On the Issue of Contraposition of Defeasible Rules

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Abstract. The past ten years have shown a great variety of approaches for formal argumentation. An interesting question is to which extent these various formalisms correspond to the different application domains. That is, does the appropriate argumentation formalism depend on the particular domain of application, or does "one size fits all". In this paper, we study this question from the perspective of one relatively simple design consideration: should or should there not be contrapostion of (or modus tollens) on defeasible rules. We aim to show that the answer depends on whether one is considering *epistemical* or *constitutive* reasoning, and that hence different domains require fundamentally different forms of defeasible reasoning.

Keywords. epistemical reasoning, constitutive reasoning, contraposition

1. Introduction

Recent years have brought a large variety of research regarding argumentation formalisms. These formalisms tend to differ in the way that arguments are constructed and the defeat relation is defined [5,20,6], as well as in the abstract argumentation semantics [9,1,8], and in the various additional forms of functionality that can be provided [4,15].

Given the wide variety of formalisms and approaches, one can ask the question how these relate to each other as well as the question of how this variety is related to the different domains in which argumentation can be applied. As for the first question, some work has already been done by for instance Baroni and Giacomin, who provide a number of abstract properties according to which various argumentation semantics can be compared [3,2]. As for the second question, much less work has been done. Moreover, there is little clarity on whether one should aim for a general argumentation formalism that is applicable to a large variety of domains, or whether different domains require different and perhaps fundamentally incompatible classes of reasoning.

In this paper, it will be argued that the approach of "one size fits all" has serious disadvantages. We claim that there are two fundamentally different forms of reasoning, *epistemical* and *constitutive*, and that these require fundamentally different properties regarding formal entailment.

2. Default Contraposition in Epistemical Reasoning

Although the issue of applicability of default contraposition seems to be a fundamental one, it has until now received relatively little attention. Many authors treat the validity or

invalidity of contraposition as an aside when describing their respective formalisms for non-monotonic reasoning. Our analysis will therefore begin with an overview of some of the comments by various authors in the field. Brewka, for instance, provides the following counterexample against the validity of contraposition: "Men usually do not have beards, but this does not mean that if someone does have a beard, it's usually not a man." Another example would be: "If I buy a lottery ticket then I will normally not win any price, but this does not mean that if I *do* win a price, I did not buy a ticket."

Given the last two examples, it seems that there are perfectly legitimate situations in which contraposition does not hold, and that contraposition (or modus tollens) should therefore be rejected as a general principle for defeasible reasoning. The point is, however, that once one starts to accept counterexamples against default contraposition, then one should also take into consideration counterexamples against various other principles for defeasible reasoning:

irrelevance "Tux the bird": Birds fly and Tuxes are birds.[1] Do Tuxes fly? Perhaps not, because Tuxes may belong to a special subclass of birds that do not fly.

left conjunction "jogging in the rain" [19]: If it is hot, I tend not to go out jogging. If it is raining I also tend not to go out jogging. Does this mean that if it is hot *and* it is raining, I tend not to go out jogging?
"Marry both of them" [17] If you marry Ann you will be happy, if you marry Nancy you will be happy as well. Does this mean you will be happy if you marry both of them?

transitivity "unemployed students" [16] Students are usually adults and adults are usually employed. Does this mean that students are usually employed?

The above counterexamples against irrelevance, left conjunction, contraposition and transitivity look appealing at first sight. The point of each counterexample, however, is that it involves implicit background information. Tux does not fly because it is a penguin; marrying two persons generally does not make one happy (one may end up in jail instead); women have no beards at all; and students are a special class of adults that tend to be unemployed. The view that the counterexamples against contraposition, like the ones above, are flawed is shared by Ginsberg [10, p. 16], although he treats a different example himself ("Humans usually do not have diabetics").[2]

The "all or nothing" approach to the above mentioned properties of irrelevance, left conjunction, transitivity and contraposition is confirmed when one tries to give the defeasible rules a statistical interpretation. In ε-semantics [17], for example, none of these principles are satisfied, whereas the Maximal Entropy approach [11] satisfies all of them, but as defeasible principles only (that is, their instances can be blocked if specific information against their applicability is available). It appears that if one wants to make a consistent choice that includes the (defeasible) validity of properties like irrelevance, left conjunction and transitivity, then one should accept the (defeasible) validity of contraposition as well. Yet, it is striking to see that formalisms for defeasible reasoning tend not to be based on any consistent choice on these issues. A similar observation can be made

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[1]Tux is the well-known penguin logo of the Linux-community.

