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A problem for downward closure in the semantics of counterfactuals

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Abstract. Ciardelli, Zhang, and Champollion (2018b) adopt the framework of inquisitive semantics to provide a novel semantics for counterfactuals. They argue in favour of adopting inquisitive semantics based on experimental evidence that De Morgan’s law, which fails in inquisitive semantics, is invalid in counterfactual antecedents. We show that a unique feature of inquisitive semantics—the fact that its meanings are downward closed—undermines Ciardelli et al.’s semantic account of their data. The scenarios we consider suggest either adopting a semantic framework other than inquisitive semantics, or developing a non-semantic explanation of the phenomena Ciardelli et al. (2018b) seek to explain.

1 Introduction

Inquisitive semantics is a semantic framework that provides a uniform treatment of declarative and interrogative utterances. (For a comprehensive introduction to inquisitive semantics, see Ciardelli, Groenendijk, and Roelofsen 2018a.) In this paper we consider a recent application of inquisitive semantics to conditionals, proposed by Ciardelli (2016) and Ciardelli et al. (2018b).

According to inquisitive semantics, the meaning of a term is given by a set of propositions, which is constructed around a primitive notion of *resolution conditions*. Intuitively, the resolution conditions of an utterance are the set of propositions that resolve the issue it raises.

1.1 Downward closure

As Ciardelli et al. (2018a, §2.3) point out, one formal consequence of framing meanings in terms of resolution conditions is that meanings are *downward closed*:

* Thanks to Ivano Ciardelli, Alexandre Cremers, Morwenna Hoeks, Hana Möller Kalpak, Jonathan Pesetsky, Floris Roelofsen, Katrin Schulz and Zhuoye Zhao for very helpful comments. Thanks also to the participants of the ILLC inquisitive semantics seminar.

for any expression A , if a proposition p is an element of $\llbracket A \rrbracket$ (the meaning inquisitive semantics assigns to A), then any more informative proposition $p' \subseteq p$ is also an element of $\llbracket A \rrbracket$. After all, if p resolves the issue raised by A , every more informative proposition must too.

The property of downward closure distinguishes inquisitive semantics from other frameworks with a similar empirical range as inquisitive semantics, such as alternative semantics (e.g. Hamblin, 1973; Kratzer and Shimoyama, 2002) and truthmaker semantics (Briggs, 2012; Fine, 2012, 2014). Downward closure restricts the range of meanings that inquisitive semantics admits. Compare, for instance, a logical form (LF) given by an atomic sentence B with one of the form $B \vee (A \wedge B)$. In alternative semantics and truthmaker semantics, where meanings are not downward closed, these sentences receive a different interpretation. For, let $|S|$ be the set of worlds where an LF S is true. Then alternative semantics interprets B as $\{|B|\}$, but $B \vee (A \wedge B)$ as $\{|B|, |A \wedge B|\}$. While these interpretations are distinct, their downward closures are identical. Thus, without further enrichment, these sentences receive the same denotation according to inquisitive semantics.

The comparison between LFs of the form B and $B \vee (A \wedge B)$ will serve as a central example in what follows. For now we continue our introduction with inquisitive semantics for conditionals.

Inquisitive semantics has recently been applied to conditionals through the work of Ivano Ciardelli and collaborators. Ciardelli (2016) and Ciardelli et al. (2018b) assume alongside others (Alonso-Ovalle, 2006, 2009; Fine, 2012; Santorio, 2018) that the hypothetical scenarios raised by a counterfactual antecedent are a matter of semantics. However, unlike Alonso-Ovalle’s approach which relies on alternative semantics, since inquisitive meanings are downward closed—and hence typically contain infinitely many elements—inquisitive semantics needs an additional operator to extract the alternatives raised by a counterfactual antecedent, which then serve as input in the process of making counterfactual assumptions. Ciardelli (2016) and Ciardelli et al. (2018b) achieve this by taking only the weakest elements (with respect to entailment) of the meaning inquisitive semantics assigns to the antecedent and consequent. These weakest elements are called its *alternatives*.

$$(1) \quad \text{alt}(A) = \{p \subseteq W \mid p \in \llbracket A \rrbracket \text{ and for no } q \supsetneq p \text{ is } q \in \llbracket A \rrbracket\}$$

Ciardelli (2016)’s semantics for conditionals also involves a conditional connective \Rightarrow holding between propositions, to be defined in terms of one’s favourite semantics of conditionals, such as similarity among worlds (Stalnaker, 1968; Lewis, 1973) or causal models (Briggs, 2012; Santorio, 2016; Ciardelli et al., 2018b). Writing $>$ for the conditional construction, the clause is as follows.

