as 0 to 8, so that the implication of summing to

100% is not present" (228). In other words, they do not want the values of gender dimensions to influence each other in any way.

3.3. Advantages of multispectral models

In Subsection 2.6, I claimed that the problems of the standard gender spectrum (or, equivalently, Tauchert's (2002) fuzzy model of gender) stem from the fuzzy joint exhaustivity of the terms "male" and "female," i.e., the fact that their values add up all the way to a 100%. The spectrum ranges only between "the hegemonic opposites of heterosexual male and heterosexual female" (Biana and Joaquin 2020, 362), defining every identity in-between by the binarist norm (also Plumwood 1993). I singled out three different (but connected) problems for the standard gender spectrum:

1. It doesn't allow for (partly or fully) agender identities.
2. It doesn't allow for other genders except "male" and "female."
3. It suffers from *overdetermination* between gender categories.

None of these emerge in the multispectral models, with one possible exception. By allowing no kind of mutual dependency (let alone mutual exclusivity) between the values on gender dimensions, the multispectral models avoid the problems raised against the standard gender spectrum.

Regarding the first item, in the bispectral and the trispectral model, one *can* escape being gendered. Every scale measures an amount of a separate *gender* category, but the tab on the scale doesn't have to go all the way to the maximum. There can be some "empty" space left on the right-hand side, which can be interpreted as representing the genderless (agender) part of a person's gender identity. The representation of agender identities, however, is not so straightforward in the multispectral models, as I discuss in the following subsection.

Further, the multispectral models *do* allow for other genders aside from "male" and "female." The trispectral model does, at the very least. There we explicitly find "other gender(s)." In the bispectral model, as the name suggests, we have only two continua. Perhaps, on the one hand, Biana and Joaquin's (2020) criticism raised above against Tauchert (2002) can be reiterated for the bispectral model. Maybe identities are here, in a way, "still defined by the norm" (2020, 362). On the other hand, in defense of the bispectral model, one can apply the same strategy as for the agender identities. In the bispectral model, if one is not fully female nor fully male, this can mean that they are (partly) of some other gender(s).

Lastly, in the multispectral models of gender, there is no overdetermination between the values of gender categories—and hence no threat of "incorporation" and "homogenization" (Plumwood 1993). In Tauchert's model, where the notions "male" and "female" are contrasted by the opposition of fuzzy contradiction, to say one value is to say them both. Since the two values always add up to a 100%, the value of femaleness is absolutely determined by the value of maleness (and vice versa), so it can be left out as redundant—which is problematic from a feminist perspective. Nothing like this, however, happens in the multispectral models, where values across the spectra are conceived as independent. There, for instance, one's percentage of maleness says nothing about their percentage of femaleness. All genders are measured in their own right and no value can be calculated from any other. If we want to have the full picture, we have to list *all* genders.

3.4. Disadvantages of multispectral models

Even though the multispectral models have considerable advantages over the standard gender spectrum, they face some difficulties of their own. I want to focus here on three problems for these accounts:

1. They graphically misrepresent agender identities.
2. They feature ambiguous identifications.
3. They suffer from *underdetermination* between gender categories.

Ad 1). I said earlier that the multispectral models are better than their predecessor because they can account for (partly) agender identities. However, the way they do this, in my opinion, leaves much to be desired. All "positive" genders have their own continuum, while the agender option can be expressed only by the amount left over on all the continua, i.e., by the "empty" space on the right-hand side of the tab on each scale. Take as an example a person who identifies as mostly not having a gender, but the little they do have is feminine. How would they answer the question about gender identity, given, say, the bispectral model? I imagine they would move the tab on the scale of masculinity fully to the left (i.e., to zero), representing their lack of it. What do they do with the femininity scale then? With a 100 points still to go, they would need to leave additional "empty" space on the femininity scale, because the zero they ticked on the masculinity scale awards only a 100 points to their lack of gender, and they still need to score more points in order to express the prevalence of agenderness over genderness. So, maybe they put 30 points (percent) on the femininity scale. The final score is the following: 0% male, 100% non-male, 30% female and 70% non-female. Out of the total 200 points (two spectra ranging from 0 to a 100), 30 is awarded to *gender* categories (male or female), and 170 to "non-gendered" categories (non-male or non-female). This, however, presents a problem. The amount of a person's agenderness is in the bispectral model not read as easily as the amount of their femaleness and maleness. This information is scattered across the spectra. It can be seen only at a second glance, when we add up the "empty" space left on the *gender* dimensions. The trispectral picture has an analogous problem with agender identities, which are there scattered across three continua. In the multispectral models, agender identities are not on equal footing with "gendered" identities. Even though they can be expressed, they do not get a continuum of their own. We can thus say that in the multispectral models agender identities are *graphically misrepresented*. (A difficulty unique to the bispectral model is a graphical misrepresentation of otherwise-gendered identities, analogous to that of agender identities. I don't discuss this problem since it does not apply to the trispectral model.)

But maybe we can solve the problem by measuring the extent of agenderness in the same way as for other gender categories. A simple solution, it would seem, would be to add another independent continuum for "agender" or "genderless." Let's say we add an additional spectrum to the *trispectral* model since this model does a better job of representing genders other than male and female. This option, the "quadrispectral model" is shown in Figure 5. Like in the multispectral models, all values are to be measured separately.