[2]As an aside, it appears that the "counterexamples" against contraposition involve rules where the antecedent contributes negatively to the consequent. That is, the consequent holds in spite of the antecedent. See [7] for a more elaborate discussion.

regarding the to contraposition related principle of *moduls tollens*. Both Reiter's default logic [22] and the formalism of Prakken and Sartor [20] sanction a defeasible form of modus ponens, but do not sanction any form of modus tollens. A systematic analysis of the actual meaning of a default is often not provided. Yet, it is this analysis that should serve as a basis for determining which principles should or should not be sanctioned. The current trend seems to be to sanction various principles, but not those of (defeasible) modus tollens or contraposition. It is an anomaly that is rarely questioned, and one may wonder whether this is because many researchers have become acquainted with it. Or, as Ginsberg states when discussing the reasons behind the opposition against contraposition [10, p. 16]:

> (...) although almost all of the symbolic approaches to nonmonotonic reasoning do allow for the strengthening of the antecedents of default rules, many of them do *not* sanction contraposition of these rules. The intuitions of individual researchers tend to match the properties of the formal methods with which they are affiliated.

3. Default Contraposition in Constitutive Reasoning

In the current section, we again ask the question whether contraposition should be sanctioned, this time not from the perspective of probabilistic empirical reasoning, but from the perspective of *constitutive* reasoning. The difference between these two forms of reasoning can perhaps best be illustrated using a mirror example, which is a small logical formalization that can be given two informal interpretations with opposite conclusions [7, section 2.2.5].

Informal Interpretation 1 (II_1): The goods have been ordered three months ago (TMA) and the associated customs declaration is still lacking in the customs information system (LIS). If the goods have been ordered three months ago, then they will probably have arrived by now ($TMA \Rightarrow A$). If the goods have arrived, then there should be a customs declaration for them ($A \Rightarrow CD$). If the registration of the customs declaration is still lacking in the customs information system, then there probably is no customs declaration ($LIS \Rightarrow \neg CD$).

Informal Interpretation 2 (II_2): John is a professor (P) who is snoring in the university library (S). Snoring in public is usually a form of misbehaviour ($S \Rightarrow M$). People who misbehave in the university library can be removed ($M \Rightarrow R$). Professors cannot be removed ($P \Rightarrow \neg R$).

In the "arrival of goods" example (II_1) it seems reasonable to apply contraposition on $A \Rightarrow CD$ to construct an argument for $\neg A$. In the "snoring professor" example (II_2), however, it would be very strange to have contraposition on $M \Rightarrow R$ since this would allow us to construct an argument for $\neg M$. In fact, example II_2 has been taken from [18, p. 185] where it is claimed that the justified conclusions should include M, but not R or $\neg R$. Hence, the above pair (II_1, II_2) can be considered as a mirror example in the sense of [7, section 2.2.5]. The next question then is how this situation should be dealt with. That is, do we (1) reject at least one of the formalizations as "incorrect" or (2) acknowledge that the two examples are related to fundamentally different forms of reasoning? In this paper, we choose for the second option. That is, we claim that there is a fundamental difference that makes contraposition applicable to II_1 but not to II_2.

Direction of fit

In order to understand the nature of constitutive reasoning, it is useful to distinguish between statements that have a *word to world* direction of fit, and statements that have a *world to word* direction of fit [24,25]. It should be noted that also one of the differences between II_1 and II_2 concerns the direction of fit.

The defeasible rules of II_1 are meant to describe when a certain fact holds in the object-world. This object-world has an existence that is independent of the rules that express our knowledge about it. These rules, therefore, have a *word to world* direction of fit. Their correctness depends on a validity that has an independent existence.