- (2) A counterfactual $A > C$ is true at a state s just in case for every $p \in \text{alt}(A)$ there is a $q \in \text{alt}(C)$ such that $s \subseteq p \Rightarrow q$ (Ciardelli, 2016)

As Ciardelli explains, “The intuition is that in order to support [a conditional], a state needs to contain information that implies, for every alternative for the antecedent, that if that alternative were to obtain, then some corresponding alternative for the consequent would obtain” (2016, 741).

In the following section we consider a recent application of inquisitive semantics to counterfactuals. This analysis will serve as the focus of our discussion to come.

2 De Morgan’s law in counterfactual antecedents

Ciardelli et al. (2018b) present experimental evidence against De Morgan’s law in counterfactual antecedents. De Morgan’s law is the equivalence of $\neg(A \wedge B)$ and $\neg A \vee \neg B$. Many semantic frameworks that have been applied to conditionals validate De Morgan’s law, such as possible-worlds semantics (Stalnaker, 1968; Lewis, 1973) and truthmaker semantics (Fine, 2012; Briggs, 2012). In contrast, inquisitive semantics—alongside alternative semantics (Alonso-Ovalle, 2006) and intuitionistic truthmaker semantics (Fine, 2014)—does not validate De Morgan’s law.

The experimental data in Ciardelli et al. (2018b) concern the scenario below featuring two switches, A and B, connected to a light. As the wiring diagram in Figure 1 shows, the light is on just in case both switches are in the same position (i.e. both up or both down). Currently, both switches are up, so the light is on.

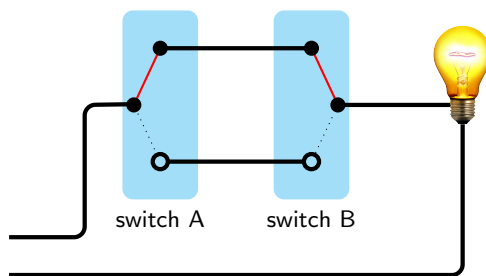


Fig. 1: Scenario used in Ciardelli et al. (2018b)’s experiment

- (3) a. If switch A or switch B was down, the light would be off.
 b. If switch A and switch B were not both up, the light would be off.

Comparing 1425 responses, Ciardelli et al. (2018b) found a significant difference between the two sentences in (3). (3a) was judged true by a wide majority (True $\approx 70\%$), whereas (3b) was generally judged false or indeterminate (True $\approx 22\%$).

Ciardelli et al. (2018b) choose to offer a *semantic* explanation for the difference in acceptability between (3a) and (3b). In their framework, it is the difference in semantic value between $\llbracket \neg(A \wedge B) \rrbracket$ and $\llbracket \neg A \vee \neg B \rrbracket$, together with their method of adopting hypothetical assumptions, which leads to (3a) and (3b) raising different counterfactual scenarios. Specifically, in Ciardelli et al.’s framework, evaluating (3b) but not (3a) requires considering the scenario where both switches are down.

In the following section we turn to an addition inquisitive semantics requires to make the correct predictions regarding counterfactuals. In section 4 we will see that this addition raises a problem for the account in (Ciardelli et al., 2018b).

3 Exclusification

Earlier we saw how downward closure makes B equivalent to $B \vee (A \wedge B)$. In this section we consider a variant of the scenario in Figure 1 which shows that the equivalence of B and $B \vee (A \wedge B)$ is not valid in counterfactual antecedents. Though we will see in section 3.2 that there is a natural proposal available to inquisitive semantics to resolve the problem.

3.1 A scenario with new wiring

Consider the following variant of the scenario in Figure 1. As the wiring in Figure 2 depicts, the light is on just in case switch A is down and B is up. Suppose that currently, both switches are down, so the light is off, and consider (4).