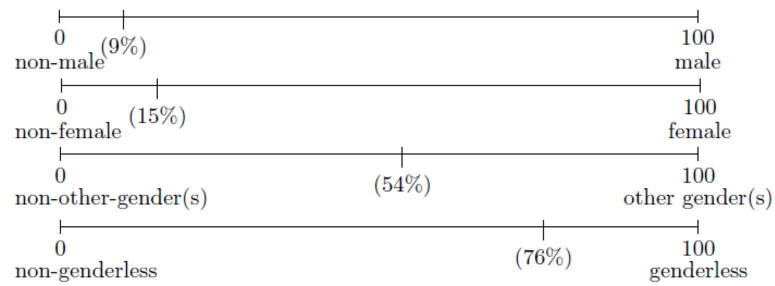

Figure 5: **Quadrispectral model of gender** with an example of a gender identity

As in the Figures 3 and 4, the continua are labeled in such a way as to more closely resemble the continuum of fuzzy truth values; but, to get a more intuitive picture, you can disregard the negative categories on the left-hand poles. So, is Figure 5 a model of gender that should be proposed instead of the multispectral models? I don't believe so. Take a look at the example of a gender identity shown in the figure. Firstly, we see from the last scale that the person is not fully gendered—they are three-quarter agender. In the quadrispectral model, the value of genderlessness is treated like any other. Like the remaining three, "gendered" categories, it is measured independently and it cannot be inferred from any other. And it can be read *explicitly*. This gets rid of the graphical misrepresentation of agender identities. So far so good, but, in that case, what does the "empty" space on the first three continua stand for? What do the numbers on the four scales *actually* report? The person in question is not fully male, not fully female, and not fully of any other genders. So, does the amount of their non-maleness (91%), non-femaleness (85%) and non-other-genderness (46%) also count as agender? It seems it would need to. Since in the quadrispectral model *every* gender category is listed, there is nothing other left for the "empty" space to mean. The amount of agenderness again becomes the source of confusion. Instead of being represented as straightforwardly as other genders, it is in actuality scattered across *four* spectra. So, it seems that the problem of graphical representation cannot be solved by merely adding another spectrum. Not, that is, if we still keep the values on the spectra mutually independent, as the proponents of the multispectral models want to do.[5]

Ad 2). Moreover, it is not just the case that in the multispectral models agender identities are graphically misrepresented, these identities are also in a sense *overrepresented*, which leads to ambiguity. Consider the case of myself, a person with fully male gender identity. If I was asked to represent my gender identity in the bispectral model, I would put a 100 on the masculinity scale and a 0 on the femininity scale. I would thereby signify that I'm a 100% male (i.e., 0% non-male) and a 100% non-female (i.e., 0% female). But how would the ones who interpret these results know what I meant by the amount of non-femininity? How would they know that I didn't instead mean my non-femininity to refer to my agenderness? Maybe a person who is half male and half agender would represent their gender identity in exactly the same way. Similar goes for the trispectral model. If I leave the femininity and other gender(s) scales at zero, who is to say I didn't want to report that two thirds of my gender identity are without gender? So, on both multispectral models, it seems that everyone who didn't move the tabs on the scales all the way to a 100 can be read as (partly) agender, including those who put a 100 on one dimension and left the other dimension(s) at 0. There is ambiguity in the multispectral models—and this problem, like the previous one, affects *agender* identities. Also, similarly to the previous problem, the trispectral does better. It has conflicting interpretations "only" regarding agender identities, while in the bispectral model, the "empty" space can also refer to other gender(s), introducing even more confusion.

Ad 3). Regarding the last item on the list, labeling "underdetermination" as a problem may, admittedly, be cheating. At least at this point. Let me explain. In the standard gender spectrum, one of the two values is omissible, because it is completely determined (overdetermined) by the other. One value says *everything* about the other. In the multispectral model, on the other hand, one value says *nothing* about the other(s). The values are there totally mutually independent. But imagine there was a model of gender that solves the first two problems for the multispectral models (and the problems of the standard spectrum), and that this model is made to be somehow "in-between" the standard and the multispectral options: there, the gender values say less than everything but more than nothing about each other, i.e., they say *something*. If such a model exists, then one could say that total independency of values is an overreaction—that we should not too hastily disregard the possibility of semantic co-dependence between the gender categories. The argument would go like this. Multispectral models construe gender dimensions as totally independent, but by doing so, they invite graphical misrepresentation and ambiguity. If we modify the independence clause, those problems disappear (and no old ones reappear). Therefore, gender categories in a model should not be totally independent. Of course, this argument works only if its second premise is shown to be true. As I will argue in Section 5, there are many models that speak in favor of the said premise, and the kind of dependency they use is a dependency that is not a burden, but an asset.

4. Classical structures of opposition

This section is a logical intermezzo. The models of gender considered so far have the advantage of being quite intuitive and easy to read. This is not much so with the model(s) of gender I will propose in the following section. I want to argue that gender categories can be modeled by fuzzy structures of opposition, a family of logical diagrams used to describe relations between propositions or concepts. Structures of opposition, at least ones that are understood by means of classical, two-valued logic, are meant to represent the usual way we reason about, among other things, everyday concepts. In this section, I introduce classical structures of opposition, particularly the "logical hexagon." In the following section, I propose the fuzzy version of the hexagon as a model for gender identity. Let me start by defining the remaining two Aristotelian oppositions, in the classical setting.

4.1. Other classical oppositions: contrariety and subcontrariety

A distinction between different kinds of opposition dates back to Aristotle (*An. Pr*. B15 63b 24–27). Today, they are called *contradiction*, *contrariety,* and *subcontrariety*. These oppositions were initially proposed in a classical, two-valued setting, but they can also have a fuzzy interpretation. I described the oppositions of classical and fuzzy contradiction in Subsection 2.3. Two contradictory propositions or predicates can be understood as each other's negation (see the last paragraph of 2.1). According to one definition of the said opposition, two propositions are contradictory if they cannot both be true at the same time nor both be false at the same time. Analogously, two predicates are contradictory if they cannot both simultaneously apply nor both simultaneously fail to apply to something. According to an alternative definition, two propositions/predicates are contradictory if they are mutually exclusive and jointly exhaustive.

