Ontological Categorizations and Ontological Relativity in Biomedical Sciences. A Case Study

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In the domain of biomedical sciences, the integration of ontological and conceptual analysis holds the potential for valuable progress in deepening our comprehensive understanding and management of complex phenomena. This paper explores the ontological assumptions of ophthalmology in clinical practice in the context of glaucoma, a multifaceted eye condition that defies singular classification. Drawing on a case study of glaucoma surgery and intervention in New York State hospitals, we examine how ontological assumptions shape medical theory and clinical practice, ultimately promoting innovative interdisciplinary research in a concrete manner. Patient confidentiality has been strictly maintained throughout the study.

Keywords: Ontology; Ontological Relativity; Ophthalmology; Glaucoma

I. Ontological Categorizations and Ontological Relativity: A Few Premises

Among the various philosophical analyses applied to biomedical sciences, ontology holds a prominent position due to its unique nature and utility in conceptual analysis, that has been generally acknowledged by the literature in philosophy of medicine (Chute 2000; Scheuermann-Ceusters-Smith 2009; Robinson 2011; Bandrowski *et al*. 2016), even though mostly within information theory (e.g., with a disease ontology to integrates medical vocabularies, ontological maps to enhance compatibility among anatomical classifications for various species or a gene ontology for the sake of consistent descriptions across databases) and less so within philosophical ontology.

Ontology, in this sense, refers to a formal framework or model that captures the essential concepts, objects, and relationships within a specific domain of interest, usually the domain of a scientific theory (Guarino 1985; Cocchiarella 2007; Valore 2016; Cappelen 2018; Burgess-Cappelen-Plunkett 2020; Chalmers & Jackson 2001; Chalmers 2020). Mapping an ontology requires not only the identification, for a given theory, of the relevant categories of entities, their properties, and the connections between them, but also the hierarchical organization of concepts and relationships within a structured representation of knowledge in levels of generality. Such a hierarchy allows for better understanding, scrutiny, and communication within the domain and facilitates knowledge integration and reasoning. For instance, mapping concepts and studying relationships within the taxonomy of given domains of objects helps clinical data retrieval and analysis, defining "classes" or "types" of cases (the "I've seen a case like that before"-moment), specifying the relevant properties we consider when assigning a certain individual entity to a category of cases we already know, and helps also establishing notions such as subclass, part-whole, or associative relationships (Smith & Medin 1981; Poli-Simons 1996; Munn-Smith 2008). In addition to ontology as a structured framework for knowledge representation, for the sake of classification, organization, and navigation of objects within the domain, we believe that philosophy can contribute in its unique way, mapping the ontological trees of a given theory to reveal the philosophical background presuppositions that guide our selection of meaningful properties and give sense to our sorting strategies. Clearly, evaluations of alternative maps presuppose normative concepts and preferences (or even bias) between

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what is meaningful and what is not, and we recommend exploring these presuppositions rather than applying them blindly. We think that philosophical ontology can facilitate this exploration.

One cannot avoid, in fact, to recognize that ontological categorizations are not fixed or always valid, since fundamental categories are subject to change, revision, and even viewpoint-dependence (Rehder & Hastie 2001; Ahn & Kim 2000), in the sense of what is sometimes called "conceptual relativity". Conceptual relativity refers to the idea that different conceptual perspectives that arise from philosophical, cultural, historical, and contextual factors can be employed to understand and classify the same phenomena. The relativity is mirrored in our taxonomies in ontology: "ontological relativity" is the approach that acknowledges the existence of alternative maps and classifications based on different background assumptions. It recognizes that different perspectives and conceptual frameworks can shape how we categorize and understand a given domain and acknowledges that alternative (but equally valid) ontological classifications can emerge based on alternative tacit conventions, cultural norms, disciplinary perspectives, or even philosophical preferences.

The concept of ontological relativity (Quine 1969; Putnam 2004; Rosch & Mervis 1975; Rosch 1978; Sosa 1999; Sosa 2009; Valore 2024) is based on the philosophical reconstruction of the connection between individuals (e.g., patients, or individual symptoms) and categories (e.g., kinds of patients, or diseases), as observed in the instantiation relation, which relies on the notion of "similarity" among cases (Rehder & Hastie 2001; Valore 2018). We believe that a central notion of ontological relativity, when we say that an individual instantiates a certain category, is "resemblance" or "similarity". When analyzing the theoretical knowledge embedded in human understanding of kinds, types, and categories, it becomes evident that the concepts of "resemblance" cannot simply be assumed in a pre-theoretical, naïve way, but requires further philosophical and conceptual clarification, for the simple fact that it is not even clear that we have one single notion of "resemblance".

