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A Compatibilist Approach in Ontology: Steps Towards a Formalization

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Abstract. Commonsense ontology often conflicts with the ontology of our best scientific and philosophical theories. However, commonsense ontology, and commonsense belief systems in general, seems to be remarkably efficient and cognitively fundamental. In cases of contrast, it is better to find a way to reconcile commonsense and "theoretical" ontologies. Given that commonsense ontologies are typically expressed within natural language, a classical procedure of reconciliation is semantical. The strategy is that of individuating the "ontologically problematic" expressions of natural language and paraphrasing the sentences in which they appear in a (formal) language whose commitments are compatible with those of our best theories. We believe that this strategy of reconciliation, though quite standard, especially in the philosophical literature, is problematic: for a start, it forces us to conclude that the "real content" of our commonsense expressions and beliefs is different from what it appears. Commonsense ontology becomes just an illusion. We will thus propose an alternative approach: according to our view, a commonsense ontology is reconciled with a theoretical ontology in case it is shown that the explanation of why we believe in the existence of a problematic entity is compatible with our best theories. We will call this kind of reconciliation "epistemic". The advantage of an epistemic reconciliation is that commonsense ontology is treated in its own right and could be taken *prima facie*. Another advantage of the view is that epistemic reconciliation can be analysed through the notion of *explaining away*: a commonsense ontology is epistemically reconciled with a theoretical ontology if and only if the problematic entities of the commonsense ontology are explained away by "respectable" entities of the theoretical ontology. In the final part of the paper, we sketch a formal analysis of explaining away.

Keywords. commonsense ontology, theoretical ontology, ontological commitment, paraphrases, explaining away

1. Introduction

Commonsense ontologies aim to represent large portions of commonsense knowledge and play a fundamental role in the construction of general-purpose ontologies (top-level ontologies) such as DOLCE, Cyc or WordNet. According to Kriegel (2011), "a commonsense ontology [is] any ontological theory whose verdicts about what there is do not diverge overmuch from the verdicts of commonsense". Given that the "verdicts of commonsense" are typically expressed in natural language, there seems to be a strong relation between natural language ontology and commonsense ontology, even though the two theoretical enterprises are not completely identifiable (Moltmann, 2017).

The ontology coming from commonsense or from a descriptive analysis of natural language often conflicts with so-called "theoretical ontologies": we use this term to refer to any ontology coming from a "theory" (scientific or philosophical, hereafter TO). For example, the ontology of commonsense physics also known as "folk" or "naive" physics may conflict with the ontology of scientific physics, the one described in physics textbooks: folk physics may categorise material objects and processes/events in two distinct ontological categories, whereas this might not be so for textbook physics (Smith & Casati, 1994).

A second example comes from philosophy: according to commonsense ontology, the world is full of middle-sized artefacts such as tables and chairs, and all manner of highly visible, ordinary objects; this ontology conflicts with (at least) two types of theoretical ontologies. According to *eliminativism*, there are no ordinary macroscopic objects, but only atomic particles arranged in a certain way (Merricks, 2001; van Inwagen, 1990), so where commonsense ontology counts a table, eliminativists count many objects. According to *permissivism*, "there are wide swathes of highly visible extraordinary objects" (Korman, 2017), so where commonsense ontology counts a table and the Eiffel Tower as two distinct objects, permissivism counts three objects: a table, the Eiffel Tower and the object composed by the first two.

A third example comes from engineering design and concerns *functions*. Design methodologists acknowledge that engineering is faced with different meanings of "function" (see the survey by Erden et al. (Erden et al. (2008)). To these different meanings correspond different ontological ways of conceiving *functions*. A descriptive analysis of these ontologies corresponds to what Carrara et al. in (Carrara, Garbacz, and Vermaas (2011)) called a *descriptive strategy* of formalisation and contrast with a revisionary strategy, where a piece of ontology comes from a "theory". An example of this theoretical approach to ontology is Arp and Smith's (Arp and Smith (2008)) ontological characterisation of *function*. In the Basic Formal Ontology (BFO) they define a *function* as a realisable dependent continuant such that (1) it has a bearer, and (2) its type usually has realisations such that (2.a) they are processes in which that bearer participates, (2.b) they exist in virtue of the bearer's physical make-up, (2.c) this make-up is had by the bearer because of how the bearer came into existence. Such an ontology is revisionary because (a) it excludes certain entities from the domain of functions although they are usually included in engineering models, and (b) it includes certain objects as functions although they are rarely, if ever, included in engineering models.