Each version of the definition of contradiction has two constituents, both of which have to hold. In the case of the remaining two types of opposition, only one of the two is present. Two propositions in the opposition of (classical) contrariety cannot both be true at the same time, but they can both be false at the same time. Two (classically) contrary predicates cannot both hold at the same time, but they can both fail to hold at the same time (hold about the same thing, that is). Further, two (classically) contrary propositions/predicates are mutually exclusive, but not jointly exhaustive. With the opposition of subcontrariety, it's the reverse. Two subcontrary predicates can both hold at the same time. They are not mutually exclusive, but only jointly exhaustive. Before providing concrete examples of the three oppositions, let me say how they relate.

4.2. The logical hexagon

The interplay between different kinds of (classical) opposition can be represented by *structures of opposition*, a family of logical diagrams used to describe relations between propositions, predicates, or concepts. The most famous and influential (and also the simplest) among them is the *square of opposition*, a diagrammatic representation of the four different relations between the four prototypical types of propositions used by Aristotle in his syllogistics. In the diagram, the four propositions form corners of a square (with diagonals also being drawn). Different lines then correspond to different logical relations (the three oppositions included). The second most famous structure of opposition is the (classical) logical hexagon, an extension of the square discovered independently by Jacoby (1950), Sesmat (1951), and Blanché (1953).

The classical logical hexagon in particular has proven to be very useful in conceptual analysis. It can provide a model for a lot of everyday notions.[6] (Because the hexagon is so widely applicable, Blanché (1966) even speculated that it is a universal and underlying structure of the mind, but see Dufatanye (2012) for a critique of this view.) The classical logical hexagon can be used on any three *trichotomous* concepts or predicates. If you take a trichotomy and put each of the three concepts in the correct corners of the diagram, all the relations between the concepts become explicit. The other three corners of the hexagon are filled with negations of the three initial concepts, so we can also see how the "positives" relate to the "negatives." The logical hexagon tells you everything there is to know about the logical relations between three trichotomous concepts. Here is an example. In Figure 6, I show Demey's (2019) model of the classical logical hexagon proposed to aid the debate between theism and atheism.

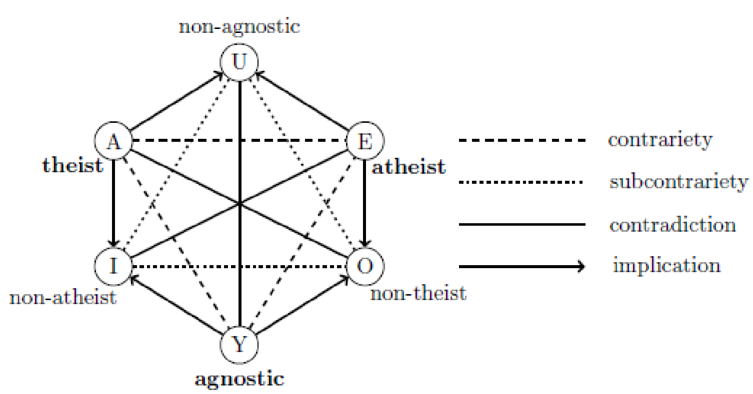

Figure 6: Classical logical hexagon for the theism/atheism debate

In the figure, the trichotomy is that between the notions "theist," "atheist" and "agnostic" (in boldface). You can be only one of the three. Remember, we are in the classical framework. No degrees are allowed here, only (full) truth and (full) falsity. This, however, seems to work well for the proposed concepts.

Let me first talk about the classical logical hexagon in the abstract and then consider Demey's particular, as it is sometimes called, "decoration" of the structure with concepts having to do with faith. The hexagon, obviously, consists of six corners. Each of them is labeled by a different vowel, according to the French taxonomy, where Y also counts in.[7] Each corner of the hexagon is connected to every other corner, but not always by the same relation. There are four different relations by which the corners can be connected, namely contrariety, subcontrariety, contradiction, and implication. Not all the relations in a structure of opposition are oppositions—implication is not an opposition, but it makes the figure complete by making the logical relations between the corners more explicit. Implication is, like negation, a logical connective. If *p* implies *q*, that means that *q* must be true if *p* is true.

The hexagon is pretty symmetric. Each corner is connected by an opposition of contradiction to exactly one different corner. The contradictory pair of corner A, for example, is the corner O. And since two contradictory propositions/predicates are each other's negation, each corner can be defined in terms of its contradictory pair, using negation. For instance, instead of "A," one can name the corner "non-O" (and vice versa). Aside from having one unique contradictory corner, each corner also has *two* unique corners with which it is connected by an opposition different from contradiction. Corner A, for example, is *contrary* to corners E and Y. Corner I, for example, is *subcontrary* to corners U and O. There are two important triangles in the logical hexagon, the sides of both are formed by a single type of (non-contradictory) opposition. The first—and more important for the present purpose—is the *triangle of contraries*, A-E-Y. The second is I-O-U, the *triangle of subcontraries*. There is another way to define a corner in terms of other corners (besides by negation), depending on which triangle the corner is located in. Any corner in the triangle of contraries (i.e., A, E, and Y) can be defined as a *conjunction* of its two neighboring corners. Conjunction is, like negation and implication, a logical connective, meaning "and." So, for instance, A can be defined as "U and I." This conjunction may not be visible in the hexagon, but it is in line with the fact that A implies both U and I. On the other hand, any corner in the triangle of subcontraries (i.e., I, O, and U) can be defined as a *disjunction* of its two neighboring corners. Disjunction reads like "or." So, for instance, O is equivalent to "Y or E."

The logical hexagon, as well as any other structure of opposition (see below) is an abstract structure that can be interpreted ("decorated") in many different ways. But seeing that it also features definitions for every corner as well as other logical relations between notions, it can be also called a *theory* (Béziau 2012). When no meanings are assigned to the corners, it is an *abstract* logical theory.[8] When the actual concepts or propositions are assigned to the corners, we get a logical theory of *something*, for instance, religious belief.

