TEMPORAL AND CIRCUMSTANTIAL DEPENDENCE IN COUNTERFACTUAL MODALS

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This paper analyzes counterfactual readings of *might/could have* using circumstantial rather than metaphysical modal bases. This accounts for scenarios in which the assumptions of the metaphysical analysis are not met, for a phenomenon of truth value varying with contextual assumptions, and is consistent with deterministic models.

1. Branching time semantics for *might/could have*

Mondadori (1978) and Condoravdi (2002) advanced the hypothesis that uses of *might have* like in (1) have a semantics which exploits branching time models. In a model where the sentence is true relative to a world w_0 and time n, there is a time t which precedes n and a world w which is a metaphysical alternative to w_0 at t such that in w there is an event of John winning which is temporally included in the interval $[t,\infty)$. Metaphysical alternative means that w and w_0 are exactly the same up to t. Informally, w is a branch from w_0 at t where John later wins.

(1) At that time, John might have won the game, but he didn't. (Condoravdi 2002)

I assume along with Condoravdi that the time operator associated with *have* scopes over the modality (but see Stowell 2004), and that in examples where the main verb is eventive there is always a covert futurity inside the scope of the modal (see also Abusch 1998). (2) is Condoravdi's denotation for *might*, where M(w,t)(w') is understood as "w' is a metaphysical alternative to w at t".

(2) $[\![\text{might}]\!] = \lambda p \lambda w \lambda t \exists w'[\text{M}(w,t)(w') \wedge \text{AT}([t,\infty), w', p)]$

I argue that there are examples which should fall under the same analysis as (1), but where the modality can not be metaphysical, because the requirement that the alternatives should be literally the same as the base world up to the reference time is not met. Consider this scenario: there were two huge old trees in my front yard, of similar age and appearance. In a summer storm, one of them was blown down. Fortunately, it fell away from the house onto the driveway, rather than towards the house onto my husband's office. When we looked at the broken trunk, we saw that it was rotted inside, so this was a dangerous tree. My husband made the argument in (3). I made the argument (4) to an opposite conclusion.

(3) HUSBAND: I might have been killed, because the tree could have fallen onto my office. Let's cut down the other tree. It might fall onto my office in another storm.
(4) WIFE: We bought the house for the trees, and now you want to cut them down? Anyway the tree guy told us that because of the location of the rot in the trunk, the tree could only fall away from the house. So the tree could not have fallen onto your office.

The specific problem is that the rot in the trunk was in a specific location before the storm in the base world w_0, and we can assume that this specific location makes it impossible for the tree to fall onto the house. In this case, the husband's statement is false on the branching-time analysis. How then can his argument have any validity? Also, intuitively, the husband's argument ignores the specific location of the rot, while the wife's argument pays attention to it. It is not clear how to fit these assumptions into the branching-time analysis.

Similar points can be made about sports-math modality, which is a modal idiom of sports writers and fans which has a very specific semantics. In assessing the truth of sentences (5) and (6) in a world *w*, one pays attention to the schedule of league play in *w*, the results in *w* of games up to week 11, the league regulations in *w* which concern participation in the post-season playoffs, and nothing else.

(5) In week 11 of the football season, mathematically, Buffalo could still have reached the playoffs.
(6) In week 11 there was still a mathematical possibility of Buffalo reaching the playoffs.

It seems that (5) and (6) can be true in models where the base world w_0 has no metaphysical alternatives at week 11 where Buffalo reaches the playoffs, as a result of *other* facts in the base world and (therefore) in its metaphysical alternatives, such as all the Buffalo players having broken legs.