In II_2, on the other hand, the very nature of the rules is different. The rules do not merely describe the reality, but to some extent also construct it, especially if we assume these rules to be taken from, say, the library regulations. The rule $S \Rightarrow M$, for instance, contributes to the definition of misbehavior in the context of the library regulations. The rule essentially *makes* it the case that snoring is considered to be misbehavior, as far as the library is concerned. The defeasible rules of II_2, therefore, have a *world to word* direction of fit. Their application results in the creation of new (legal) facts.

Epistemic versus constitutive reasoning

Based on the direction of fit, one can distinguish two kinds of reasoning: epistemic and constitutive[3]. The nature of this distinction can be described as follows [12, p. 60]: "Epistemic reasons are reasons for believing in facts that obtain independent of the reasons that plead for or against believing them. Constitutive reasons, on the contrary, influence the very existence of their conclusions".

In order to understand the differences between epistemic and constitutive reasoning, we provide the following abstract example[4] (AE): $\mathcal{P}remisses = \{A; D\}$, $\mathcal{D}efeasible\ rules = \{A \Rightarrow B;\ B \Rightarrow C;\ D \Rightarrow \neg C\}$ conflict: $A;\ A \Rightarrow B;\ B \Rightarrow C$ versus $D;\ D \Rightarrow \neg C$

Now, take the following two constitutive interpretations of this example.

deontic The following example is somewhat similar to that of the Christian Soldier. An artillery soldier is given the order to destroy an enemy military installation, and orders should generally be obeyed ($order \Rightarrow O(shoot)$). When the soldier looks through his binoculars, he observes some movements that probably mean that some people are really close to the target ($movements \Rightarrow people$), thus making it from an ethical point of view imperative not to shoot ($people \Rightarrow O(\neg shoot)$). Thus, we have: $\mathcal{P}remisses : \{order,\ movements\}$ and $\mathcal{D}efeasible\ rules = \{movements \Rightarrow people;\ people \Rightarrow O(\neg shoot);\ order \Rightarrow O(shoot)\}$. Conflict: $movements;\ movements \Rightarrow people;\ people \Rightarrow O(\neg shoot)$ versus $order;\ order \Rightarrow O(shoot)$

Here, the conflict is between the obligation to shoot and the obligation not to do so. In some logics, like Standard Deontic Logic, such a conflict would lead to an inconsistency. If we would allow for contraposition, the effect would be that *people*

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[3]The term "constitutive rules" was originally introduced by Searle [23]. In this essay, however, we use the term in the sense of [13,12].

[4]The reader will notice that the structure of this example is similar to II_1 and II_2.

is no longer justified. This is, of course, absurd; the belief in empirical statements should not depend on the presence or absence of deontic conflicts.

legal An example of a legal interpretation is II_2. Here, the reasoning concerns whether or not certain legal facts obtain. Even though the conflict could be described in deontic terms (is the library personnel permitted to remove the person in question or not), the conflict ($Permitted(remove)$ v.s. $\neg Permitted(remove)$) is essentially not of a deontic nature, like in the previous example ($Obliged(shoot)$ v.s. $Obliged(\neg shoot)$). The question is whether it is legally permitted to remove the person or not, and this question does not rely on the specifics of deontic reasoning. The fact that this conflict exists, however, is no reason to reject the intermediate conclusion of M. To make this point more clear, suppose that the library regulations contain an additional rule saying that those who misbehave have to pay a fine of ten euro ($M \Rightarrow F$) and that no rule is available that provides professors with exemption for this fine. Then, the fact that the intermediate conclusion M can lead to R (which conflicts with $\neg R$) is no reason to disallow the entailment of F.

The point is that constitutive reasoning obeys different principles than epistemic reasoning. Under epistemic reasoning it is perfectly reasonable to sanction contraposition, as was argued in section 2. Under constitutive reasoning, on the other hand, contraposition is *not* valid by default, as was discussed above. In legal reasoning, for instance, the leading paradigm is that the law should be interpreted as consistently as possible. Hence, in the snoring professor example the potential conflict between R and $\neg R$ is not a reason to create a conflict between M and $\neg M$ and hence reject M or F. The idea is to keep the effects of possible conflicts as local as possible [12, p. 109]. A great deal of research has been dedicated at stating and formalizing meta-principles (such as *lex posterior*, *lex specialis* or *lex superior*) for determining which of the conflicting rules should be applied, and which should not. But even in the case that no determining meta-principle is available, the application of *both* rules is blocked and the conflict does not have consequences for conclusions that do not depend on it. Our snoring professor, even though he may not be removed, still has to pay his 10 euro fine.