4.3. A logical hexagon in action

Demey (2019) discovered that the classical logical hexagon can be decorated by the conceptual trichotomy theist/atheist/agnostic. If the concepts are put in the right places, he noted, we get a logical theory of religious belief, which could aid the debate. The way in which one proceeds in decorating the hexagon is usually by considering a trichotomy, like theist/atheist/agnostic. These three concepts are then put in the triangle of contraries (corners A, E, and Y). Each of the considered notions is contrary to the other two because no two terms alone exhaust all the options. For instance, "theist" and "atheist" are not jointly exhaustive, so they need to be connected by contrariety, not a contradiction. At this point, it doesn't matter which corner you choose for which concept. The next step is to decorate the remaining three corners—I, O, and U. The concepts that need to be put there are negations of the initial three concepts. This is because every corner has its contradictory counterpart, and two contradictory terms are each other's *negation*. The negated versions of the initial notions have to be put into correct places, according to the line which represents a contradiction. So, if you put "theist" on you the A-corner, you should put "non-theist" on the O-corner. With the hexagon fully decorated, we can see how the notions logically relate. So, let us finally see what this particular logical hexagon can do.

The classical logical hexagon for the theism/atheism debate (see Figure 6) shows us, for instance, that being a theist implies not being an agnostic, i.e., being "non-agnostic" (since corner A implies corner U). This is not so surprising. But the hexagon also shows us that being a theist implies not being an atheist, which is worded as being "non-atheist" (corner A implies corner I). Now, the notion "non-atheist" is perhaps more interesting. As the hexagon shows, the notions "non-atheist" and "theist" do not mean the same thing, even though one would *prima facie* think that the double negation in the previous term would cancel itself out. The fact that the notions are not the same can be inferred from the fact that they occupy different corners in the logical hexagon. The concept "theist" is on the A-corner, while "non-atheist" corresponds to I-corner. Moreover, if we consider the mutual definitions of the corners, we can further see the difference. According to the hexagon, to be a theist is the same as to be "non-agnostic and non-atheist" (since A equals "U or I"). But to be a non-atheist means, the hexagon informs us, to be "theist or agnostic." This last fact is revealing. Theists are only one variety of non-atheists. The other are agnostics. The notions "non-atheist" and "theist" do not refer to the same set of things. Rather, the latter is a subset of the former: "theist" implies "non-atheist," but not vice versa.

Further, as Demey's hexagon shows, being a "non-theist" is different from being an atheist. This can again be seen from the fact that these terms occupy different corners, O and E. The first concept is located in the triangle of subcontraries while the other is found in the triangle of contraries, which makes their definitions different. A "non-theist" means "either an atheist or an agnostic." Like in the previous case, it is a wider category. You can *not be a theist* in two ways: either actively believe that god doesn't exist, or simply suspend belief, to neither believe that he does nor that he doesn't exist.

Let me consider one *subcontrary* opposition in Figure 6. This kind of opposition, according to the definition, makes the two terms jointly exhaustive, but not mutually exclusive. Take the notions "non-agnostic" and "non-theist" (the mutually subcontrary corners U and O). According to the logical theory of religious belief provided by the classical logical hexagon, everyone is either a non-agnostic or a non-theist. And this checks out. "Non-agnostic" is equivalent to "theist or atheist," while "non-theist" is equivalent to "agnostic or atheist." So, in different words, everyone is either "theist or atheist" or "agnostic or atheist." Getting rid of the duplicate notion, we get that everyone is either a theist, an atheist, or an agnostic. And this is exactly what was initially accepted. Some logical truths found in the logical hexagon, like this one, can seem artificial and unusual. But none of them, I believe, are counterintuitive.

A note about mutual exhaustivity and contrariety. To reiterate the definition, two contrary notions are mutually exclusive but not jointly exhaustive. However, the *three* notions "theist," "atheist" and "agnostic," all mutually contrary, *are* jointly exhaustive. This may appear confusing. However, contrariety, like all oppositions, is construed as a *binary* relation, holding between *two* propositions or concepts. So, the expression "three contrary notions" should be understood as a shorthand for "three instances of contrary pairs" (see lines A-E, A-Y, and Y-E in Figure 6).

4.4. Other structures of opposition

The classical logical hexagon spells out everything there is, logically, to know about a *trichotomy*. When it comes to more nuanced conceptual divisions, a more complex structure of opposition needs to be used. But no matter how complex, every structure of opposition is built in the same manner and by the same "material" as the logical hexagon. There can be many corners, but there are still only four possible relations between them: the three oppositions (contradiction, contrariety, and subcontrariety) plus implication. Also, as it can be seen from the hexagon, every structure has twice as many corners as there are concepts in the initial exhaustive division of concepts. Mathematically, there is an infinite array of more and more complex structures of opposition (Moretti 2004). For instance, to represent the relation between five jointly exhaustive categories, one would need the logical decagon (see Joerden 2012, for an example).

5. Fuzzy logical hexagon as a model of gender identity

In this section, I propose the *fuzzy* logical hexagon as a model of gender identity. The fuzzy interpretation of the logical hexagon was first proposed by Dubois and Prade (2012), who soon also offered more complex fuzzy structures of opposition (2015). Fuzzy structures of opposition need to be used when the concepts we are considering can come in degrees or percentages—and gender categories are a case in point. In the literature, to my knowledge, there are not many conceptual decorations of the fuzzy logical hexagon (unlike for the classical version). A prominent example is a model of modal concepts like "necessary" and "possible," provided they are understood as allowing for degrees—consider, for instance, the phrase "very possible" (cf. Dubois and Prade 2012). In fuzzy structures of opposition, everything is fuzzified, not only the truth values of the corners but also the relations.

