

Experimenting with (Conditional) Perfection

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Abstract: We present and discuss a series of experiments designed to test one of the most promising pragmatic accounts of conditional perfection—the phenomenon according to which conditionals can sometimes be strengthened to biconditionals. We test the idea that conditional perfection is a form of exhaustification triggered by the kind of question that the conditional is used to answer. We uncover evidence that conditional perfection is a form of exhaustification, but not that it is triggered by a relationship to a salient question.

[Word Count (including everything but the abstract): 9830 words]

1. Introduction

Conditional claims like (1) can, in the right context, convey additional information—the sort of information carried by (2) or (3):

- (1) If she turns in the final paper, she will pass the class.
- (2) Only if she turns in the final paper, will she pass the class.
- (3) If she does not turn in the final paper, she will not pass the class.

More generally, in the appropriate contexts, from an utterance of *If A, B* hearers can infer the biconditional *A if and only if B*. Following Geis & Zwicky (1971), we will call this inference *conditional perfection* (sometimes simply *perfection*, since it is the only kind of perfection we will be concerned with).

There is strong reason to think that perfection is not a purely logical inference—that is, it's not an inference to be explained exclusively as a semantic entailment of conditional sentences.¹ After all, theories of conditionals universally agree that *If A, B* does not entail *If B, A* (and that it does not entail *A if and only if B*). Moreover, there are many conditional statements and contexts that do not trigger perfection.

- (4) If this cactus grows native to Idaho, then it's not an *Astrophytum* (Lilje 1972).

¹ We will later consider a view on which conditional perfection does arise as a semantic entailment, but only when additional covert material is present. In other words, even at that point, we remain committed to the view that it is not a semantic entailment of the conditional.

Experimenting with (Conditional) Perfection / 2

- (5) If you look at this Canaletto painting, you'll get a good idea of what the Canal Grande looks like (Herburger 2015).

It is natural, then, to explore the idea that perfection arises, when it does, from some kind of pragmatic reasoning. The sort of pragmatic reasoning in question seems to be systematic enough to be derivable from general pragmatic principles (that is without leveraging very specific assumptions about context).

In this paper, we present a series of experiments designed to test one of the most promising pragmatic accounts of perfection. This is von Fintel's (2001) idea that whether perfection arises depends on what kinds of questions are, implicitly or explicitly, driving the inquiry of the participants to the conversation (we present the essentials of von Fintel's account in the next section). Because our findings will be mostly negative, we emphasize at the outset that von Fintel's proposal is avowedly speculative. We are interested in testing it experimentally because it is a plausible working hypothesis. Even if it were not to be the whole story, it is worthwhile exploring which elements of it are supported by experimental scrutiny and which aren't.

Before proceeding to our main discussion, note that, while perfection is interesting in its own right as a problem for pragmatics, it has a wider significance. For instance, we believe that an account of conditional perfection might illuminate why participants in reasoning experiments are sometimes willing to endorse the fallacious inferences of *Affirming the Consequent* and *Denying the Antecedent*—the invalid cousins of *Modus Ponens* and *Modus Tollens*.² Indeed, the connection between perfection and these forms of argument is at the center of our experiments.

2. From implicatures to exhaustivity.

Conditional perfection, we said, is not a purely logical inference. More generally, it seems wrong to maintain that it is the sort of inference that arises solely on the basis of the linguistic material that is explicitly made available by a conditional sentence. Geis & Zwicky (1971) illustrated the phenomenon of perfection with:

- (6) If you mow the lawn, I will give you five dollars.

No doubt, they had in mind a context in which (6) conveys the information that mowing the lawn is the only way for the hearer to get the five dollars. But it's easy to come up with

² The connection between conditional perfection and the fallacies is already made in Geis & Zwicky (1971, p. 562). For reviews of the experimental findings concerning the conditional fallacies see Evans and Over (2004, chap. 3) and Oaksford and Chater (2007, chap. 5). For a proposal about how to account for the findings, given a story about perfection, see Cariani and Rips (forthcoming).

contexts in which this is not true. For instance, imagine (6) being uttered immediately after:

(7) If you tidy your room, I will give you five dollars.

In this case, perfection seems blocked by a feature of the surrounding discourse. In general, linguistic context broadly understood can determine whether the inference is licensed or blocked.

So, what features of context license perfection? There is a long history of controversial pragmatic analyses.³ Fast-forwarding to one of the later stages of this debate, Horn (2000) proposes a view that (with interpretational help from von Stechow 2001) we understand as follows: conditional perfection is licensed when *If A, B* is in Gricean competition with *B, no matter what*. By uttering *If A, B*, a cooperative speaker conveys her inability to make the stronger statement that *B* holds unconditionally (that is to assert: *B, no matter what*). That does license a hearer to infer something that goes beyond *If A, B*. But, as von Stechow (2001) points out, that license is well short of perfection. Even if one's assertive utterance of *If A, B* signals reluctance to assert *B, no matter what*, it does not rule out another antecedent *D*, not equivalent to *A*, such that *If D, B*. So it does not imply that *A* is the only such antecedent (i.e., that *A* is necessary as well as sufficient for *B*).