One could think that we already have an easy way to address this complexity: we could try reducing the notion of resemblance to more manageable (and clearer) concepts like set-membership. When considering an individual I_i from the set of individuals I:{I_1, I_2, …, I_n} and a set of predicates P:{P_1, P_2, …, P_n}, we expect to be able to match the suitable predicate P_i or its negation $\neg P_i$ to that individual. For instance, a particular patient could be acknowledged as a case of a specific kind of patient if he exhibits the property relevant to be that kind of patient. Or certain phenomena can be considered a case of a certain disease if it exhibits the property relevant to that disease. This strategy could be a reliable way to build our ontologies, without the philosophical worries we just mentioned. However, it is not

clear how this could work: the strategy is based on the idea that properties do not exhibit degrees of variation (allowing the decision, for a given entity, to definitely consider or not consider a patient of a certain kind), while, in practice, it is not always feasible to determine whether a particular predicate P_i holds true for a given individual I_i. Quine (1969) notably discussed an attempt to improve this approach by introducing a degree of similarity, defined through joint membership in sets: "I_1 is more similar to I_2 than I_3" could simply mean that I_1 and I_2 are members of more sets together than I_1 and I_3". However, since sets are generated by exhaustively considering combinations, the number of sets to which any two elements jointly belong is not determined by their similarity but by the total number of elements. Recent literature (Bird & Tobin 2016; Beebee & Sabbarton-Leary 2010; Campbell, O'Rourke, & Slater 2011) tries to address the issues raised by set theory by adopting a narrower notion of kind with different strategies, but the level of success is unclear.

We believe that it is important to first establish our goals and context, when we face choices about what is appropriate or fitting, clarifying the background theory that define what is desirable or suitable and why. In other words, we need a guiding principle that can reliably produce the correct or suitable grouping for our objectives. The challenge here lies in the fact that our aims are chosen from an evaluative perspective, which may introduce a bias in the data towards a preferred perspective among the many possibilities. Ontological relativity offers an approach that incorporates alternative perspectives in our organizational strategies. The main point is that we should be cautious about the notion of one singular, definitive taxonomy for different kinds or one single, definitive classification of individuals without considering what properties are deemed relevant or preferred and the rationales behind those choices. In a nutshell, ontological relativity proposes a tolerant and pluralistic view on what counts as "natural" and "normal" categories. As LaPorte (2004) puts it: "the taxa recognized by different systems of classification may be natural in different respects."

In the context of biomedical sciences, the pluralistic approach of ontological relativity provides a powerful framework for categorizing and understanding medical phenomena. Recognizing the role of ontological categorizations and understanding their conceptual relativity in biomedical sciences allows for a more nuanced and critical analysis of data and it encourages researchers and professionals to be mindful of the underlying assumptions and philosophical perspectives that influence our understanding and classification of diseases or patients. Along the lines of our acceptance of ontological relativity as a general framework, ontological analysis in biomedical sciences can help our in-depth scrutiny of medical data through the systematic examination and clarification of key terms and categories

and also incorporates the acknowledgment of a set of underlying background presuppositions (that are not data themselves but are needed to make sense of data). These presuppositions guide alternative strategies in medical research and clinical practice, identifying the relevance and significance of given information and determining what is assumed to be essential within a given context. Moreover, ontological analysis in biomedical sciences often extends beyond purely philosophical inquiry, enhancing data interoperability, decision support systems, and research advancements.

Analyses from the point of view of ontology, encompassing both philosophical and computational perspectives, as well as mereology, have been already applied to various aspects of biomedical sciences, with general analysis of the concept of "disease" (Sulmasy 2005: Schwartz 2007; Dragulinescu 2010; Lemoine 2013) or the notion of "kinds of patients" (Hadorn 1997), and specific consideration of anatomy (Donnelly 2004), cardiology (Valore 2017), radiology (Marwede-Fielding 2007). However, the framework and background theory of the ontological categories in the case of ophthalmology, in the sense of ontological relativity, have seemingly benefited less from cross-fertilization among medicine and philosophy.

We selected the categorization of glaucoma in the field of ophthalmology as a paradigmatic case study to apply our conceptual analysis through the lens of ontological relativity. The classification and understanding of diseases (or family of diseases) like glaucoma can vary based on different ontological categorizations. One framework may focus on the anatomical aspects of the eye, while another may emphasize the underlying physiological or neurological processes. These different categorizations can lead to variations in diagnostic criteria, treatment approaches, and even research methodologies.

By focusing on this specific area, we aim to explore how different conceptual background assumptions can influence the categorization of glaucoma, highlighting the relativity of ontological frameworks in understanding and classifying this intricate condition, thereby potentially influencing the effectiveness of treatments and, ultimately, the well-being of patients.

II. A Lack of Clear Categorization

The term 'glaucoma' originated from the Latinized form of the Greek word 'glaukoma,' which referred to 'cataract' or 'opacity of the lens.' It is believed to have been derived from the combination of 'glaukommatos,' meaning 'gray-eyed,' which consists of 'glaukos,' an adjective of uncertain origin denoting 'gray' or 'gleaming,' and 'omma,' meaning 'the eye.' This terminology was attributed to the grayish appearance of the eye observed in advanced stages of the disease. The ancient concept of glaucoma emphasized the notion of a "hardened eye," suggesting an occlu-

sion of fluid outflow and, historically, the understanding of glaucoma was often intertwined with broader concepts of ocular diseases. With advancements in anatomical knowledge and the development of the ophthalmoscope, the understanding of glaucoma started to evolve and focus on the appearance of the optic nerve and the intraocular pressure as defining factors in glaucoma gained prominence.