How should we behave in case of conflict between a commonsense ontology and a theoretical ontology? On the one hand, commonsense ontologies seem to be "remarkably efficient" and "cognitively fundamental" (Smith, 1995); on the other, theoretical ontologies are the ontologies coming from our *best* theories, so we should take them seriously. The "revisionists", who prefer the theoretical ontologies (TO) over the commonsense ones, pay the price of losing the cognitive fundamentality and the generality of all-purpose commonsense ontologies. The "descriptivists", who prefer the commonsense ontologies over the theoretical ones, are at risk of using ontologies that are simply wrong.[1] Both revisionists and descriptivists are thus in trouble.

[1]The dichotomy of "revisionistic metaphysicics"/"descriptivist metaphysics" comes from Strawson (1959).

2. Semantic reconciliations

There is at least one way out from the dilemma between revisionism and descriptivism. This way out is called "compatibilism". According to compatibilism, in case of conflict between commonsense and theoretical ontologies, we should try to find a *reconciliation* between the two. The typical form of reconciliation is *semantical*. Given that commonsense ontology comes from natural language, the strategy consists of individuating the "ontologically problematic" expressions of natural language and paraphrasing the sentences in which they appear in a way compatible with the ontological commitments of our best theories. Consider a natural language sentence ϕ whose *prima facie* ontological commitments are towards entities of type E. Assume that, according to some of our best theories, entities of type E do not exist or that our best theories are committed to entities incompatible with Es. Entities of type E thus belong to a commonsense ontology but do not belong to or are in conflict with a theoretical ontology. The conflict is, of course, not always possible to solve, but it would be solved in a reconciliatory way in case it is shown that there is a plausible *paraphrase* of ϕ that does not commit us to the existence of E.

Let us consider three cases in which this strategy can and has been applied.

Average mums. Consider the sentence:

(1) The average mum has 2.4 children.

1 seems to commit us to the existence of "average mums", entities that, of course, cannot be part of any theoretical ontology. A way to reconcile the ontological commitments of 1 with our best theories is to paraphrase the original sentence as follows:

(2) There are 2.4x as many children as mums.[2]

This does not commit us to the existence of average mums, but it is necessarily equivalent to a sentence apparently committing to average mums.

Chairs. Another case is the following:

(3) There is a chair in Sam's closet.

A sentence like 3 entails the existence of chairs and, in general, of middle-sized composite artefacts. But assume that you are an eliminativist. A semantic way of reconciling a commonsense ontology with middle-sized artefacts is to paraphrase 3 with the following:

(4) There are some atoms arranged chair-wise in Sam's closet.

4 does not entail the existence of chairs nor of any middle-sized composite artefact, it is compatible with the theoretical ontology of eliminativism and is equivalent to 3 [3].

[2] For a discussion of this kind of paraphrase, see Melia (1995).

[3] For a discussion of this kind of paraphrase, see van Inwagen (1990).

Cracks. Finally, consider the following sentence:

(5) There is a crack on your vase

As with the other two cases, a sentence like 5 commits one to the existence of cracks, but the existence of such kind of entities (such as holes, shadows) seems to be problematic, and we may want to built our best theories without this kind of commitment. Even in this case, there seems to exist a paraphrase of 5 that does not commit one to the existence of cracks:

(6) Your vase is cracked.[4]

In all these cases, a sentence ϕ is a paraphrase of a sentence ψ (and thus 2 of 1, 4 of 3 and 6 of 5) in the sense that ϕ is *necessarily equivalent* to ψ without having its problematic consequences (at least from the perspective of our preferred theories).