(Im)perfect procedures versus pure procedures

The difference between epistemic and constitutive reasoning is comparable to the difference between (im)perfect procedures and pure procedures, as distinguished by Rawls. To illustrate the concept of a *perfect procedure*, Rawls provides the example of cake-cutting [21, p. 74]:

> A number of men are to divide a cake: assuming that the fair division is an equal one, which procedure, if any, will give this outcome? Technicalities aside, the obvious solution is to have one man divide the cake and get the last piece, the others being allowed their pick before him. He will divide the cake equally, since in this way he assures for him the largest share possible. This example illustrates the two characteristic features of perfect procedural justice. First, there is an independent criterion for what is a fair division, a criterion defined separately from and prior to the procedure which is to be followed. And second, it is possible to devise a procedure that is sure to give the desired outcome.

One of the assumptions of the above cake-cutting example is that the person cutting the cake can do so with great accuracy. As long as deviations in cutting are ignored, the result will be an equal distribution. If we assume that the deviations in cutting cannot be ignored, cake-cutting becomes an *imperfect procedure*. The characteristic mark of an imperfect procedure is that while there is an independent criterion for the correct outcome, there is no feasible procedure which is sure to lead to it [21, p. 75].

A *pure procedure*, on the contrary, is the case when there is no independent criterion for the right result: instead there is a correct or fair procedure such that the outcome is likewise correct or fair, whatever it is, provided that the procedure has been properly followed. An example of a pure procedure is a free election. The outcome of elections cannot be evaluated as "right" or "wrong" according to an outside objective standard. The idea is that any resulting outcome should be accepted, as long as the election process itself was carried out in a correct way. In general, one can only fight the outcome of a pure procedure by arguing that the procedure itself was not applied properly [14].

Since the process of reasoning can to some extent be seen as a procedure, it is interesting to evaluate how the kind of reasoning as performed in II_1 and II_2 can be seen in terms of (im)perfect and pure procedures.

II_1 is basically an instance of empirical (epistemic) reasoning. One uses potentially incomplete information and rules of thumb, with the idea that the reasoning process is likely to generate a correct result. Even though an outside criterion exists to evaluate correctness (the goods have either arrived or not), there is no guarantee that the reasoning process indeed obtains this result. Hence, the reasoning process as performed in II_1 can be seen as an imperfect procedure.

II_2 is an instance of constitutive reasoning. The idea of the library regulations is that applying them defines which (legal) consequences hold in a particular situation. There is no outside criterion, other than the library regulations themselves, that allows us to evaluate the legal implications as far as the library is concerned. Hence, the reasoning process can be seen as a pure procedure.

The difference between epistemical and constitutive reasoning has implications for what principles do or do not hold in the reasoning process. Let us ask the question of whether some principle (like contraposition) holds in constitutive reasoning. The answer, of course, is that it depends on how the particular form of constitutive reasoning is defined. This definition needs not to be explicit. It may very well be that a certain type of informal reasoning has become common in a certain community, and that it is the researcher's task to provide a formal model of this reasoning; this is essentially what happens in, for instance, AI & Law.

In epistemical reasoning, an outside criterion is available for determining whether the results are considered correct or not. The task of the reasoner is to perform its reasoning in such a way that the outcome approximates the objective criterion as closely as possible. In a certain sense, the presence of an objective criterion *forces* the reasoning process to become of a certain shape, in which certain properties (like contraposition) hold and other properties do not hold.

In constitutive reasoning, such an objective criterion is absent. For the community of reasoners, there is nothing that forces their reasoning process to become of a certain shape. In essence, the reasoners rely only on their own opinions and intuitions regarding what such a reasoning process should look like and which properties it should adhere to. Wason's card experiment, however, makes clear that a large group of people has

difficulties with the principle of contraposition; it should therefore not come as a surprise that, when no outside constraint or criterion is present that *forces* its validity, the type of unreflective reasoning that a group of people comes up with does not necessarily sanction contraposition.

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