Finally, in the 20th century, the introduction of improved tonometry measurements, visual field testing, and better imaging techniques facilitated more accurate diagnoses and monitoring of glaucoma. The concept of primary open-angle glaucoma (POAG) emerged as the most common form, characterized by progressive optic nerve damage and visual field loss, but alternative perspectives, such as the vascular theory and the neurodegenerative theory, were proposed, highlighting the multifactorial nature of glaucoma. Throughout these historical developments, ontological relativity can be observed to the point that glaucoma has been considered a broad category encompassing a wide variety of clinical entities, clinical findings, diagnostic techniques, and treatment options (Choplin & Traverso 2014: xii) and even a number of distinct diseases (Azuara-Blanco *et al.* 2002: 17). Different conceptual frameworks influenced the understanding and categorization of glaucoma, and these varying conceptual frameworks and ontological categorizations have resulted in different diagnostic criteria, treatment approaches, and research directions.

In recent debates surrounding the definition of glaucoma, several key points have emerged, underscoring the urgency to undertake a thorough conceptual analysis and categorization of what is encompassed by the term "glaucoma."

The first essential aspect is the inclusion of functional and structural factors. Traditionally, glaucoma has been primarily defined based on elevated intraocular pressure (IOP) and characteristic optic nerve damage. However, there is an ongoing discussion about the importance of incorporating functional factors, such as visual field loss, alongside structural indicators. This broader perspective aims to capture the full spectrum of glaucomatous damage and its impact on visual function. This implies a shift from considering one or more properties that were previously regarded as predominantly relevant for the definition of the disease to emphasizing different properties or additional aspects. More technically, this methodological aspect of conceptual analysis is crucial in determining which property or properties hold significance when assessing whether an individual can be categorized as an instantiation of a particular set (in our case, an instantiation of glaucoma). For instance, if the term "glaucoma" is understood to represent a disease marked by an irreversible impairment in visual function, then individuals experiencing symptomatic episodes of high IOP or those with narrow drainage angles who are current-

ly asymptomatic would not fulfill the criteria for nerve injury associated with glaucoma (Foster *et al.* 2002).

Another key point is the emphasis on early detection and intervention. With advancements in diagnostic techniques, there is a growing emphasis on the early detection and treatment of glaucoma. The debate revolves around determining the threshold at which a patient should be diagnosed and classified as having glaucoma, considering factors such as risk assessment, structural changes, and functional impairment. Early intervention can potentially prevent or delay vision loss and improve long-term outcomes. The determination of the boundary that distinguishes cases that qualify as instances of glaucoma from those that do not is unquestionably a matter of categorization. This process also entails an examination of vagueness issues and necessitates careful analysis and treatment of the property needed for certain phenomena to be qualified as an instantiation of glaucoma. It may not be enough to determine whether an object A satisfies a property P, indicating that A meets the criteria or conditions specified by the property P, in order to express that $A \in P$. We may need to introduce the concept of "degree of satisfaction" or "degree of fulfillment." Instead of a binary understanding of possession, this perspective acknowledges that properties can be satisfied to varying extents or degrees. Thus, an object A can be said to have a degree of satisfaction or fulfillment of a property P, denoted as $A \in P$ with a specified level of satisfaction indicated.

In addition, there is recognition that glaucoma is a complex and heterogeneous disease or family of diseases with variations among individuals. This has led to discussions about the need for a more personalized approach to diagnosis and management, considering factors such as age, race, genetics, lifestyle, and patient preferences. Tailoring treatment strategies to the individual characteristics of each patient is seen as essential for optimizing outcomes.

Another direction is offered by the addition of imaging technologies. The use of advanced technologies, such as optical coherence tomography (OCT) and visual field testing, has significantly enhanced the understanding and diagnosis of glaucoma. The debate focuses on the standardization and interpretation of these measurements, as well as their role in guiding treatment decisions and monitoring disease progression.

Overall, there is a conceptual shift towards a multifactorial disease model: a notable debate centers around moving away from a simplistic view of glaucoma as solely an IOP-driven disease. Instead, there is an increasing recognition of the multifactorial nature of glaucoma, involving complex interactions among genetic, environmental, vascular, and mechanical factors. This shift calls for a more comprehensive and holistic understanding of the disease and its underlying mechanisms.

These recent debates highlight the evolving nature of glaucoma definition and classification, reflecting a deeper appreciation for the complexity of the disease and the need for careful handling of the ontological map and an improved conceptual analysis of glaucoma.

III. Different Types Based on Different Categorizations

Glaucoma is an excellent example of how ontological categorization profoundly influences treatment approaches. In order to fully grasp the significant impact of ontology and ontological relativity, it is useful to delve into the proper categorization of glaucoma as an eye condition, assuming that there is a "proper" one.