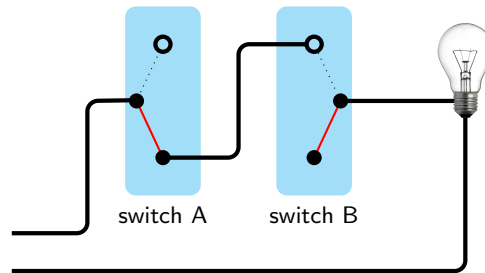


Fig. 2: The light is on just in case A is down and B is up.

- (4) a. If switch B was up, the light would be on. $B > \text{On}$

- b. If switch B was up, or switches A and B were up, the light would be on. $B \vee (A \wedge B) > \text{On}$

Intuitively, when we interpret (4a) we keep the position of switch A fixed while imagining switch B up, in which case the light is on. But when we consider both switches being up we find that the light is off. Thus in the scenario raised by (4a)'s antecedent, the light is on, making the conditional (4a) as a whole true. But in one scenario raised by (4b)'s antecedent the light is off, making (4b) false.

Since B is equivalent to $B \vee (A \wedge B)$ according to inquisitive semantics, without further refinement inquisitive semantics predicts both (4a) and (4b) to be true. However, there is an attractive story available to inquisitive semantics that avoids the equivalence of (4a) and (4b), which we turn to now.

3.2 Embedded exclusivity operators

A promising proposal is that the disjunction in $B \vee (A \wedge B)$ is interpreted *exclusively*. This would make B *is up* or A and B *are up* no longer equivalent to B *is up*, but instead to something paraphrasable as, *Only B is up, or A and B are up*, which is arguably further paraphrasable as *B is up and A is not up, or A and B are up*.

A further argument inquisitive semantics can make in favour of an exclusive interpretation of the disjunction in (4b) comes from Hurford's constraint (Hurford, 1974), illustrated in (5).

- (5) # If John were from France or Paris, he would speak French.

Many authors explain the infelicity of (5) in terms of *redundancy* (Simons, 2001; Katzir and Singh, 2013; Meyer, 2013, 2014; Ciardelli et al., 2017). Since every Parisian is French, the disjunct in (5) raising the assumption of John being Parisian is redundant, being already included in the assumption of John being French. By the same reasoning, one would expect the disjunction $B \vee (A \wedge B)$ in (4b) to be infelicitous because the disjunct $A \wedge B$, which entails B , is redundant.

However, unlike (5), clearly (4b)'s antecedent *If switch B was up, or switches A and B were up* is acceptable. We can explain this by pointing out that, while $B \vee (A \wedge B)$ contains a redundant disjunct, its exclusive interpretation $(B \wedge \neg A) \vee (A \wedge B)$ does not. This is analogous to the explanation of good Hurford disjunctions, such as (6), in terms of a local embedded exhaustivity operator (Chierchia, 2004).

- (6) Nancy ate EXH(some) or all of the chocolate.

Roelofsen and van Gool (2010) define an exhaustivity operator EXH that is suitable for inquisitive semantics, which Aloni and Ciardelli (2011) have already put to use in the interpretation of imperatives. Applying this operator to $B \vee (A \wedge B)$ produces

$(B \wedge \neg A) \vee (A \wedge B)$, which is intuitively the correct result. Under any adequate semantics for counterfactuals, this interpretation also makes (4b) false, as desired.

Thus, with sufficient enrichment inquisitive semantics for counterfactuals can provide the correct judgements in the scenario of Figure 2. In so doing, the analysis renders $B \vee (A \wedge B)$ as $(B \wedge \neg A) \vee (A \wedge B)$. It turns out the difference between $B \vee (A \wedge B)$ and $(B \wedge \neg A) \vee (A \wedge B)$, though subtle, gives rise to a difference in the truth value of conditionals in certain environments. This is because $|B \wedge \neg A|$ is a stronger proposition than $|B|$. In terms of conditional antecedents, we might loosely describe the difference by saying that imagining switch B up does not say anything about switch A, whereas imagining $B \wedge \neg A$ involves considering switch A not up.

In what follows we design a situation making the difference between $B \vee (A \wedge B)$ and $(B \wedge \neg A) \vee (A \wedge B)$ explicit, even when switch A is already not up.