2. Factual-circumstantial modality

Notice that all of the assumptions we are talking about are facts. In a possible worlds framework, we want to assess truth with respect to a possible world *w*, but factor in a choice of facts about *w* which are considered relevant. This kind of modality is known as a factual or circumstantial modality. Kratzer (1991) proposed the following framework for circumstantial modality, as a special case of a general framework. A contextually given function, here notated as Pr, maps any possible world *w* to a set of facts about *w*. A fact about *w* is a proposition *p* such that *p* is true in *w*. Adding a time argument gives the type $[(I\rightarrow W\rightarrow[W\rightarrow 2]\rightarrow 2]$, with the constraint that for any *w*,*t* and *p* such that $Pr(t)(w)(p) = 1$, $p(w) = 1$. $Pr(t)(w)$ is used as a set of relevant facts about $\langle w,t\rangle$ which enters as a modal base into the semantics of a modal which is evaluated at $\langle w,t\rangle$. Three kinds of information are relevant to the truth assessment of sports math modality: (i) propositions describing the league schedule in *w* at *t*; (ii) propositions describing the result of play in *w* up to *t*; and (iii) propositions describing league regulations in *w* at *t*. Only the propositions in (ii) are necessarily facts about $\langle w,t\rangle$. Regarding (i), it might be that the play which is planned in *w* is not carried out, because of a natural disaster. In this case, the propositions describing the planned play are not all facts about $\langle w,t\rangle$. Regarding (iii), it might be that the league regulations for picking the teams that participate in the playoffs are not followed in *w*, because of a computer error. So sports-math is a circumstantial-deontic modality, with a specific factual-circumstantial modal base function Pr_{sm}, and a specific deontic ordering function Or_{sm}. A speaker who uses a sports math sentences intends to fix parameters in the lexical entry of the modal as Pr_{sm} and Or_{sm}. (7) describes Pr_{sm} semi-formally using a lambda expression with a question as a body, assuming the Karttunen semantics for questions.

(7) $Pr_{sm} = \lambda t\lambda w$[what NFL team plays what NFL team at what time preceding *t* in regular-season play with what final score in *w*]

Let's use the logical form (8b) for (8a), where the modal has two hidden arguments filled by referential indices. The first hidden argument is used as the modal base, and the second hidden argument is used as the ordering source function. In a sports-math context, the contextual assignment function *g* satisfies $g(1)=Pr_{sm}$ and $g(2)=Or_{sm}$. Adding time sensitivity to the semantics for an existential modal found in Kratzer (1991) results in (9) as the lexical entry of the modal.

(8) a. In week 11, mathematically Buffalo could have reached the playoffs .
b. [[in week 11][have [might(1)(2) [Buffalo reach the playoffs]]]]

(9) ⟦might⟧ is the function *f* such that $f(Pr)(Or)(P)(t)(w) = 1$ iff

$$(\exists u\in\cap Pr(t)(w))\ (\forall v\in\cap Pr(t)(w))[v\leq_{Or(t)(w)}u\ \rightarrow\ (\exists z\in\cap Pr(t)(w))[z\leq_{Or(t)(w)}v\ \wedge P(t)(z)]]$$

where $v\leq_X u$ iff $\{p|\ p\in X\wedge p(u)\}\subseteq\{p|\ p\in X\wedge p(v)\}$

When Pr_{sm} is the first argument of *might*, the domain of quantification for any quantifier in the formula in (9) is the set of worlds which have the same history of play as the base world up to week 11. In any model of reasonable complexity, this is a much more inclusive set than the set of metaphysical alternatives to the base world at week 11. Furthermore, the ideal worlds according to Or_{sm} are ones where the schedule and the regulations for determining participation in the playoffs are followed. This makes it relatively easy to find witnesses for the existential quantifiers. Indeed one can use as a witness for both $\exists u$ and $\exists z$ any old world w_2 which has the same results as the base world up to week 11, which follows the regulations and schedule, and has a particular pattern of results for the whole season which allows Buffalo to qualify. It does not matter if in the base world at week 11, the Buffalo players are in such bad shape that Buffalo does not win any more games in the base world or its metaphysical alternatives, because the domain of quantification is not limited to metaphysical alternatives, just to worlds which have the same results as the base world up to w_0. Or suppose we are talking about computer football matches, where the systems play according to certain deterministic algorithms. Then we can get the kind of shift illustrated in (10).

(10) In week 11, Buffalo could still technically have reached the playoffs. But that would require Buffalo defeating Chicago in week 12. And that is impossible because of the algorithms implemented in those systems.