An ontological taxonomy provides a hierarchical structure to organize and classify different types of glaucoma within the broader context of eye conditions. For example, we could narrow down the broader category of "Eye Conditions" to "Glaucoma" as a specific condition within that category and then provide more specific subcategories and types of glaucoma. Spaeth (1994) considers six ways for generating the taxonomy of Glaucoma, something we would define as a *meta-taxonomy* for glaucoma (Figure 1):

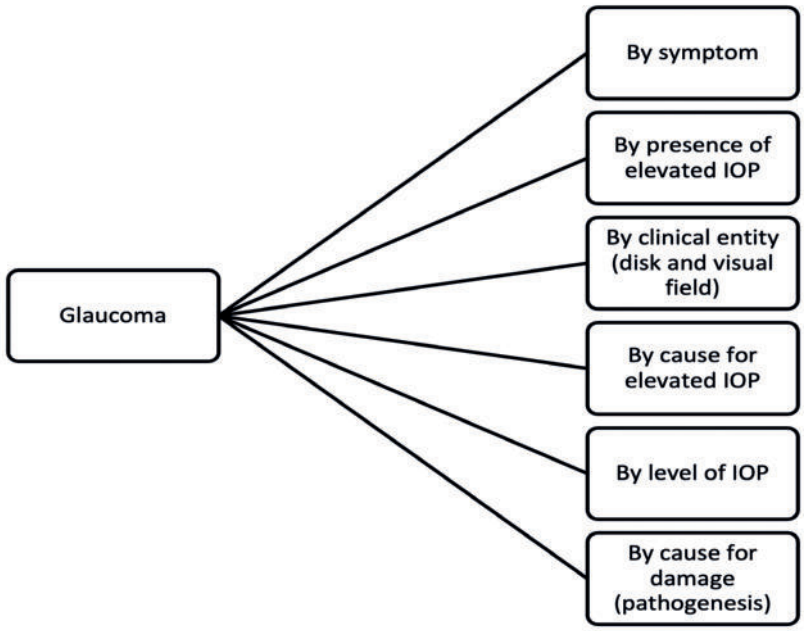

Fig. 1

The meta-taxonomy provided in Figure 1 is a simplified example and can serve as a starting point for organizing the types and subtypes of glaucoma in taxonomies. However, it is important to note that constructing an ontological taxonomy can be a complex and challenging task, and there can be several potential issues and unclear presuppositions associated with it. Here are some reasons why the taxonomy can be problematic:

1. *Ambiguity and Overlapping Categories*: The boundaries between different types of glaucoma can sometimes be blurred, leading to ambiguity and overlapping categories. For instance, there can be cases where it is challenging to determine whether a particular glaucoma case falls under the category of primary or secondary glaucoma.
2. *Evolution of Knowledge*: The field of glaucoma research is constantly evolving, with new discoveries and advancements shaping our understanding of the disease. As knowledge evolves, the taxonomy may need to be revised and updated to accommodate new information and reclassify certain types or subtypes.
3. *Individual Variations and Heterogeneity*: Glaucoma is a complex condition that can manifest in various ways and exhibit heterogeneity among individuals. The taxonomy may not capture the full spectrum of variations and nuances in the disease presentation, leading to potential gaps or limitations in its classification.
4. *Cultural and Contextual Differences*: The taxonomy presented may not fully account for cultural or contextual variations in glaucoma classification. Different regions or medical traditions might have alternative categorizations or terminologies that need to be considered for a more comprehensive understanding. E.g, the European Glaucoma Society Glaucoma Classification allows more than 70 types and subtypes of glaucoma, with the "aim of improving the mutual understanding of this disease in Classification of Glaucoma". This is not an easy task, since, for instance, "Childhood Glaucoma" is based on the definition of "childhood" as "younger than 18 years" in the US and as "16 years or younger" in the EU, UK and for UNICEF (Cf. Beck-Chang 2013; Beck-Chang 2016-Freedman 2013).
5. *Diagnostic Challenges*: The taxonomy assumes clear-cut diagnostic criteria and reliable methods for classifying glaucoma. However, in reality, diagnosing glaucoma can be complex, involving multiple assessments, such as intraocular pressure, visual field testing, optic nerve evaluation, and corneal thickness measurements. Uncertainties or limitations in diagnosis can impact the accuracy and consistency of the taxonomy. For instance, the highest level of certainty entails the presence of optic disc abnormalities (ver-

tical cup-to-disc ratio >97.5th percentile in the normal population) and a visual field defect consistent with glaucoma, but if a visual field test cannot be adequately performed, a severely damaged optic disc (vertical cup-to-disc ratio >99.5th percentile in the normal population) would be deemed sufficient for diagnosis. And if this assessment is not possible, because the optic disc examination is hindered by media opacity (preventing a visual field test), an intraocular pressure surpassing the 99.5th percentile of the normal population or evidence of prior glaucoma filtering surgery may be considered adequate for a diagnosis of glaucoma (cf. Foster *et al.* 2002). One problem with setting the bar at such high percentiles, however, is that many cases of glaucoma will be missed by this approach. There will be no false positive cases (patient without glaucoma who are diagnosed with the disease) but many false negative cases (patient who have glaucoma but are deemed to be negative for the disease). Because glaucoma is an irreversible disease that can cause blindness, practitioners would typically rather err on the side of having too many false positives than false negatives, so patients don't needlessly lose vision. Thus, many patients are categorized as glaucoma "suspects" (those with worrisome optic nerves but no definitive findings of glaucoma) to make sure these patients are followed closely so that if they develop definitive glaucoma, they can be identified early and treated appropriately to prevent vision loss.

