An Ontological Investigation of Incompatibilities in Normative Systems

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Abstract

Contradictions, oppositions, and incompatibilities are pervasive in human cognition, social practice, and in a large number of applications. These phenomena are particularly significant in normative domains, where rules, obligations, and recommendations often interact in conflicting ways, as in clinical practice guidelines in healthcare. This work aims to advance the ontological understanding of contradictions and incompatibilities in normative systems by analyzing forms of opposition among propositions, the interaction of different deontic forces, and the role of agents' intentions acting inside a normative system.

Keywords

Incompatibility, Contradiction, Normative System, Practical Reasoning, Foundational Ontology

1. Introduction

The absence of 'contradiction' is often taken as a fundamental principle. For example, Descartes [1] treated contradictions as inconsistencies that would undermine the soundness of reasoning. At the same time, 'contradictions', 'conflicts', 'oppositions', 'incompatibility' and 'inconsistency' arise naturally in human thinking and can be considered inevitable in our social lives. It is hence not surprising that the theme has sparked debate in science and philosophy throughout history.

Whereas Cartesian rationalism treats contradiction as a formal inconsistency that renders a system invalid, dialectical and argumentative reasoning adopts a different stance, recognizing contradictions as significant elements of reasoning and inquiry. Dialectical proofs were not considered a plausible rational form for decades [2, 3] but Chaïm Perelman argued that reality is complex and analytical reasoning may not be sufficient. Thus, when there is no agreement about the deductive nature of some kind of thought, using dialectical proofs is unavoidable [4]. Without denying Cartesian reasoning, Perelman and Olbrechts-Tyteca established an argumentation theory recovering Aristotelian dialectic as a possible way of reasoning, reinterpreting apparent contradictions as contextual incompatibilities that require interpretation, choice, and revision rather than logical rejection [5].

While Perelman and Olbrechts-Tyteca defended argumentation as a means to deal with inconsistency and incoherence, Albert Camus went further to posit our inability to understand reality [6, 7, 8]. According to Camus, the world is absurd because it is incoherent, it is contradictory in itself.

Thomas Kuhn [9] argued that contradictions and anomalies are an inherent part of scientific inquiry. He highlighted that anomalies may arise in an established scientific paradigm when it is not sufficient to explain or address a particular phenomenon within its domain. Indeed, it is at this point that scientific knowledge has the potential to expand. Science, even if operating through the Cartesian scientific method, also progresses through the inconsistencies and anomalies it encounters.

In addition to being a focus of attention of scholarship, 'contradictions' (and related notions) have significant practical relevance in a number of domains of human inquiry and action. This is notably the case in normative/evaluative domains that establish rules, norms, principles, obligations, values or recommendations. The (apparent or actual) 'inconsistencies' caused by 'conflicting' normative elements are the subject of this research.

Proceedings of FOIS 2026 Satellite events co-located with the 16th International Conference on Formal Ontology in Information Systems (FOIS 2026), September 21-25, 2026, Vitória, Brazil.

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CEUR Workshop Proceedings ceur-ws.org ISSN 1613-0073

published 2026-11-27

CEUR-WS.org/Vol-4342/short4.pdf

We are particularly interested in accounting for this phenomenon as it appears in the medical domain, in which Clinical Guidelines (CGs) provide (possibly conflicting) evidence-based recommendations to assist healthcare professionals in treating patients. Several computerized representations of clinical guidelines have been proposed in the literature[10]. Given the complexity of the interaction between guideline recommendations, many studies have focused on identifying, understanding an managing these interactions [11, 12, 13]. These approaches commonly adopt an execution-oriented formalism, as they are primarily designed to support the execution of Clinical Guidelines.

In contrast, the Transition-based Medical Recommendation (TMR) is designed to capture the core knowledge structure of CGs[14]. It is a conceptual model for representing clinical recommendations through interventions and their effects on the patient's condition. The TMR also allows the modeling of possible interactions and conflicts between recommendations that may arise when multiple guidelines are applied concurrently to patients with comorbidities.

The goal of this work is to deepen the ontological comprehension about contradictions (or incompatibilities) for example in normative systems as the normative system surrounding clinical guidelines and their recommendations. The investigation will examine the nature of incompatibility among propositions and concepts, seeking to characterize the various forms that opposition may take. It will also explore how different deontic forces within normative and recommendation systems interact, and how these interactions can give rise to normative conflicts and other forms of opposition. Finally, it will investigate how agents interact with normative systems in light of their intentions, examining how intentions may both generate additional incompatibilities and facilitate the practical resolution of existing conflicts.

2. Theoretical Background

This research is developed through three theoretical approaches, described below: the Theory of Opposition, the formalization of acts-in-the-law in Legal Institutions Theory and the Practical Reasoning.