The method of "reconciling paraphrases", typical of Quinean meta-ontology, seems thus able to reconcile sentences of natural language with theoretical sentences and thus, indirectly, seems to be able to reconcile, at least in some cases, a common-sense ontology with a theoretical ontology. According to this semantic form of reconciliation, commonsense ontology is, after all, a theoretical ontology. The ontologically problematic sources of commonsense ontology (natural language expressions) are firstly "sanitised" in terms compatible with our best theories. The ontology of natural language is thus a theoretical ontology in disguise. The conflict between commonsense and theory is thus merely illusory and it depends on the way in which a certain view is formulated in natural language.[5]

The problem with these kinds of semantic reconciliations is that they are grounded on a semantic and, in some cases, a cognitive assumption: the semantic assumption is that the paraphrased sentences and the paraphrasing sentences have the same meaning, that the "real content" of the former is the same as the one of the latter. The cognitive assumption is that ordinary speakers really think the content of the paraphrasing sentences or, more weakly, that ordinary speakers are not really committed to what the paraphrased sentence apparently commits them or that they are "neutral" with respect to the real commitment of such a sentence. This neutrality is often justified by appealing to the claim that ordinary speakers should not be taken completely literally when they utter ordinary sentences such as 1, 3 and 5. Ordinary uses of ontologically committing sentences are thus treated as loose and popular ways of expressing what could more precisely be expressed in theoretical uses.

Both assumptions seem to us problematic: the semantic assumption is problematic because there seems to be no evidence in the sense of no proper *linguistic* and *semantical* evidence that the "real" meaning of the paraphrased sentence is given by the paraphrasing sentences. What we know is only that paraphrases are necessarily equivalent to the original sentences and that they are not implying the ontologically offending entities (from the perspective of our preferred theories), but this is very far from constituting evidence for the distinctive semantic claim that the "real meaning" of a commonsense sentence is the theoretical one. The cognitive assumption is problematic because it attributes

[4]For a discussion of this kind of paraphrase, see Lewis and Lewis (1970).

[5]For a thorough discussion of such reconciling paraphrases, see von Solodkoff (2014), Keller (2015).

to ordinary speakers a non-transparent access to the content of their thoughts. It is surely true that some ordinary uses of sentences should not be taken seriously (consider, for example, ordinary uses of "the sun is moving across the sky"), but this does not seem to apply to existentially committing discourse such as the one about artefacts. In what sense should "there are chairs is in the closet" be taken in a loose way or in some sort of non-literal way?

Another problem of semantic reconciliations is that these kinds of reconciliations operate on sentences, not directly on ontologies. If there is a conflict between commonsense and theoretical ontology, the conflict is solved by showing that the *sentences* encoding the first ontology can be paraphrased with sentences compatible with the second ontology. In some cases, this passage through a public language may sometimes be problematic or simply impossible.

We conclude that this kinds of semantic reconciliation are problematic, and we propose our alternative view in the next section.

3. Epistemic reconciliations

The alternative to a semantic kind of reconciliation is an *epistemic* kind of reconciliation. Assume again, as a starting point, that there is a conflict between commonsense ontology and a theoretical ontology. According to commonsense ontology $O1$, there are entities of kind E; according to theoretical ontology $O2$, there are not entities of kind E or there are entities whose existence is incompatible with the existence of Es.

In our view, $O1$ and $O2$ are epistemically reconciled just in case it is shown that the need to postulate E by $O1$ *is explained* in a way that is compatible with the ontological commitments of $O2$. In other words, $O1$ and $O2$ are epistemically reconciled just in case the explanation of the need to postulate E is compatible with $O2$.

An explanation here should be taken simply as a set of sentences from which it is possible to infer the explanandum. In this way, to say that an explanation and a theory are compatible means that the explanation and the theory are consistent, namely possibly true together. Notice that, in the case of the epistemic reconciliation between $O1$ and $O2$, the explanandum is not Es (otherwise $O2$ would be committed to such entities) but the need to postulate Es, and the need to postulate Es might be explained, at least in some cases, independently of the existence of Es. In such cases, we have an epistemic reconciliation.