In addition to the awareness of potential issues and uncertainties linked to any ontological taxonomy, it is crucial to acknowledge a more substantial problem, that can be explicitly faced through ontological relativity.

We can in fact, have not only different taxonomies, but also different metataxonomies.

Choplin (2014: 7-11) considers four modes of categorizing glaucoma:

1. *By Mechanism*. The significance of gonioscopy in reaching an accurate diagnosis is underscored by this categorization. This classification holds therapeutic implications. For instance, primary open-angle glaucoma often exhibits positive response to miotics like pilocarpine, whereas treatment with miotics may aggravate inflammatory glaucoma. Iridotomy is an appropriate intervention for managing angle closures caused by pupillary block, but not for non-pupillary block angle closures.
2. *By Intraocular Pressure*. This classification plays a crucial role in the development and progression of glaucoma. For instance, the most common type of glaucoma typically progresses slowly over time, while a sudden increase in IOP can lead to a rapid and severe elevation in pression and requires immediate medical attention.

3. *By Age of Onset* Including developmental glaucomas.
4. *By Stage of Disease*.

And several competing strategies can be employed.

For instance, years ago (cf. Spaeth 1975), it was customary to classify glaucoma based on fluorescein angiography, according to the basic mechanism of visual loss, postulating four categories: 1) primary hyperbaric, 2) primary ischemic, 3) secondary ischemic, and 4) mixed. More recently, we prefer to build our taxonomy with divisions and specific subcategories and types of glaucoma based on different types of angles, such as "Open-Angle Glaucoma," and "Angle-Closure Glaucoma". Each level of the taxonomy provides more specific subcategories and types of glaucoma. For example, in Figure 2, under "Open-Angle Glaucoma," there are subtypes like "Primary Open-Angle Glaucoma" and "Secondary Open-Angle Glaucoma," and more subdivisions can be introduced, such as "Acute angle closure", or "Chronic angle closure".

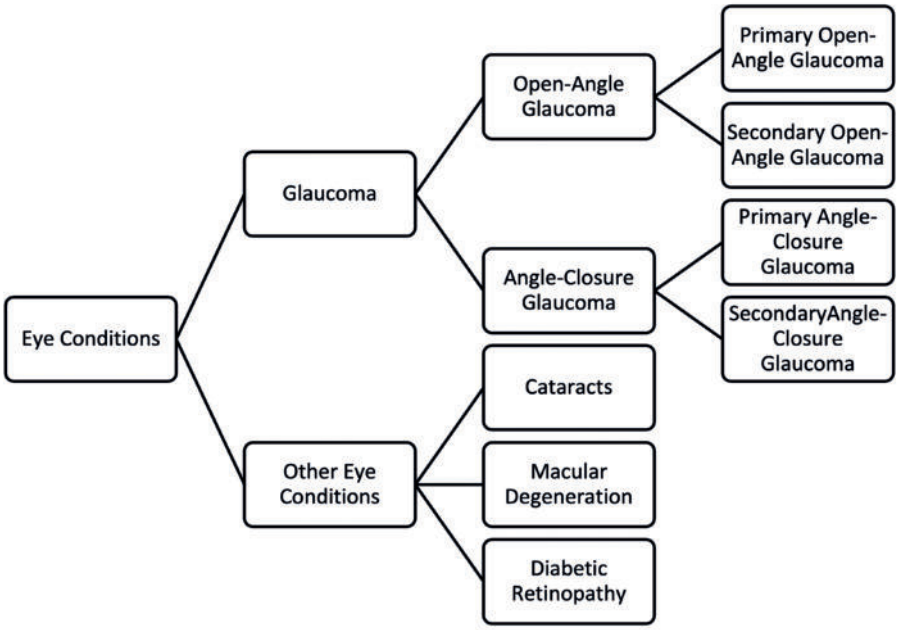

Fig. 2

We can also reorganize our data in an alternative categorization, where the focus shifts towards the underlying mechanisms of glaucoma development rather than specific clinical manifestations or subtypes. This categorization, based on the underlying abnormality that causes raised intraocular pressure is actually the most common classification (see, e.g., Azuara-Blanco–Wilston–Costa 2002: 17, based on a modification of the classification in Ritch–Shields–Krupin 1997: 717).