2.1. Theory of Opposition

Theory of Opposition brings light to the different kinds of opposition relations between concepts or propositions. Apuleius and Boethius proposed a geometric organization of opposing relations in what is known as Square of Opposition[15]. As seen in Figure 1, the Square relates four different statements (A, I, E and O). The statements can be be expressed in simplified terms as "universal affirmative" (A), "particular affirmative" (I), "universal negative" (E) and "particular negative" (O) and can be systematically related through the application of negation [16].

External negation is the negation of the whole statement. The external negation of the universal affirmative A, ***all*** *cats are white*, brings us to the statement ***not all*** *cats are white* (O). Starting from A again, ***all*** *cats are white*, but now applying an *internal negation*, where the negation is applied inside the content of the concept or proposition, we arrive at statement E, ***all*** *cats are* ***not****-white*, or in other words ***no*** *cat is white*. From statement E ***no*** *cat is white*, applying external negation, we arrive at corner I, ***not*** *no cat is white*, or ***some*** *cats are white*.

Opposition relations among the statements are formally specified. A **contradictory** relation between statements occurs when they do not share the same truth value. In that way, both statements cannot be true at the same time or false at the same time. For example, ***all*** *cats are white* (statement A) and ***not all*** *cats are white* (statement O) are contradictory. The **contrary** relation occurs when the statements can be both false but cannot be both true simultaneously. For example, ***all*** *cats are white*(A) and ***no*** *cat is white* (E) are contraries. And the **subcontrary** relation applies when both statements can be true at the same time, but not false at the same time. For example, ***some*** *cats are white* (I) and ***not all*** *cats are white* (O) are subcontraries. Finally, the **subalternate** relation reflects the logical implication of A to I and from E to O: if all cats are white, (A), then some cats are white (I) - and likewise for E to O.

The theory evolved and Robert Blanchè, maintaining a geometrical structure, proposed the Hexagon of Opposition adding two more statements on the Square: **U** statement (a disjunction of A and E) and **Y**

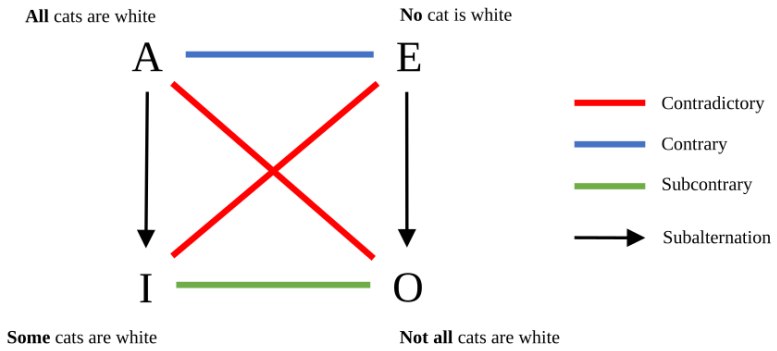

Figure 1: Square of Oppositions[17]

statement (a conjunction of I and O)[18]. The Figure 2 shows the Hexagon of Oppositions with the new statements.

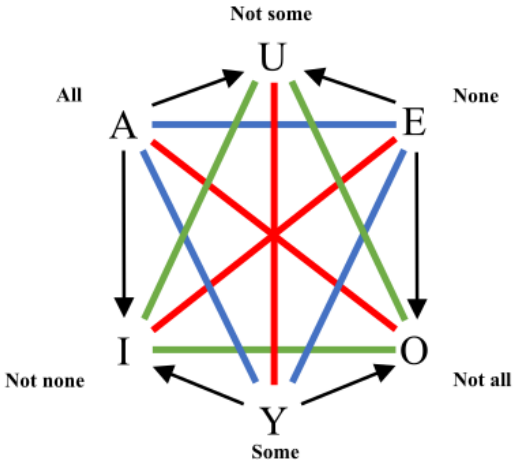

Figure 2: Hexagon of Opposition of Robert Blanchè[17]

2.2. Legal Institutions

According to Dick Ruiter, Legal Institutions can be understood as legal systems governing specific forms of social conduct[19]. In more extensive way, we can apply this concept to normative systems as Clinical Guidelines, for example. Within the scope of Legal Institution and based on John Searle's theory of speech acts, Ruiter explores the different kinds of acts-in-the-law and brings light to different kinds of deontic forces they operate [20]. **Declarative Acts-in-the-law**, for example, yield a legally valid state of affairs. **Imperative Acts-in-the-law** yield a legally valid order directed at the hearer to carry out some future course of action. **Hortatory Acts-in-the-law** yield a legally valid inducement aimed at influencing the hearer's future conduct.