An additional point is that the circumstantial analysis is consistent with deterministic models, while the metaphysical analysis is not. In a deterministic model (take one where all worlds have a deterministic classical physics), metaphysical alternative sets are trivial, consisting of singleton sets, so metaphysical modals are vacuous. But there can still be non-trivial circumstantial alternative sets. If we think natural language semantics should be consistent with a range of model types including deterministic ones, this is a good consequence.

In the tree example, the husband's and wife's facts both include facts about the storm, the size and configuration of the tree, the fact that there was such-and-such degree of rot in the trunk, and (perhaps in the ordering source) a scientific or rule-of-thumb theory of tree motions under the influence of wind. The wife's facts include in addition the specific location of the rot on the driveway side of the tree. This removes the apparent contradiction between (3) and (4), and formalizes intuitions about the arguments. To this one has to add an account of the validity of the husband's argument about the other tree. I suggest the facts are centered, with a parameter for the tree.

3. Temporal dependence

An important consequence of the metaphysical analysis is the account it gives of time-senstitivity. The branching-time story about (11) is that at w_0 at 12:00, there is a branch (a metaphysical alternative) which leads to a win of John. In w_0 at 12:30, some branches have been passed, and there are no branches which lead to a win of John.

(11) At noon, John still might have won the race. But at 12:30, he could not have won the race.

Does the new analysis have the same kind of time dependency? Formally, this is simple. As formulated above, the premise function has world and time arguments. In a compositional semantics that manipulates properties of time, we can set up the rules and denotations such that in the denotation of *could win the race*, the temporal argument of the property is identified with the temporal argument of the premise function. In fact this is already achieved in (9). The move is technically possible because the description of the function [[might]] can refer to the temporal argument of the premise function and the temporal argument of the property denoted by the phrase headed by *might*.

As long as the premise function is time dependent – as long as for a given world, it can have different values at different times – the denotation of the phrase headed by the modal can be time dependent too. Pr_{sm} is time dependent, because $\mathrm{Pr}_{sm}(w,t)$ has information about a monotonically increasing set of game results as t increases. In fact, if $t < t'$ then $\mathrm{Pr}_{sm}(t)(w) \subseteq \mathrm{Pr}_{sm}(t')(w)$, and therefore $\cap\mathrm{Pr}_{sm}(t')(w)$ is a subset of $\cap\mathrm{Pr}_{sm}(t)(w)$. So as time passes, the domain of quantification shrinks. This is similar to what happens in the branching-time analysis, where as time passes the set of metaphysical alternatives $\lambda v[\mathrm{M}(t,w)(v)]$ used as a domain of quantification shrinks monotonically. In fact, the new analysis is a generalization of the old one. (12) defines a premise function in terms of the metaphysical-alternative relation M. Using it in combination with a trivial ordering source reconstructs the branching time analysis within the circumstantial analysis.

(12) $\mathrm{Pr}_m = \lambda t \lambda w \lambda p[p = \lambda v[\mathrm{M}(t,w)(v)]]$

4. Epistemic readings

What I have analyzed as circumstantial readings can also have an epistemic flavor. In example (13) about oil prospecting, we can say either that salient facts about the base world were consistent with there being oil reserves under the ranch, or that this was consistent with the beliefs of the speaker at that time or with information available to the speaker and others. Similar examples are discussed in von Fintel and Gillies (2007).

(13) We bought a ranch which might have contained a significant oil reserve. But there is nothing under this ranch but salt water. Let's sell it and move on.

But consider this variant of the tree example. The two trees are in a part of our forest reserve which we never visited before. The tree fell away from a plantation of endangered orchids. We find it several months after it fell. The facts about the rot are as before. Here is the sentence:

(14) The tree could have fallen on the orchids. Let's cut down the other tree. It might fall on the orchids in another storm.

In this case, there was nobody around before the time of the storm who believed the propositions in the modal base or took them to be common ground. So the modal base or ordering source could not be epistemic. On the other hand, there is no problem with saying that the modality refers to relevant information about the tree at the time of the storm, as represented in the modal base, combined with an ordering source capturing our rule-of-thumb theory of tree motions.

Because the framework is one which is also applied to counterfactuals with *if*, we can account for certain relations to sentences like (15).

(15) If the rot had been on the opposite side, the tree might/would have fallen on the office.

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