The taxonomy based on the pathophysiology can, for instance, further specify Primary Open-Angle Glaucoma into "Trabecular Meshwork Dysfunction" and other mechanisms contributing to intraocular pressure elevation and subsequent optic nerve damage, and Angle-Closure Glaucoma into "Pupillary Block" and "Plateau Iris" as the primary mechanisms causing an obstruction of aqueous humor outflow. Correspondently, Secondary Glaucoma will encompass various subtypes that result from underlying conditions or factors, such as neovascularization in neovascular glaucoma or inflammation in uveitic glaucoma. The taxonomy can obviously be further expanded or customized based on specific research needs and clinical contexts, for instance considering other abnormalities of the trabecular meshwork, such as Posner-Schlossman (trabeculitis) or other abnormalities in the elevated episcleral venous pressure, such as Sturge–Weber syndrome, Thyroidopathy and Cavernous sinus thrombosis. Figure 3 shows an example of this alternative classification (a simplified and slightly modified version based on Choplin 2014: 8).

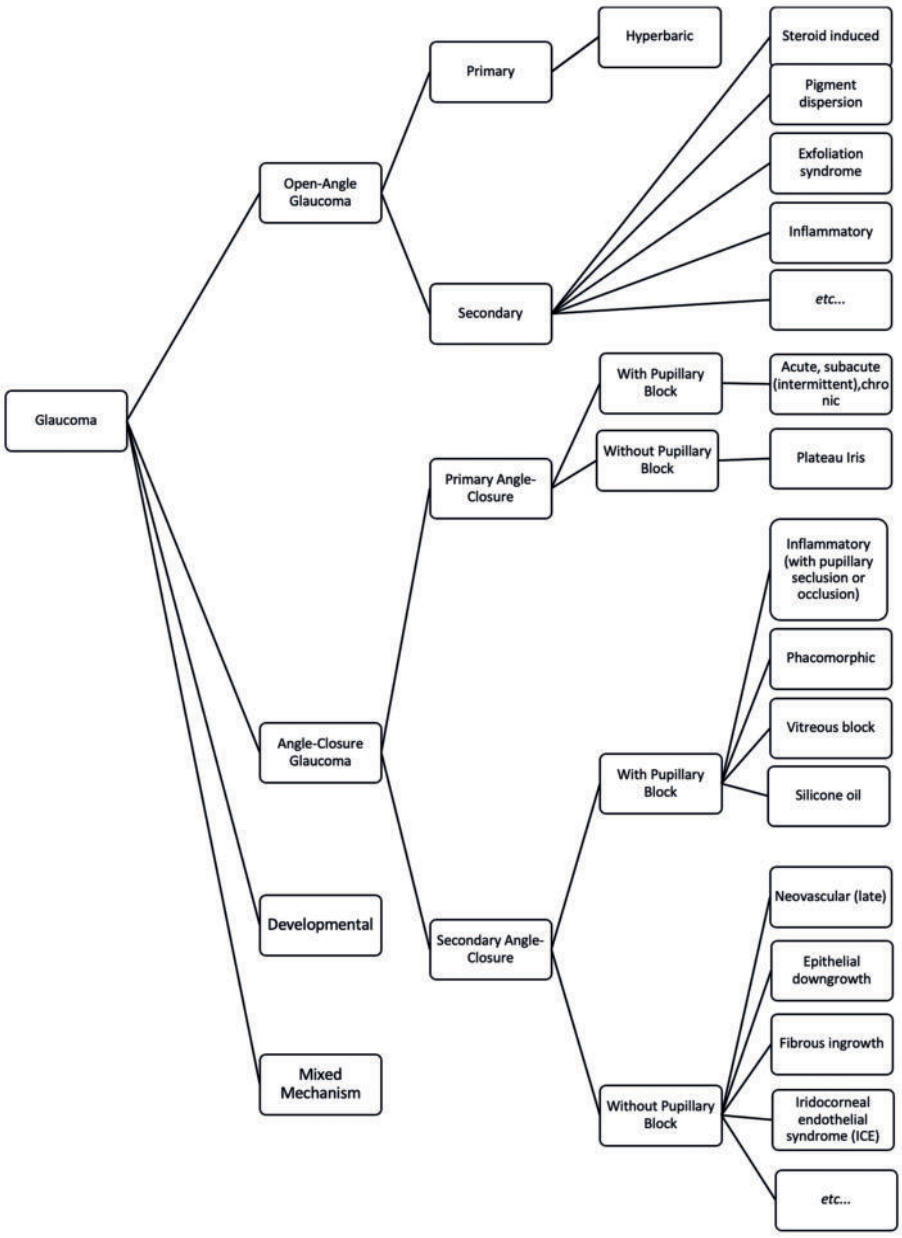
Glaucoma
Open-Angle Glaucoma
Primary
Hyperbaric
Secondary
Steroid induced
Pigment dispersion
Exfoliation syndrome
Inflammatory
etc...
Angle-Closure Glaucoma
Primary Angle-Closure
With Pupillary Block
Acute, subacute (intermittent),chronic
Without Pupillary Block
Plateau Iris
Secondary Angle-Closure
With Pupillary Block
Inflammatory (with pupillary seclusion or occlusion)
Phacomorphic
Vitreous block
Silicone oil
Without Pupillary Block
Neovascular (late)
Epithelial downgrowth
Fibrous ingrowth
Iridocorneal endothelial syndrome (ICE)
etc...
Developmental
Mixed Mechanism