Thus, an Imperative Act-in-the-law implies in an obligation or a prohibition. A Hortatory Act-in-the-law encourages or discourages certain actions. Act-in-the-law produces normative effects within an institutional legal system but have different implications and their interactions that may cause some kind of normative conflict. If two obligations cannot be fulfilled simultaneously, a normative conflict arises that Ruiter characterizes as 'irreconcilable'. Similarly, an obligation and a recommendation (a hortatory act-in-the-law) may interact in a way that generates a form of incompatibility.

Of course, normative systems are not merely logical systems, they are designed for practical application. Their function is to guide and regulate behavior. Consequently, normative systems typically

seek to avoid conflicts, such as simultaneously imposing an action and its omission. However, in the healthcare context, for example, different Clinical Guidelines pertinent to the same patient may issue conflicting recommendations. Ruiter provides a useful framework for understanding and resolving such normative conflicts. Also, the Theory of Opposition can also be applied to analyze these normative conflicts [17].

2.3. Practical Reasoning

Michael Bratman's theory of practical reasoning holds that intentions are central elements to (rational) action[21]. Intentions are understood as plans that coordinate decision-making and guide behavior. However, agents may sometimes form inconsistent intentions, and Bratman's theory provides a framework for understanding how they maintain coherence among their actions, plans, and commitments despite the possibility of such inconsistencies.

Bratman also discusses two kinds of norms that interact with agent's intention, and then, with agent's reasoning. First, internal norms of the agent are related to prior agent's own intentions. The external norms are norms which primary use is not in the agent's own practical reasoning but rather in reaching some external assessment of the agent, or a system of norms to which the agent is subject to.

Practical reasoning theory will be used to examine agents' potentially inconsistent intentions and to analyze how their intentions interact with normative environments in guiding action, as well as the conflicts that may arise from these interactions.

2.4. Unified Foundational Ontology

The Unified Foundational Ontology (UFO) was developed putting together a number of theories from different areas such as Formal Ontology in Philosophy, Linguistic and Cognitive Sciences[22, 23]. It comprises a set of interconnected micro-theories addressing fundamental concepts that shared across multiples domains. In this research we are specially interested in two specific aspects of UFO: the UFO-C and UFO-L.

UFO-C is an ontology of social entities [24] and a fragment of it can be seen in Figure 3. The main distinction made is between **objects** and **agents**. The last one create **actions**, perceive events and have **intentional moments** like **desire**, **belief** and **intention**. A particular entity of UFO-C is the **normative descriptions**, a kind of object that defines norms or rules recognized by some agent.

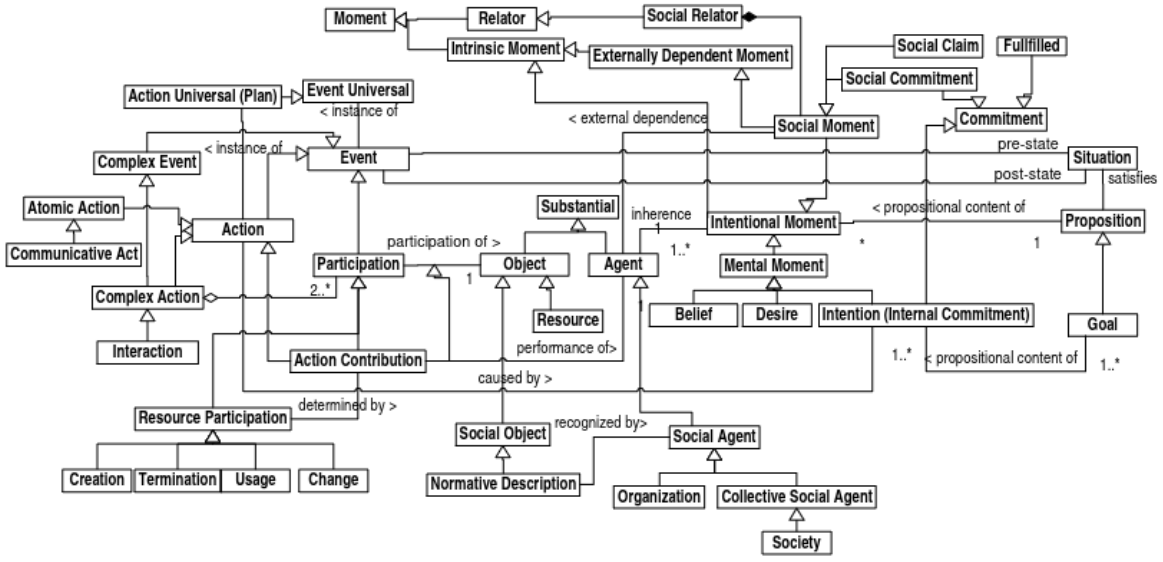

Figure 3: UFO-C fragment

Still, UFO-L is a core ontology that captures essential notions of legal domain. It provides conceptual primitives such as legal relators to to represent legal norms with different deontic forces, including obligations and permissions[25].