5.1. Other fuzzy oppositions: contrariety and subcontrariety

One of the fuzzy oppositions, fuzzy contradiction, was already described in Subsection 2.3. Tauchert (2002) chooses it as the relation between gender categories "male" and "female," inviting some critiques. From now on I speak about oppositions only in terms of mutual exclusivity and joint exhaustivity, as well as only about predicates, as opposed to propositions. I do this because gender categories can be better understood as predicates or concepts (rather than sentences, i.e., propositions), and the notions of mutual exclusivity and joint exhaustivity apply well to predicates.

Two predicates in the opposition of fuzzy contradiction are both fuzzy mutually exclusive and fuzzy jointly exhaustive. They are mutually exclusive in the sense that, although they can mix, the percentage of one grows at the expense of the other. They are jointly exhaustive in the sense that the percentages of the two values always add up to a 100%. The other two fuzzy oppositions, like in the classical case, can satisfy only one of the two conditions. Fuzzy contrariety includes fuzzy mutual exclusivity but not fuzzy joint exhaustivity, and fuzzy subcontrariety includes fuzzy joint exhaustivity but not fuzzy mutual exclusivity.

5.2. The fuzzy logical hexagon applied to gender categories

In Subsection 2.6, I claimed that the problems for Tauchert's (2002) model (as well as for the standard gender spectrum) stem from the fuzzy joint exhaustivity of the notions "male" and "female," the fact that the two values add up *all the way* to a 100%. So, if we are looking for a better fuzzy opposition between two gender categories, fuzzy contrariety seems to be the only candidate (given that fuzzy subcontrariety also features joint exhaustivity). A model with this kind of opposition is, what I call, the "fuzzy gender hexagon," the fuzzy logical hexagon decorated with gender terms, shown in Figure 7. The figure also shows an example of a gender identity (the percentages associated with each corner.)

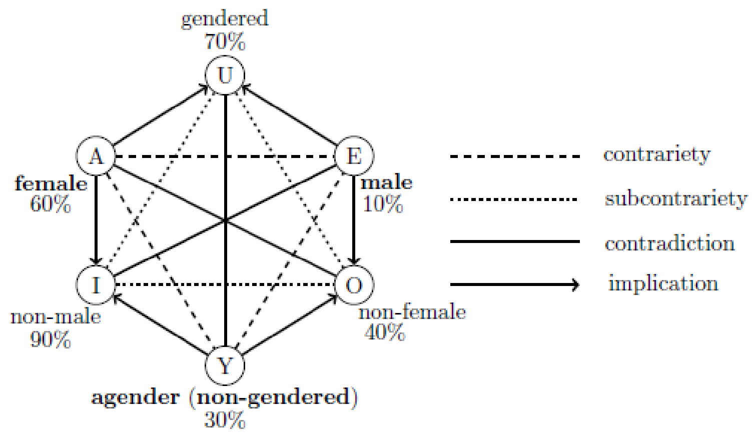

Figure 7: **Fuzzy gender hexagon** with an example of a gender identity

The figure looks like the classical logical hexagon, but it uses fuzzy, continuum-valued semantics. The fuzzy gender hexagon takes as its initial trichotomy the gender categories "female," "male" and "agender" (in boldface) and places these notions in the triangle of (fuzzy) contraries (A-E-Y). The other corners are then decorated with corresponding (fuzzy) negations of the three concepts, the same procedure as with the classical hexagon. The negation of "agender" (or "non-gendered") is worded as "gendered."

There is an important semantic proviso in the fuzzy logical hexagon: the values of the three terms which constitute a trichotomy (corners A, E, and Y) *have to add up to a 100%* (Dubois and Prade 2015, 84). This is a fuzzy way of representing trichotomies. In a classical trichotomy, an object can have one and only one of the three properties, which make up for all the "logical space." In fuzzy trichotomies, although now properties can mix, they still make up the whole logical space, the whole 100%. The person considered in Figure 7 is 60% female, 10% male, and the remaining 30% agender. The other percentages are calculated from the given values. For instance, the person is 40% non-female, since corners A and O are each other's fuzzy negation (i.e., in the opposition of fuzzy contradiction) and have to add up to a 100%.

Like in Tauchert's (2002) model or the standard gender spectrum, gender categories in the fuzzy gender hexagon add up to a 100%. But there is now a notable difference: instead of just the two traditional genders, there is also a third option ("agender"). This stems from the fact that any two gender categories, like "male" and "female," are not construed as fuzzy contradictory but fuzzy contrary. The person represented in Figure 7 is 60% female and 10% male. This adds up only to 70%, which means that the two terms are not jointly exhaustive. There is still some "semantic space" left.

All the logical relations from the classical logical hexagon still hold in its fuzzy iteration. Firstly, the "primitive" gender categories, located in the triangle of contraries, can be defined as *conjunctions* of their two neighboring categories. To be "female" means to be "gendered and non-male"; to be "agender" means to be "non-male" and "non-female" etc. Moreover, the notions found in the triangle of subcontraries (I-O-U) can be defined as *disjunctions* of their neighboring corners: "non-male," for instance, is equivalent to "female or agender." In the fuzzy hexagon, the logical connectives are understood according to fuzzy, continuum-valued semantics. So, these definitions feature fuzzy conjunction and fuzzy disjunction, more precisely "fuzzy strong conjunction" and "fuzzy strong disjunction" (Gottwald 2007). I leave the definitions of other fuzzy connectives (besides negation) for another occasion. Let me instead show how the percentages in Figure 7 relate.

The person shown in Figure 7 is 60% female, 10% male, and 30% agender. The values add up to a 100%, as the fuzzy logical hexagon demands. The person in question is then, it follows logically, 40% non-female. This follows by fuzzy negation, but it also follows by fuzzy disjunction—you can calculate the 40% of non-femaleness from its two neighboring corners: "male" and "agender." The person is 10% male and 30% agender, which are genders that are *not female*. When these values add up, you get 40% of non-femaleness. The values that we started with can also be calculated. In Figure 7, we can get the 60% of the person's femaleness (corner A) by adding the values of their genderness (corner U, 70%) and their non-maleness (corner I, 90%), and then subtracting a 100%. This second definition is perhaps not quite intuitive, but I believe all the percentages in Figure 7 check out.