Fig. 3

Another classification can be built based on the specific mechanism of outflow obstruction (Figure 4):

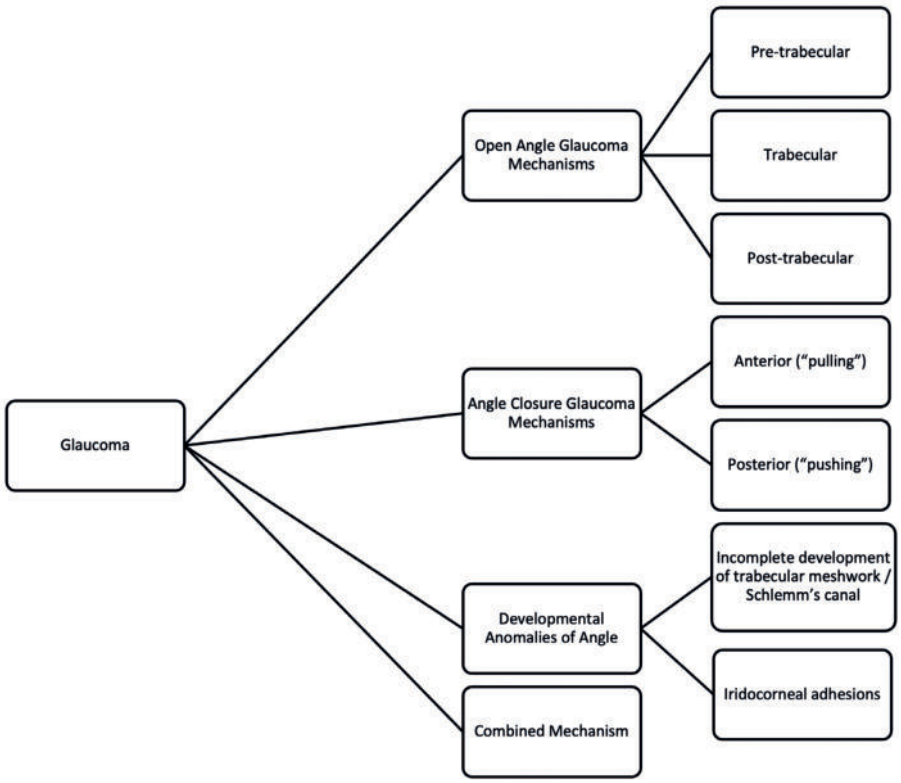

Fig. 4

Both the taxonomies built on clinical presentations or specific types and the alternative sorting out strategies based on the pathophysiology, or the initial events are valid in their own right and reflect different perspectives and emphases within the field of glaucoma classification. They also in part overlap, but some terms may be misleading: e.g., the classification that includes the "Angle-closure Glaucoma" does not match the label "Narrow-Angle", because narrowing of the anterior chamber angle does not hold significant implications until it reaches a state of closure, either partially or completely (Choplin 2014: 7).

The choice between classifications may depend on the specific research or clinical context, the goals of the classification system, and the underlying theoretical framework being employed. It is not just a matter or reorganizing data: amid

evolving fundamental concepts of glaucoma, numerous clinical entities emerged, some of which were defined by certain individuals as "glaucoma" and frequently questioned by others. Also, the same label "glaucoma" may require completely different treatment choices in clinical practice, as we mentioned in the opposition of primary open-angle glaucoma and inflammatory glaucoma.

Unfortunately, the theoretical framework that guides and justifies the choice of concepts, categories and ordering strategies is often not even investigated and simply tacitly assumed.

IV. Applications in Clinical Practice

In clinical practice, the significance of definitions and alternative categorizations of glaucoma for treatments is confirmed. Glaucoma is traditionally defined as a group of diseases of the optic nerve and retinal nerve fiber layer that may not necessarily involve elevated intraocular pressure: the current definition, such as that provided by the US National Eye Institute[1], focuses on the damage to the optic nerve. This new definition aims to address the fact that glaucoma can occur even with normal intraocular pressure.

However, in practical clinical settings, the old emphasis on IOP remains the most relevant because the elevated intraocular pressure is the one factor that can be treated. And even in cases of normal IOP, reducing the pressure by 30 percent is clearly beneficial. Additionally, there are instances where early glaucoma may be present without visible nerve damage yet and, as the pressure increases, treatment is initiated regardless of the appearance of the optic nerve. For instance, the analysis of clinical data in hospitals and private practices in New York State showed that healthcare professionals choose often to consider cases with high intraocular pressure and no nerve damage as a case of glaucoma (for instance, treating any pressure above a certain threshold, such as 21, 25 or 30).