Given that the case that interests us is one where $O1$ is a commonsense ontology, we might assume that the need to assume entities of kind E by $O1$ is grounded on being a *commonsense belief* that Es exist. The cognitive fundamentality of a commonsense ontology depends in fact from the fact that it represents the ontology of a *commonsense system of beliefs*. In this situation, we have an epistemic kind of reconciliation between $O1$ and $O2$ with respect to entities of kind E in case there is *an explanation* of why it is commonly believed that Es exist, which is compatible with the ontological commitments of $O2$. Again, an explanation of why it is commonly believed that Es exist does not necessarily require the postulation of Es. An epistemic reconciliation is just an explanation of the commonsense belief that Es exists that does not presuppose the existence of Es.

Let us see how epistemic reconciliation works in the cases discussed above.

Average mums. Assume that there is an ontology $O1$ that postulates "average mums" (or, in general, that for a certain series of predicates $N_1, \ldots, N_n$, it postulate the entities of the kind "average N_i"). Assume that there is another ontology $O2$ that does not postulate such entities. We say that $O1$ is epistemically reconciled with $O2$ just in case the need to postulate entities such as average mums is explained in a way compatible with the ontological commitments of $O2$. An explanation of the need to postulate average mums can be explained without any reference to average mums, but also with reference to facts about proportions between two quantities (number of mums and number of children). Talking about and postulating average mums could be accepted as long as such talking and postulation is explained in terms of an "ordinary mums" ontology.

Chairs. Assume that there is an ontology $O1$ that postulates "chairs" (or, in general, that postulates the existence of middle-sized composite artefacts). Assume that there is another ontology $O2$ that does not postulate such entities or that postulate entities that are incompatible with the existence of artefacts. We say that $O1$ is epistemically reconciled with $O2$ just in case the need to postulate entities such as chairs is consistent with the ontological commitments of $O2$. In such a case, the need to postulate the existence of chairs and artefacts might be explained in a way that presents them as a kind of "cognitive shortcut"; this kind of explanation does not need essential reference to artefacts, but only to atoms arranged in a certain way. So, our reconciliation will be compatible with eliminativism.

Cracks. Assume that there is an ontology $O1$ that postulate the existence of some kind of "minor entity" such as cracks, shadows, holes, surfaces, etc.[6] Assume that your preferred ontology $O2$ does not postulate such entities. $O1$ would be reconciled epistemically with $O2$ just in case the explanation of the need to postulate, say, cracks is done in a way compatible with $O2$. Assume, for example, that you believe that cracks are cognitive illusions useful to solve figure-ground problems. The explanation of why we need cracks in our cognitive systems would be done in this case without postulating the existence of such entities and so in a way compatible with $O2$.

Semantic and epistemic reconciliations are distinctively different: the former are based on a form of what we might call (semantic) "recarving": the sentences containing a commitment to problematic entities are reformulated in order to eliminate any reference to the offending entities. A corollary of this view, as we have seen, is that the content of the natural language sentence from which we start is really another one: when we are talking about average mums, we are really talking of proportions among the number of mothers and the number of children, when we are talking about chairs, we are really talking of atoms arranged "chair-wise" when we are talking about cracks, we are really talking of cracked objects. In such a way, average mums, chairs, cracks, etc. are not really part of our commonsense ontology, they are just illusions. After a semantic reconciliation, the only ontology that "remains" is the theoretical one, and this is because the source of the commonsense ontology (natural language) is drained by the reconciling paraphrases. Sentences containing expressions with problematic ontological commitments are true, but their meaning is different from what it appears.