4 When exclusification is too strong

Consider the scenario below (Figure 3) where switch A can take three positions: up, in the middle or down. We might imagine that switch A is a caretaker’s ‘master switch’, which can fix the light on by being up, fix the light off by being down, or let a user decide by being in the middle. Switch B is then the user’s switch, which as before can only be up or down.¹ Currently, switch A is in the middle and switch B is down, so the light is off.

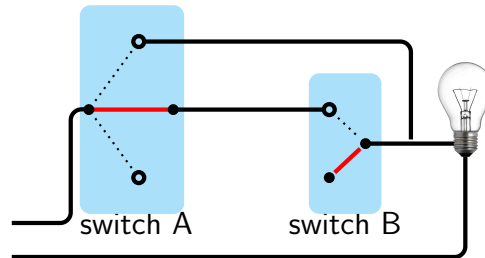


Fig. 3: The light is on just in case A is up, or A is in the middle and B is up

With respect to the scenario of Figure 3, consider the counterfactuals in (7).

- (7) a. If switch B was up, the light would be on. B

¹ Thanks to Alexandre Cremers for coming up with this description of the scenario.

- b. If switch B was up, or switches A and B were up, the light would be on. $B \vee (A \wedge B)$
- c. If switch B was up and switch A was not up, or switches A and B were up, the light would be on. $(B \wedge \neg A) \vee (A \wedge B)$

If we are asked to imagine switch B up, and asked nothing about switch A, it seems intuitively we keep the position of switch A fixed. This is different from being asked to imagine switch A not up, as in (7c), even though switch A is already not up. Loosely, we can say that (7c)'s antecedent raises the possibility of switch A being down, and hence the light being off.

In the previous paragraph we phrased the interpretation of (7b) and (7c) purely in terms of intuition. There is nonetheless experimental evidence in its favour. In a similar scenario to those considered here, Schulz (2018) presents experimental evidence that in counterfactual antecedents, mentioning something that is already true does not make the same contribution as not mentioning it at all.

In the section scenario we considered (Figure 2), where switch A can only take two positions, inquisitive semantics can avoid the problems posed by downward closure by appealing to the exclusification story above. But here this same story predicts the equivalence of (7b) and (7c). In contrast, a semantic framework in which meanings are not downward closed, such as alternative semantics (Alonso-Ovalle, 2006) and truthmaker semantics (Fine, 2014, 2017), can reproduce the correct judgements here since they do not appeal to exclusification in the first place. Thus, for example, alternative semantics can distinguish between the antecedents of (4a) and (4b) in the first scenario, and of (7b) and (7c) in the second, all under their usual interpretation.

One avenue available to inquisitive semantics is to propose that overt negation has additional effects in conditional antecedents beyond its semantic contribution. Inquisitive semantics could still interpret $\text{EXH}B \vee \text{EXH}(A \wedge B)$ as $(B \wedge \neg A) \vee (A \wedge B)$, but propose that the operator EXH does not have the same effect as an overt negation. Of course, inquisitive semantics already has a semantic entry for negation, so this additional effect would have to be non-semantic.

However, this proposal on behalf of inquisitive semantics undermines the semantic explanation of violations of De Morgan's law in counterfactual antecedents that Ciardelli et al. (2018b) provide. To preserve the explanatory value of inquisitive semantics in such cases, one would have to ensure that the proposed additional effects of overt negation do not explain what Ciardelli et al. (2018b) wish to explain in purely semantic terms. This is a challenging task given the structural similarities between the scenario Ciardelli et al. (2018b) originally tested (Figure 1) and the scenario just considered (Figure 3), both of which involve the effects of negation in raising additional counterfactual scenarios.

5 Counterfactual exhaustification

One way to solve the problem posed in section 4 is to make the EXH operator sensitive to counterfactual alternatives.² Loosely, the idea is to exhaustify with respect to the *changes* that one makes when moving from the actual world to the hypothetical scenarios raised by a conditional antecedent.