3. Problem Statement

Clinical guidelines (CGs) provide a set of established evidence-based disease-specific recommendations to supporting healthcare professionals on the definition of an appropriate treatment for a pacient. Zamborlini et al [14] proposed the Transition-based Medical Recommendation (TMR) Model for Clinical Guidelines, a conceptual model that captures the knowledge at the CGs.

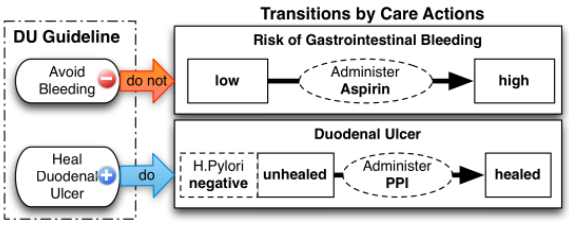

Figure 4: Instance of the TMR model depicting two recommendations within a Duodenal Ulcer (DU) CG [14].

Figure 4 shows an instance of the TMR model, which is composed by four main elements. A **Situation Type** represents a property that characterizes a patient together with its admissible values (*H.Pylori negative*). The elements *Administer Aspirin* and *Administer PPI* are **Care Action Types** and represents the actions that healthcare professionals may perform in order to modify a patient's situation. A **Transition** captures the possibility of changing a patient's situation through the execution of a care action type (in the figure, *Risk of Gastrointestinal Bleeding* and *Duodenal Ulcer*). Finally, a **Recommendation** represents a suggestion to either promote or avoid a given transition (*avoid bleeding* and *heal duodenal ulcer*).

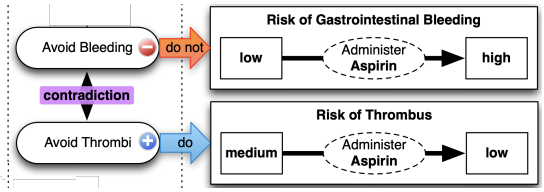

Figure 5: Opposed recommendations to *Administer Aspirin*.

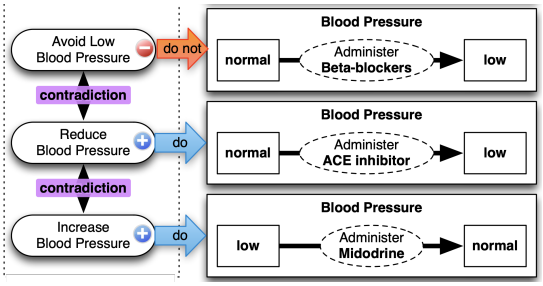

Figure 6: Opposed recommendations to transition *lower blood pressure* and recommendations to inverse transitions *lower versus increase blood pressure*.

Particularly in a case of comorbidity, where more than one clinical guideline is applicable, undesired interactions between recommendations could happen leading to what the model calls a contradiction. Three kinds of contradictions were proposed in [14]. The **opposed recommendations to the same care action** is when transitions promoted by a same care action are recommended to be pursued in a CG and avoided in another. Figure 5 shows the *Avoid Bleeding*recommendation indicating to *do not* administer Aspirin while the recommendation *Avoid Thrombi* indicate to *do* administer Aspirin. **Opposed recommendations to similar transitions** is when a situation is the post-condition of transitions promoted by different care actions that are recommended to pursued and to be avoided. Figure 6 shows the transition *lower blood pressure* being recommended (*Reduce Blood Pressure*) and not recommended (*Avoid Low Blood Pressure*). Lastly, **recommendations to inverse transitions** two

recommendations that revert each other effect. In Figure 6 the recommendations to *reduce blood pressure* and to *increase blood pressure*.

These forms of conflict reveal that clinical guideline systems may generate structurally diverse and conceptually distinct types of incompatibilities, suggesting that such contradictions cannot be fully captured by a single uniform notion of inconsistency.

This motivates a more systematic investigation of incompatibilities in normative systems, particularly in the context of clinical guidelines, grounded in the Theory of Opposition, Legal Institutions and Practical Reasoning. We aim to answer the following questions: Can the Hexagon of Oppositions be applied to better characterizes clinical recommendations contradictions? How do different types of recommendation interact with each other considering different deontic forces? And what role do agents' intentions play in these interactions? Is the current UFO system sufficient to address these issues, or how could it be extended to better support this class of problems?

With the potential to enhance the understanding of normative conflicts, especially in clinical guideline recommendations, this work aims to support normative systems in dealing more effectively with inevitable incompatibilities.

4. Declaration on Generative AI

The author has not employed any generative AI tools.

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