Epistemic reconciliations are not based on such kinds of recarvings and are compatible with a more "descriptive" approach to metaphysics. The widely shared belief in

[6] On the metaphysics of minor entities, see Casati (2009).

the existence of chairs is what motivates the inclusion of chairs and other artefacts in a commonsense ontology, but the way in which such a commonsense ontology is epistemically reconciled with a theoretical ontology does not pass through a reformulation or a transformation of the commonsense beliefs about chairs. We do not need to say that commonsense beliefs in the existence of chairs are, really, beliefs in atoms arranged chair-wise. Commonsense beliefs about chairs are just beliefs about chairs! Epistemic reconciliation leaves the source and the structure of a commonsense ontology untouched and acts instead at the level of explanation. For an eliminativist, for example, a commonsense ontology committed to chairs is wrong (because, for an eliminativist, there are no chairs) but a commitment to such entities and their inclusion in a commonsense ontology is *reasonable* as far as we have an explanation of the need to postulate such entities that is compatible with eliminativism.

There might be cases where a commonsense entity, or better, the need to postulate it, cannot be reconciled with our best theories. This is a case where we simply should dispense with the entity in question.

Finally, to understand better the relations between semantic and epistemic reconciliations and why the latter should be preferred, consider the following example.

The sun. The theoretical ontology coming from Copernican cosmological theories, according to which it is the Earth rotating around the sun, conflicts with the commonsense ontology of naive physics, according to which the sun is moving across the sky.

In effect, it is commonly believed that the sun is moving across the sky, but, as it happens, we have a very good explanation for the tendency we have to form this belief. It originates from our impression of seeing the sun moving, and this impression depends on our position – the fact that we live on the Earth – and on the effects on our cognitive systems of the Earth rotating around its axis and orbiting around the sun.

Once we have this explanation at hand, the belief that the sun is moving seems to be reconciled with our Copernican cosmological theory, and thus we have a way to reconcile the two ontologies. We are in fact in a position to explain the conflict, but also to explain why we tend to form such a belief, couched in a theory that does not presuppose that the sun is moving.

In such a situation, something along the lines of a semantic reconciliation would sound totally implausible. It would in fact be quite implausible that when someone says:

(7) The sun is moving across the sky,

one is really talking and thinking about the axis of the Earth and not really believing that the sun is moving across the sky. What we say or think should be taken at face value and made compatible with our best theories in the sense of explaining it in a way compatible with our best theories.[7]

4. Epistemic compatibilism and explaining away

For ease of exposition, we repeat here the definition of epistemic reconciliation between two ontologies (of course, the case that interests us more is one in which $O1$ is a commonsense ontology and $O2$ is a theoretical ontology):

[7] See Carrara and Morato (2020) for a more detailed presentation of the notion of epistemic reconciliation.

Epistemic reconciliation: $O1$ is epistemically reconciled with $O2$ with respect to entities of kind E just in case the explanation of the need to postulate E in $O1$ is compatible with $O2$.

An advantage of the epistemic approach to the problem of the reconciliation between ontologies is that it could easily be connected with the notion of *explaining away*.

Explaining away is a common pattern of causal reasoning.[8] An example of explaining away reasoning is the following. Consider a situation in which there is a common effect caused by two causes, for example, a fever that can be caused both by a bacterium and by a virus. When the fever is observed, the probability of one of the two causes, say the virus, increases. But if it is then further observed that the bacterium is present, then the probability that the virus is also present decreases. In such a case, we would say that the bacterium *explains away* the virus. In general, we have a case of explaining away in all those cases when an effect is present and when we have the reduction of the probability of one cause when another is observed.

It is possible to generalise this pattern of reasoning from merely causal to explanatory reasoning in general and to partially abstract away from its probabilistic flavour. Assume that you have two hypotheses $H1$ and $H2$ and a certain phenomenon, or claim, in need of justification or explanation S. We have a case of explaining away, namely a case where $H2$ explains away $H1$ just in case:

- Both $H1$ and $H2$ are capable of explaining S
- $H1$ and $H2$ are independent
- Any evidence in favour of $H2$ reduces the need to invoke $H1$.

What kind of evidence reduces the need to invoke an explanatory hypothesis in favour of another may vary and may depend on the overall theoretical needs (in some cases, meta-theoretical considerations such as simplicity or elegance may become relevant).