It is generally agreed that the contribution EXH is determined with respect to a set of alternatives. If these alternatives are given by a question under discussion, then we can embed this proposal into standard accounts of exhaustification by making EXH sensitive to a question under discussion that asks explicitly about counterfactual alternatives. In this case, the question under discussion would be $Q = \textit{What happened to the switches in the hypothetical scenarios generated by the given counterfactual antecedent?}$

More precisely, we can formalise the idea of ‘nothing happening’ in terms of the counterfactual selection function f , defined in terms of one’s favourite semantics of counterfactuals. Here is how the proposal would work on the first disjunct of (4b), repeated as (8a).

- (8) a. If switch B was up or switches A and B were up, the light would be on.
 b. $\text{EXH}_Q(\text{switch B is up})$
 c. Switch B is up, and nothing happened to switch A
 d. $\forall w' \in f(\text{switch B is up}, w) : \text{switch B is up in } w', \text{ and } w' \text{ agrees with } w \text{ on the position of switch A}$

Note that, for reasons of compositionality, the interpretation of EXH—appearing at the level of the counterfactual antecedent—cannot depend directly on the mechanism of making counterfactual assumptions, which only enters the computation at the level of the entire conditional. To see this, consider the following LF for (4b) according to the restrictor analysis of conditionals (or, the Lewis/Kratzer/Heim approach, as dubbed by Partee (1991)).

- (9) [Modal [if [EXH(B is up) or EXH(A and B are up)]]] [the light is on]

EXH appears below *if* and the modal. Thus the introduction of the selection function f in the calculation of EXH_Q cannot come from the presence of these constituents. However, we could say that EXH features λf in its semantic entry, although this seems highly costly, requiring the introduction of a special ‘counterfactual exhaustification operator’ tailor made for counterfactual antecedents. Alternatively, we could say that f is indicated by the presence of counterfactual morphology, in particular the X -marking on the antecedent.

² I am grateful to Floris Roelofsen for suggesting this proposal.

The intriguing idea of counterfactual exhaustification deserves to be considered in full detail, for which there is not space here. It would certainly require a much more sophisticated kind of exhaustification, one that does not interfere with the unique subtleties of the selection function, such as keeping some aspects of the actual world fixed while allowing others to vary. For now we will leave the proposal of counterfactual exhaustification as a sketch and move to one final concern that comes from raising problems for inquisitive semantics. The problem is about how fine-grained our notion of semantic content ought to be.

6 Accounting for Hurford’s constraint

In section 4 we saw that inquisitive semantics struggles with Hurford violations in conditional antecedents. In contrast, a more fine-grained notion of semantic content—as in alternative semantics or intuitionistic truthmaker semantics—can distinguish B from $B \vee (A \wedge B)$ without resorting to embedded exclusivity operators.

There is however an argument against adopting a more fine-grained perspective on semantic content, due to Ciardelli and Roelofsen (2017, section 5.1). They argue that alternative semantics has difficulty implementing an account of Hurford’s constraint based on redundancy (proposed, e.g. by Simons, 2001; Katzir and Singh, 2013; Meyer, 2013, 2014). For instance, even when A entails B , in alternative semantics B is not equivalent to $A \vee B$; e.g. for atomic A and B , $\llbracket A \rrbracket = \{|A|\}$ and $\llbracket B \rrbracket = \{|B|\}$ but $\llbracket A \vee B \rrbracket = \{|A|, |B|\} \neq \{|A|\} = \llbracket A \rrbracket$. But (5) is still infelicitous.

In what follows we respond to above objection on behalf of more fine-grained approaches to meaning by making the notion of redundancy sensitive to the function of utterance type at hand.

Intuitively, we can say that a constituent of an utterance is redundant just in case there is a simpler utterance that *performs the same function* as the first. After all, this is just what redundancy means: for something to have a redundant part is for the part to fail to contribute to the object’s goal.

As usual, Hurford’s constraint will follow from the claim that an utterance is infelicitous if it contains a redundant constituent. Nonetheless, the proposed function-sensitive analysis of redundancy contrasts with that proposed by Katzir and Singh (2013) and adopted by Ciardelli and Roelofsen (2017). Katzir and Singh define a constituent of an utterance to be redundant just in case there is a simpler utterance *receiving the same interpretation* as the first. Since the same constituent can appear in utterances with different functions, the two analyses of redundancy make different predictions about when a constituent is redundant.