5.3. Some features of the fuzzy gender hexagon

Like the three models of gender considered previously, the fuzzy gender hexagon is also a *spectral* model. It contains three spectra/continua ranging from 0 to a 100: between non-male and male (I–E), between non-female and female (O–A), and between agender and gendered (Y–U). In this regard, it is more closely comparable to the bispectral model and the trispectral model, where gender categories are portrayed as ranging from a negative to a positive gender category (see Figures 3 and 4).

The proposed model is different from the standard gender spectrum (i.e., Tauchert's model of gender), where there is only a single spectrum ranging from "male" to "female." It *does* connect these notions, but it doesn't make them the poles of a *spectrum*. A spectrum or a continuum has to range from 0 to a 100%, i.e., the opposed values have to add up to a 100%. In the fuzzy gender hexagon, the sum of values can be less. The line that goes from "female to "male" in Figure 7 is not a continuum, but a rather different kind of line. The terms "male" and "female" are no longer jointly exhaustive. However, they are still mutually exclusive—one grows only at the expense of the other. This marks an important difference between the fuzzy gender hexagon and the multispectral models. Unlike the multispectral models, the proposed model construes the values of the gender terms as *mutually dependent*. Being that there is fuzzy mutual exclusivity, not all combinations of values for the gender categories are possible. They have to, in accordance with the "semantic proviso" of the fuzzy logical hexagon, add up to a 100%.

The fuzzy gender hexagon (more precisely, the *idea* that it conveys) can be represented in a more straightforward way. We may not always need *all* the information we can find in the hexagon. Like Demey's (2019) classical hexagon for the theism/atheism debate (see Figure 6), the fuzzy gender hexagon can be called a *theory*, in the sense that it contains a lot of "logical truths" about gender notions. It shows which notion implies (or is implied by) which other, and offers (multiple) definitions for all the terms. The fuzzy gender hexagon is, of course, also a *model*, in the sense that it can be used to represent a person's gender identity (like in Figure 7). However, if we just want to see how a person identifies, we don't need all the logical information. In this case, a more readable way to represent the fuzzy gender hexagon is to use a pie-chart with three slices, each slice representing the amount of a (primitive) gender category. This representation would mirror the initial semantic proviso of the hexagon—adding up to a 100%.

I believe that the fuzzy gender hexagon is a legitimate model of gender (identity) supported by a sound logical theory. And I believe that it is, in a sense, already in use. In my understanding, Ho and Mussap's (2019) results show that some people already picture the amounts of gender categories as slices of a pie. As noted above, the authors notice that some of their respondents' answers across the three continua added up to a 100%, which may have been done on purpose. Some respondents, in other words, made the values mutually dependent (mutually exclusive), contrary to Ho and Mussap's intention. If they did this on purpose, these respondents were thinking of gender in line with the fuzzy gender hexagon—and

I agree with them a 100%. In the following subsection, I discuss the advantages of the proposed model over its spectral predecessors.

5.4. Advantages over the other spectral models

By weakening the opposition of fuzzy contradiction to that of fuzzy contrariety, the fuzzy gender hexagon avoids most of the pitfalls of the standard gender spectrum or Tauchert's (2002) "fuzzy gender" model. The problems with Tauchert's account, as I argued, stem from the fact that the terms "male" and "female" are there conceived as fuzzy jointly exhaustive. That is why Tauchert's account i) doesn't allow for (partly or fully) agender identities, ii) doesn't allow for other genders except "male" and "female" and iii) suffers from *overdetermination* between gender categories. The proposed model accounts for the first and the last one of these challenges. However, the fact that it does not account for the second one, as I will argue later, is not the fault of fuzzy contrariety (nor fuzzy mutual exclusivity).

The fuzzy gender hexagon allows for (partly or fully) agender identities since the gender category "agender" gets its own corner (or slice). But also, by adding this notion to the list of gender categories, it avoids the problem of overdetermination between gender categories. In Tauchert's model, it is redundant to say that one is 70% male and 30% female, since the two values always add up to a 100%. In the proposed model, on the other hand, one can no longer state only their percentage of, say, maleness and thereby make everything else known about their gender identity. From the fact that one is 70% male, we can, in the fuzzy gender hexagon, infer only that they are 30% *non-male*. We cannot determine their exact percentages of femaleness and agenderness—these have to be measured separately. All we can determine is that femaleness and agenderness take up 30% of the person's gender identity. There is *some* determination, but no *overdetermination*. I believe this also answers the Plumwoodian feminist critiques of Tauchert's model I raised above. One cannot define away the amount of femaleness and thereby "incorporate" it into the talk of maleness. Nor is the notion of "non-male" "homogenized," seen as only *the rest* and not further explored or developed (see Plumwood 1993). Here, "non-male" is further divided into "female" and "agender."

Moreover, the fuzzy gender hexagon solves the three problems raised against the multispectral models, which i) are guilty of graphically misrepresenting agender identities, ii) feature ambiguous representations and iii) suffer from *underdetermination* between gender categories. Firstly, agender identities are not graphically misrepresented since the term "agender" is in the hexagon treated in the same way as terms "male" and "female," receiving its own corner/spectrum/slice. The percentage of one's agenderness is noticed at a first glance, as opposed to being inferred from other categories. Secondly, the amounts of gender categories in a particular model (like in Figure 7) are unequivocal. In the multispectral models, the values lesser than a 100% can be (over)interpreted as pointing to agender parts of a person's identity, in such a way that agenderness would fill the remaining, "empty" space—even when this is not what the respondent wanted to report. In the proposed model, because the values are dependent, there is no such ambiguity. Each corner/spectrum/slice has a unique definition, so there is no place for confusion. If any of the values are lesser than a 100%, we always know what the remaining portion of gender identity is supposed to represent.