Given that ontologies also have explanatory potential, the generalised definition of explaining away can also be applied to them. Assume that there is an ontology $O1$ that postulate entities of kind E and that is able to explain a certain claim S. Assume further that there is an ontology $O2$ that does not postulate entities of kind E but is able nonetheless to explain S. This is a situation in which $O2$ explains away $O1$ wrt S.

As it should be clear, in case of ontologies, the notion of explaining away is strongly related to Occam's razor. Evidence in favour of the more economic explanation should be favoured over a less economic theory with the same explanatory potential.

Le us see how this works in cases of average mums, chairs and cracks.

Average mums. An ontology $O1$ that explains S (where S could be the fact that average mums has 2.4 children) postulating average mums is explained away by an ontology $O2$ that explains S not postulating average mums, but only proportions between number of mums and number of children. The need to postulate average mums in a case where proportions between "ordinary" mums and children explains S clearly decreases.

[8] See Pearl (1988); Wellman and Henrion (1993).

Chairs. An ontology $O1$ that explains S postulating chairs (and middle-sized artefacts in general) is explained away by an ontology that explains S without postulating them, but only, for any artefactual predicate F, atoms arranged F-wise. Assume that S in this case is the common belief that there are chairs and other middle-sized artefacts. If the emergence of such common beliefs could be explained in a psychological theory that does not require the existence of such entities, then the need to postulate artefactual entities is clearly reduced (remember that this reasoning is plausible in case we assume that eliminativism is our best theory of material objects).

Cracks. An ontology $O1$ that explains S postulating cracks (or other minor entities) is explained by an ontology that explains S without postulating them but only cracked objects. If our best theories and thus theoretical ontologies do not postulate entities such as cracks, then, in case the explanatory roles of cracks could be explained by a "crackless" ontology $O2$, $O2$ clearly reduces the need to postulate cracks and explains away $O1$.

Our view is that there is an interesting and robust connection between the notion of explaining away and the epistemic kind of reconciliation presented in the previous section: an ontology $O1$ is epistemically reconciled with an ontology $O2$ if and only if $O2$ explains away $O1$.

Let us prove this equivalence.

From epistemic reconciliation to explaining away. Assume first that $O1$, a commonsense ontology, is reconciled with $O2$, a theoretical ontology. We have seen that epistemic reconciliation is always relativised to certain kind of entity E over which the two ontologies conflict. Now, if $O1$ and $O2$ are reconciled with respect to E, then the explanation of the need to postulate E in $O1$ is consistent with $O2$. By hypothesis, $O2$ is not postulating E, but $O2$ is able to explain, *without* Es, everything $O1$ explains *with* Es. So, $O1$ and $O2$ have the same explanatory potential, but then $O2$ explains away $O1$.

From explaining away to epistemic reconciliation. Assume now that $O2$ explains away $O1$. From this it follows that $O2$ has the same explanatory potential of $O1$ without postulating entities of kind E. However, then $O2$ is able to explain the need to postulate E and this explanation will be, of course, compatible with $O2$. $O1$ is then epistemically reconciled with $O2$ with respect to entities of kind E.

The equivalence between epistemic reconciliation and explaining away is important, because the latter notion could receive a formal treatment in a number of logical frameworks. In the following section, we will give a sketch of how the notion of explaining away could be formalised in the context of justification logic, a branch of epistemic modal logic developed by Fitting (2005).

5. Steps towards the logic of *explaining away*

Aim of this section is to give a formalization of the notion of *explaining away* in terms of justification logic.

Justification logics are epistemic logics, expressing knowledge and belief modalities with *justification terms*: $t, s, \ldots$. Intuitively, a justification term corresponds to evidence we might have in favour of a certain claim.