It is a straightforward observation that different utterance types perform different functions. To simplify greatly, in general the following utterance types perform the following functions, assuming speaker sincerity.

- The function of a declarative utterance is to communicate information.
- The function of an interrogative utterances is to raise issues.
- The function of a conditional antecedent is to raise contexts of evaluation.

Let A be a constituent appearing in an utterance U , and U' be the competing utterance to U where A is removed from U (and any changes required for grammaticality are made). Further, let $\text{info}(U)$ and $\text{inq}(U)$, respectively, be the informative and inquisitive content of an utterance U given in terms of one's favourite semantics of declaratives and interrogatives, and f be a selection function given by one's favourite semantics of conditionals, which takes a semantic object of some type τ and a world w and returns the set of worlds at which a conditional consequent is evaluated when w is the actual world.³ Further, let alt be a function from utterances to sets of objects of type τ , and for any world w let us use $\text{hyp}(U, w) = \{f(x, w) : x \in \text{alt}(U)\}$ to denote the 'hypothetical content' of U at w . We mention alt here to make the account compatible with inquisitive semantics of conditionals, which as we saw in section 1.1, needs the extra operator alt due to downward closure.

Then according to Katzir and Singh (2013), U is infelicitous if U and U' receive the same interpretation (i.e. $\llbracket U \rrbracket = \llbracket U' \rrbracket$), while under a theory where redundancy is sensitive to utterance types, we can propose that U is infelicitous if

- U is declarative and $\text{info}(U) = \text{info}(U')$
- U is interrogative and $\text{inq}(U) = \text{inq}(U')$
- U is a conditional antecedent and $\text{hyp}(U, w) = \text{hyp}(U', w)$ for every world w .^{4, 5}

Let us now show that the new analysis can account for the familiar data. We will only consider the case of conditionals here. Compare the conditionals in (10).

(10) a. # If John were from Paris or France, he would speak French.

³ Usually, τ would be the type of a proposition, i.e. $\tau = \langle s, t \rangle$. However, τ could be something else, such as the type of a truthmaker.

⁴ Note that the definition of felicity for conditional antecedents features universal quantification over worlds. This is to represent the fact that the infelicity of Hurford violations, involves a global rather than local kind of redundancy. To see this, compare (10a)'s antecedent (i): *If A was up or B was up, ...*. (10a) is infelicitous in every world, whereas (i) still seems acceptable even when, say, switch A is already up, and thus the constituent mentioning A in (i) is redundant *with respect to the actual world*. The infelicity of Hurford violations thus appears to result from redundancy of a global rather than local kind.

⁵ The felicity conditions of a conditional consequent are determined by its utterance-type, i.e. declarative for conditional assertions and interrogative for conditional questions. A conditional is infelicitous if its antecedent or consequent is infelicitous.

- b. If John were from France, he would speak French.

A theory of redundancy sensitive to utterance types can explain that (10a) is infelicitous because, according to any plausible semantics of counterfactuals, the set of worlds that result from the hearer counterfactually assuming that John is French includes the set of worlds where they counterfactually assume that John is Parisian. Thus the antecedent of (10a) and (10b) have the same hypothetical content in every world, so (10a) contains a redundant constituent, and we correctly predict the infelicity of (10a).

Nonetheless, the two analyses of redundancy differ when it comes to (4).

- (4) a. If switch B was up, the light would be on.
b. If switch B was up or switches A and B were up the light would be on.

According to Katzir and Singh (2013)'s analysis, (4b) is predicted to be infelicitous according to any semantics making B equivalent to $B \vee (A \wedge B)$. However, the proposed function-sensitive analysis of redundancy correctly predicts (4b)'s acceptability. This is because, for any world w , $f(\text{switch B is up}, w)$ is the singleton set containing the world where switch A has the same value as in w and B is up, while $f(\text{switches A and B are up}, w)$ is the singleton set containing a world like w except that both switches are up. For any world where switch A is not already up, these sets are different. Since in some worlds $\text{hyp}(\text{switch B is up})$ and $\text{hyp}(\text{switch B is up, or switches A and B are up})$ are distinct, the utterance-sensitive notion of predicts no redundancy and hence (4b)'s acceptability, without appeal to EXH and without making $B \vee (A \wedge B)$ equivalent to B .

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