Lastly, there is no underdetermination. When I talked about this problem for the multispectral models above (Subsection 3.4), I said that, at that point in the paper, characterizing this problem as a *problem* may be "cheating." However, at *this* point, taking into account that the two other, genuine difficulties for the multispectral models (graphical misrepresentation and ambiguity) can be solved by the fuzzy gender hexagon, one can point a finger at underdetermination—the fact that values are there totally independent and don't say *anything* about each other. The proposed model avoids the problems of the standard gender spectrum by construing gender categories as mutually dependent, but in a different, weaker way (keeping only the fuzzy mutual exclusivity). If weakening the opposition is enough to move away from oppressive binarism, a solution that discards opposition (dependency) altogether (i.e., in *any* form) may be seen as an overreaction. Especially if the independency between the values invites further problems. So, instead of saying *everything* or *nothing*, gender categories in a model should say *something* about each other. All this is not to say, however, that the proposed model is without faults. But before that, let me say a few more things in favor of the fuzzy gender hexagon.

5.5. Fuzzy gender hexagon in context

Opposing gender categories by fuzzy contrariety, I believe, is in keeping with Plumwood's (1993) general recommendations for a feminist reform of logic, aimed at disabling oppressive conceptual differentiations. The proposed model hopefully contributes to Plumwood's point that logic (the discipline) can be used for feminist causes, given that the logical opposition of fuzzy contrariety evades some features of oppressive contrasts (namely, "hyperseparation," "incorporation," and "stereotyping").

Further, the proposed intervention into the opposition between gender categories is congruent with Eckert and Donahue's (2020) continuation of Plumwood's (1993) program. To subvert traditional dichotomies, the authors suggest a three-valued logic in which, aside from "true" and "false," there is also the truth value called "indeterminate" or, alternatively, "intermediate." The latter reading is especially in line with the present approach since fuzzy semantics can be seen as further distinguishing between the intermediate values, by introducing "shades of grey."

Finally, the proposed model is compatible with the model proposed by Collins (2021), who also argues that fuzzy logic is a way to go when it comes to gender. His account has a different focus. It is about the ways in which we can determine one's percentage of, say, femaleness and not so much about the logical relations between gender categories. He does not, however, exclude the possibility of a person being both female and male to degrees above zero, mentioning also partial and total agender identities—all of which is in line with the logic of fuzzy gender hexagon. In this way, Collins' view can be used as supplementary to the present one, and the compatibility of the two views can perhaps speak in favor of the "fuzzy paradigm."

5.6. Problems with the fuzzy gender hexagon

All this being said, there are still (at least) three things that can be said against the fuzzy gender hexagon:

1. It doesn't allow for other genders except "male" and "female."
2. It excludes some identities that are available in the multispectral models.
3. It leads to an explosion of an infinite number of gender identities.

Ad 1). When it comes to representing genders other than male and female, the fuzzy gender hexagon is no better than Tauchert's model. There are still only two hegemonic ways of being gendered (cf. Biana and Joaquin 2020). In this regard, the fuzzy gender hexagon falls behind the multispectral accounts, especially behind the trispectral one. This, however, can be fixed in a simple manner—by adding more corners to the structure. When it is decorated with concepts, the (fuzzy) logical hexagon, as noted above, can be understood as a logic of *trichotomies*. But a trichotomy of gender categories is not enough. Aside from "male," "female" and "agender," there should be at least one more gendered option (cf. Ho and Mussap 2019). For more nuanced taxonomies like these, one would need more complicated structures of opposition (see Subsection 4.4). For instance, to represent a *four*-way fuzzy division of gender categories, one would use a graded or fuzzy *cube* of opposition (Dubois and Prade 2015; Dubois, Prade and Rico 2020), in which there are four mutually fuzzy contrary terms and their negations. The cube is a more complicated diagram than the hexagon, but the principle is the same. The four options are jointly exhaustive and mutually exclusive, and the sum of their truth values always adds up to a 100%. And, most importantly, the relation between any two gender categories is *fuzzy contrariety*. A simpler representation of the fuzzy logical cube would be a four-sliced pie chart. The inability of expressing other genders is a problem for the fuzzy logical *hexagon*, not a problem for *fuzzy contrariety*.

Ad 2). Unlike the previous problem, this one cannot be solved in the proposed framework. In the multispectral models, one can be, for instance, fully (a 100%) male and fully (a 100%) female. This is not allowed in the fuzzy gender hexagon, nor would it be allowed in any more complex structure of opposition used to model gender identity. This means that fuzzy structures of opposition are *more restrictive* than the multispectral models. In this case, the problem stems from the very notion of fuzzy contrariety, which mandates fuzzy joint exhaustivity: the gender categories always "compete for space." The best any fuzzy structure of opposition can offer to a person who identifies as fully female and fully male is "50% male and 50% female." But they don't have to accept this representation and insist that their gender identity is better expressed by one of the multispectral models. I would take this to be reason enough to prefer Ho and Mussap's (2019) approach over the one proposed here (at least when it comes to identities that cannot be represented by the proposed framework, given that the multispectral models bring their own problems).

Ad 3). This is again a problem that cannot be solved by any fuzzy structure of opposition. But it also cannot be solved by any other model that features percentages. If a model allows for an infinite number of possibilities, this leads to an explosion of an infinite number of gender identities. Now, this may not be problematic on its own, but, as Biana and Joaquin (2020) warn, "if Tauchert's model aims to give a voice to each marginalized gender category, then she might fail to do so" (362). Maybe degrees are simply not *practical,* in which ever way one decides to model them. But this is a story for another occasion. My intention was to try to show that some graded models of gender (identity) are fairer than others.[9]

6. Conclusion

The "standard" gender spectrum, a continuum ranging from *male* to *female*, is a huge improvement over the traditional binary model, according to which one can be either one or the other, and no degrees are allowed. However, the spectrum stills suffers from some inadequacies, most notably the inability to represent other genders and agender identities. This is fixed in the models by Magliozzi, Saperstein, and Westbrook (2016) and Ho and Mussap (2019), which use independent scales to measure the degree to which a person identifies with a given gender category. The former model measures only the femininity and the masculinity dimensions, while the latter adds a continuum for "other gender(s)."