Historically, justification logic was part of a project to give a semantics for intuitionistic logic. In that perspective, proofs are considered as justifications in their purest form. In justification logic we have formulas and justifications. Justifications are formal terms, built up from constants and variables using various operation symbols. If t is a justification term and X is a formula, $t : X$ is a formula whose intended reading is "t is a justification for X" or "t is evidence for X"

We apply the basic frame of justification logic to model the notion of *explaining away*. For ease of reference, let us repeat here the definition. Be $H1$ and $H2$ two hypotheses and be S a target claim explained by both $H1$ and $H2$. We have that $H2$ explains away $H1$ in case:

- $H1$ is explanatorily adequate for the relevant phenomena as it is $H2$.
- $H1$ does not make any reference to $H2$ and *vice versa* (H1 and H2 are independent).
- Any evidence in favour of $H2$ reduces the need to invoke $H1$.

A *possible world justification logic model*, (Fitting, 2005) is a structure $\mathscr{M} =< \mathsf{G}, \mathsf{R}, \mathscr{E}, \mathscr{V} >$ where $< \mathsf{G}, \mathsf{R} >$ is a standard K frame: G is a set of possible worlds, R is a binary relation on it, $\mathscr{V}$ is a mapping from propositional variables to subsets of G, specifying atomic truth at possible worlds, and, finally, $\mathscr{E}$ maps justification terms and formulas to sets of worlds. An expression like $\mathscr{E}(t,X)$ refers thus to the set of worlds where t is evidence for X.

The intuitive idea of $\mathscr{E}$ can be described as follows: if the possible world Γ is in $\mathscr{E}(t,X)$, then t is relevant or admissible evidence for X at world Γ. Notice that the evidence at work in t should not be necessarily conclusive as mathematical reasoning and its proofs are. There could be degrees of evidence. This fact will be made explicit by means of a Pr operator that allows a comparison among the degrees of evidence for claims. For example, $Pr(t : S) > Pr(s : S)$ means that the degree of evidence of t for S is greater than the degree of evidence of s for S. We could also compare evidence for different claims: $Pr(t : S) > Pr(s : P)$ means that the degree of evidence t for S is greater than the degree of evidence of s for P, thus the degree of truth of S is greater than P.

Semantics in a *a possible world justification logic model* is standard, apart from condition 4. The details are as follows. For each $\Gamma \in \mathsf{G}$:

1. $\mathscr{M}, \Gamma \models P$ iff $\Gamma \in \mathscr{V}(P)$, where P a propositional letter.
2. It is not the case that $\mathscr{M}, \Gamma \models \bot$.
3. $\mathscr{M}, \Gamma \models (X \rightarrow Y)$ iff it is not the case that $\mathscr{M}, \Gamma \models X$ or it is the case $\mathscr{M}, \Gamma \models Y$.
4. $\mathscr{M}, \Gamma \models (t : X)$ iff $\Gamma \in \mathscr{E}(t,X)$ and for every $\Delta \in \mathsf{G}$ with $\Gamma \mathsf{R} \Delta$, we have that $\mathscr{M}, \Delta \models X$.

The role of clause 4 – requiring that $\Gamma \in \mathscr{E}(t,X)$ – is to add a relevance requirement: t should give a relevant evidence for X at Γ. Informally, $t : X$ is true at a possible world if X is believable at that world in the usual sense of epistemic logic, and t gives the *relevant evidence* for X at that world.

Given the framework above, let s be the relevant evidence for H1 and t the relevant evidence for H2. We will use the expression $H1 \Rightarrow S$ as meaning something like "$H1$ explains S" ($\Rightarrow$ should thus not to be intended as a material conditional).

The three clauses defining the notion of explaining away given above could be modelled within justification logic in the following way:

Adequacy: $\mathscr{E}(s, H1 \Rightarrow S) \cap \mathscr{E}(t, H2 \Rightarrow S) \neq \emptyset$

According to this condition, $H1$ is as explanatory adequate to explain S as it is $H2$ if and only if there is at least a world where there is evidence that $H1$ is able to explain S and evidence that $H2$ is able to explain S.

Independence: for every t such that $\mathscr{M}, \Gamma \models (s : H1 \Rightarrow S)$ and every s such that $\mathscr{M}, \Gamma \models (t : H2 \Rightarrow S)$, $s \neq t$

According to this condition, $H1$ is independent from $H2$ if and only if, for every possible world, the evidence that supports $H1$ (i.e., the capacity of $H1$ to explain S) is distinct from the evidence that supports $H2$.