It's questionable whether, in these cases, the treatment is specifically targeting glaucoma, given that the optic nerve appears healthy. There could be ongoing discussion regarding the precise meaning of the concept of "glaucoma treatment" (cf. Chaplin & Traverso 2014: 4). While reducing intraocular pressure is known to diminish the likelihood of glaucoma development (in the case of ocular hypertension) or progression (in the case of established open-angle glaucoma), it can be argued that we are primarily addressing the risk associated with glaucoma rather than the condition itself. However, the point in clinical practice is that sometimes visual damage occurs after the initial insult to the optic nerve, and even while the pres-

1 - https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/glaucoma

sure is being treated, damage may still be happening and remain undetectable for months. This highlights the need to be flexible in considering the relevance of alternative factors in identifying cases of glaucoma, for instance in terms of intraocular pressure even in the absence of visible damage, given the delay in the manifestation of such damage.

Another practical effect of flexibility in moving across taxonomies is inflammatory glaucoma (glaucoma is seen in about 20% of the patients with uveitis). Uveitis is most commonly treated with steroids. However, steroid treatment can be problematic, for instance in patients already using steroids for allergies. Sadly, steroids can be a cure for inflammatory glaucoma but can also cause elevated IOP and worsening glaucoma in some cases. For instance, a patient we studied in New York State was treated with steroid eye drops by a physician because of chronic eye allergies, resulting in steroid-induced glaucoma. Unfortunately, this patient was not referred to an eye doctor promptly, leading to blindness in one eye. Because the disease (uveitis) and the treatment of that disease (steroids) can both cause elevated IOP, the clinician must be vigilant to evaluating whether the treatment is lowering or raising the IOP. It should also be noted that the response of IOP to glaucoma medications can be unpredictable in the context of uveitis and in instances where medical treatments prove ineffective, surgical intervention often becomes necessary (Bodh *et al.* 2011).

Other cases that confirm that choosing the right categorizations of glaucoma may influence the choice of treatment are certain types of secondary glaucoma, such as pigmentary glaucoma (PG) and pseudoexfoliation glaucoma (PXF). These kinds of glaucoma respond particularly well to laser trabeculoplasty. In these cases, data from patients suggest that it is preferable to initiate treatment with laser therapy rather than eye drops, which are often used as the first line of treatment for glaucoma. More recently, the LiGHT study (Gazzard *et al.* 2023) showed that it is more advantageous in the long run to even start laser before glaucoma medications in patients with garden variety Primary Open-Angle Glaucoma with laser before glaucoma medications.

Choosing the correct surgical modalities also depends on the glaucoma categorization. For example, a patient with Normal Tension Glaucoma who does not start out with an elevated IOP will need to achieve enough of an IOP drop so they end up with what is typically considered a very low IOP to prevent glaucomatous progression. Certain procedures (e.g., trabectome) that might get patients to an average IOP will not be sufficient to treat a Normal Tension Glaucoma patient based on their disease categorization.

As another example, surgical procedures that target the angle (e.g., Kahook dual blade) will not be successful for patients with very narrow or closed angles

because the angle will not be accessible to adequately perform the surgery and achieve the desired results. Some angle procedures, such as argon laser trabeculoplasty, can cause worsening angle closure in a patient with narrow angles, which can in turn lead to higher IOP and worsening glaucoma; this is an instance where the proposed treatment can actually worsen the problem for some categories of patients. In patients where it is difficult to determine the level of openness or narrowness to the angle, performing ultrasound biomicroscopy can be helpful because it gives an anatomical view of the angle and can help the clinician decide which procedure to do for a patient depending on whether the patient's angle is open or narrow.

V. Conclusions

The recognition of ontological relativity highlights the existence of alternative maps and taxonomies. Different perspectives and conceptual frameworks can shape the categorization and understanding of a given domain, emphasizing the importance of acknowledging and considering diverse viewpoints in biomedical research, acknowledging that background assumptions have been made.

Our investigation has first and foremost provided insights into the relevance of ontological relativity in the context of theoretical biomedical research, based on the breakdown of taxonomies and meta-taxonomies to analyze the definition of the concept of glaucoma and of its sub-concepts. The utilization of ontology as a formal framework for conceptual analysis has been confirmed in its utility in understanding and categorizing medical phenomena.

The analysis of data from clinical practice has further confirmed the relevance and effectiveness of the ontological approach. By applying ontological analysis to real-world medical cases and observations from patients in New York State, we have observed how the systematic examination and clarification of key terms, classifications, and background assumptions not only significantly contribute to a comprehensive understanding of diseases but can also impact the choice of treatments.

The approach that puts together conceptual analysis, the philosophical strategy of ontological relativity, and biomedical research and practice transcends disciplinary boundaries. Such interdisciplinary collaborations have the potential to lead to groundbreaking advancements and innovative solutions in the field of biomedicine and underscores the significance of ontology as a foundational tool in scientific research, highlighting the transformative power of applying philosophical principles and methodologies in practical contexts.

Declarations

FUNDING AND/OR CONFLICTS OF INTERESTS/COMPETING INTERESTS

The research undertaken for this paper was conducted without any sources of funding or potential conflicts of interest, whether financial or non-financial.

RELEVANT ETHICAL ISSUES

The research did not involve human participants as direct subject studies and therefore did not need any informed consent nor procedures for obtaining consent from the guardian/legal representative. The research does not involve personal data collection and the data processing was anonymized with no risk of unauthorized access to personal data and no data transfer activities are planned.

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