However, by conceiving the amounts of gender categories to be mutually independent, these models invite other difficulties. Firstly, they cannot measure the amount of a person's agenderness in the same way as they do for the "gendered" categories. "Male," "female" (and "other gender(s)") each get their own continuum, while "agender" does not. In this sense, agender identities are graphically misrepresented. Moreover, the multispectral models can be ambiguous. One and the same identification can be interpreted in conflicting ways. For instance, an identification of a fully male person may in the model by Magliozzi, Saperstein, and Westbrook (2016) look exactly the same as that of a person who is half male and half genderless.

In this paper, I argued that this can be solved by taking a step back towards the original spectrum and re-introducing an opposition between the gender categories. The two new models don't conceive gender categories to be in opposition of any kind, which is reflected in the fact that the values on the continua are independent. On the other hand, the standard gender spectrum does use an opposition between the terms "male" and "female." Using Tauchert's (2002) fuzzy-logical re-interpretation of the standard gender spectrum, I argued that this opposition is "fuzzy contradiction." Fuzzy contradiction is an opposition between two graded terms (i.e., terms that can come in degrees), and it is characterized by two features: "fuzzy mutual exclusivity" and "fuzzy joint exhaustivity." The problems of the standard gender spectrum, I claimed, stem from the latter feature. And we can remove it while still picturing the gender categories as being in an opposition, namely, the opposition of "fuzzy contrariety."

Fuzzy contrariety, as well as fuzzy contradiction and "fuzzy subcontrariety" can be found in "structures of opposition" (Dubois and Prade 2015), a family of abstract diagrams used in logic to represent relations between sentences or concepts. These structures apply to sentences or concepts from various domains. One such domain, I argued, can be *gender*. When fuzzy structures of opposition are filled with gender categories, we get models of gender (identity). In these models (e.g., in the "fuzzy logical hexagon") the two problems of the multispectral models do not appear, nor do the problems of the standard gender spectrum re-appear. This suggest that, instead of discarding all opposition between gender categories, we may want to reconsider it in another guise.

Fuzzy structure of oppositions (as well as their classical counterparts) can also be understood as *theories*, since they show all the logical relations between notions. However, if we want a more readable way to express the underlying idea of fuzzy structures of opposition, I argued, we can use *pie-charts*. In fuzzy structures of opposition, the gender categories relate to each other in the same way the slices of a pie-chart do. For instance, we can use the fuzzy logical hexagon to model a person's gender identity, but we can also, alternatively, use a chart with tree slices. The latter representation provides less information than the hexagon, but we may not always need *all* the information (e.g., in surveys). Can we have our cake and eat it too if we use pie-charts?

Notes

1. In logic (the discipline), "semantics" has to do with truth values, which are understood as *meanings* of propositions. In classical logic, for instance, a proposition *means* either "true" or "false." The other part of logic, "syntax," is about the manipulation of uninterpreted ("meaningless") symbols, which represents formal reasoning.

2. Aristotelian logic is not equivalent to classical logic, but the two agree on almost all basic logical principles. Importantly, they both allow only for two options regarding truth value. So, when it comes to criticizing the dichotomy of truth vs. falsity (as Tauchert does), the difference between classical and Aristotelian logic is not of great importance.

3. Fuzzy logic is not the only logic that allows for contradictions. Some logics do this in a more radical way than fuzzy logic. For instance, in Belnap (2019) and Priest (2007), some propositions can be simultaneously both fully true and fully false.

4. But not in all logics, for instance, not in "intuitionist logic."

5. But we could maybe fix this problem, in two ways. Firstly, one can say that the scale "agender" should not be independent of other scales but that it should add up to represent the "empty" space on other, independent spectra. Or, secondly, one might stipulate that "agender" should be logically prior to all other dimensions. In that case, a person could be 50% agender and then, of the 50% that is gendered, they could be 90% male and 10% female – which would make "gendered" categories dependent upon the "agender" category. I thank an anonymous reviewer for these suggestions. Personally, however, I find these solutions somewhat confusing. In both options, some scales would be mutually independent, and some would not. This may not be a graphical misrepresentation *per se*, but we still have a

situation where not all spectra are treated equally. In the model I propose in Section 5, all gender categories ("agender" included) relate to each other in the same way.

6. See, e.g., models by Blanché (1953), Béziau (2012), Moretti (2012), and Demey (2019).

7. The Aristotelian square of opposition has corners A, I, E and O, named after the Latin words "affirmo" and "nego", meaning "I affirm" and "I deny", respectively. The names A and I come from the first two vowels in the first word, and E and O come from the first two vowels in the second. The hexagon adds two corners, U and Y, which don't come from any Latin words, but from the fact that it was also the French (Sesmat 1951 and Blanché 1953) who co-discovered this extension of the square of opposition and proposed two remaining vowels for the two additional corners; although Jacoby (1950), an American, was the first one to discover the hexagon.

8. See Kalinowski (1967), Dufatanye (2012), and Restović (2022) for axiomatic representations of the logical hexagon.

9. Let me here briefly mention *genderfluid* identities. The fuzzy gender hexagon (and any other more complex structure) cannot account for them—but neither can the other spectral models considered in this paper. The fact that someone is genderfluid can be seen only if they take the same test twice, with different results. But there is no way in the proposed models to explicitly indicate that a person's gender identity is prone to change. Now, this may be a misrepresentation. If so, it indicates that further work is needed to provide a fully inclusive model of gender (identity). I thank an anonymous reviewer for pointing this out.

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