Reduction: (i) $\mathscr{E}(s, H1 \Rightarrow S) \subseteq \mathscr{E}(t, H2 \Rightarrow S)$ (ii) $Pr(t : H2 \Rightarrow S) > Pr(s : H1 \Rightarrow S)$

According to the first clause of this condition, it cannot happen that there is a world where $H1$ is able to explain S without there being some evidence that $H1$ is able to explain S. According to the second clause of this condition, in such worlds, the probability of $H2$ to explain S is greater than the probability of $H1$ to explain S. In justification logic this idea is rendered through an information about the evidence sustaining, respectively $H1$ and $H2$: the probability that s is evidence that $H1$ explains S is greater than the probability that t is evidence that $H2$ explains S.

Consider the case of average mums. In this case, the claim to be explained (S) is that the average mum has 2.4 children and then we have an ontology $O1$ ($O1 = H1$) that postulate the kind of entity "average mum" and another ontology $O2$ ($O2 = H2$) that do not postulate such entities but only mums, children and proportions among the number of them. According to our formalization in terms of justification logic, the fact that $O2$ explains away $O1$ can be understood in the following way:

- According to **Adequacy**, there is at least one world where there is evidence that the postulation of average mums explain S, namely that the average mum has 2.4 children, but in which there is also evidence that the proportion between number of mums and children is enough to explain S.
- According to **Independence**, any evidence in favour of the postulation of average mum is independent from the evidence in favour of proportions between mums and children.
- According to clause (i) of **Reduction** there is no world where there is some evidence that the postulation of average mums explains S but there is no evidence that S can be explained by the existence of "ordinary" mums, children and proportions between their numbers. Finally, according to clause (ii), those worlds where there is evidence both in favour of $O1$ and in favour of $O2$ are worlds where the probability of $O2$ is greater than the probability of $O1$. A world where we explain S in terms of proportions between mums and children is clearly a world where there is no need to postulate the existence of average mums.

All three conditions seem plausible for the case at hand, but also in general: whenever we have a conflict between two ontologies $O1$ and $O2$, **Adequacy** represents the idea that we are in a situation where we have some evidence in favour of both, **Independence** represents the idea that the evidences we have in favour of both are independent

(otherwise the conflict would not arise).[9] Finally, **Reduction** represents the idea that evidence in favour of $O2$ is always available whenever there is evidence in favour of $O1$, but that any evidence in favour of $O2$ decreases the evidence in favour of $O1$ and thus the need to invoke the entities postulated by this latter ontology.

6. Conclusions

In this paper we have defended a strategy to deal with conflicts between ontologies and, in particular, with conflicts between so-called commonsense and theoretical ontologies. We have shown that the best way of reconciling such ontologies is *epistemic*: a commonsense ontology is reconciled with a theoretical ontology in case it is shown that the explanation of the need to postulate the existence of an ontologically problematic entity in the former ontology is compatible with our best theories, i.e., with our theoretical ontologies. We have shown that this method of reconciliation is better suited than the traditional, *semantic* method, based on reconciling paraphrases. We have also shown that our view could be connected in a theoretically fruitful way with the notion of *explaining away*. In fact, an ontology $O1$ is epistemically reconciled with $O2$ (where $O2$ is the theoretical ontology) just in case $O2$ explains away $O1$. This connection is theoretically fruitful because the notion explaining away could be formalised within a justification logic. The formalization of the notion of explaining away within such a logical framework could thus give us some insights on the logical structure of epistemic reconciliations. Our aim in future works is to explain in a more detailed way how the process of explaining away could be represented in the logical framework sketched in section 5.

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[9] We might have cases of partially conflicting evidences: these kind of cases should be dealt with by a modification of **Independence** requiring that at least some evidence in favour of one ontology is distinct from that of the other. For the moment, we rest content with the more simple analysis given above.

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