The exact upshot of Horn's proposal depends on the background theory of conditionals. Let us adopt one theory as a starting point. Following a long tradition, we suppose that conditionals are universal quantifiers over a contextually set domain.⁴

Strict: *If A, B* is true in context *C* at world *w* iff for all $v \in C(w)$, either *A* is false at *v* or *B* is true at *v*

Here, $C(\cdot)$ denotes a function from worlds to sets of worlds. Intuitively, this is interpreted as the set of worlds that are relevant to the evaluation of the conditional, given that the world of evaluation is *w*.

Given this semantics, the most likely explanation for one's not being in a position to assert *B, no matter what* would be that one believes that *B* might be false in some of the relevant worlds. But if the additional information conveyed by *If A, B* is just that *B* might be false in some salient possibility, we are far from perfection. Perfection would require not just that *B* fail at some of the relevant worlds at which *A* fails; it requires the truth of the obverse conditional (i.e., *If B, A*), and so it requires that every relevant *B*-world is an *A*-world. Taking stock: Gricean competition between *If A, B* and *B, no matter what* seems to get at a real phenomenon. But that phenomenon is not perfection.

³ In addition to Geis & Zwicky (1971), see van der Auwera (1997), Horn (2000) and von Stechow (2001),

⁴ In this paper, we are agnostic as to whether these truth-conditions are obtained by treating 'If' as a restrictor or as an operator.

Why, then, it is sometimes possible to get the full perfection inference? Von Fintel (2001) sketches a different sort of pragmatic account, following an insight in Cornulier (1983). Commenting on the example,

(8) One is allowed to sit in this seat if one is disabled or one is older than 70,

Cornulier remarks:

We can suppose, very roughly, that *One is allowed to sit in this seat if one is disabled or one is older than 70* the word *if* keeps its merely sufficient condition meaning, and that the utterance situation suggests that if other sufficient conditions (allowing to sit there) did exist, they would have been mentioned, so that the only mentioned property (to be disabled or older than 70) is the only property which gives the right to sit there (presumption of exhaustivity). (Cornulier, 1983: 247)

Incidentally, Cornulier's example is especially interesting because it is a conditional permission, which might actually trigger a particularly strong form of perfection inference (our experiments did not target conditional permissions).

Von Fintel's (2001) central move is to connect Cornulier's talk about exhaustivity with off-the-shelf work on exhaustivity in response to questions (specifically Groenindijk & Stokhof, 1991; for a survey of work on exhaustivity see van Rooij and Schulz 2003). The key assumption here is that we generally, though not always, interpret simple answers to questions as exhaustive. If the doctor asks, "What did you drink last night?" and Lucy replies "Two glasses of wine", we take Lucy to provide an exhaustive list of what she drank.

This idea can be extended to conditionals. Consider a question Q such that (i) *If A B* is a possible answer to Q and (ii) when *if A, B* is provided as an answer to Q the conditional is naturally given an exhaustive interpretation. There are many different questions conditionals might be used to answer. It will be useful to isolate two categories of questions: the first category consists of questions about how the consequent might come about. We call them *consequent-directed* (abbreviated [CONS?]). Here are some examples of [CONS?] questions:

- What are all the ways in which B ?
- How might B happen?
- Is B true?

The second category consists of questions about what follows from the antecedent.

Experimenting with (Conditional) Perfection / 5

- What follows from A ?
- What happens if A ?

To make this concrete, consider an example like (6). This might be an answer to [CONS?] questions like: “What are all the ways in which I might get five dollars?”, “Will I get five dollars?”; it might also be an answer to [ANT?] questions like “What happens if I mow the lawn?”. Moreover, we should not suppose that these are the only questions: [CONS?] and [ANT?] questions are not exhaustive categories.

Von Fintel’s claim is that [CONS?] questions, but not [ANT?] ones, might help yield something like perfection. In arguing for this claim, von Fintel starts, as we do, with the assumption that the truth-conditions for $If A, B$ are captured by **Strict**.

Here, then is one possible way of deriving perfection given the assumptions we have on the table. Suppose that a [CONS?] question Q_{cons} was asked and that it was answered by $If A, B$. Then:

Step 1: provided that $If A, B$ is understood as an exhaustive answer to Q_{cons} , the speaker is not in a position to assert $If D, B$ for any D that competes with A .

Step 2: provided that the speaker is informed about the truth-values of these conditionals, she must believe all conditionals of the form $If D, B$ are false.

Step 3: if all conditionals of the form $If D, B$ are false for every antecedent that competes with A , then *if not A, not B* must be true.

To justify the reasoning from Step 2 to Step 3 we need another assumption. One approach would be to stipulate a principle to the effect that the space of competitors to A is particularly rich:

Competitors: the antecedents that compete with A are all those antecedents D that do not entail A .

This entails that there are *lots* of alternatives. In particular, it entails that for each *not A*-world w , there is an alternative conditional ($If S_w, B$) where S_w is a sentence that is only true in w .⁵

Another way of justifying this step, a more plausible one in our view, is to assume (i) that conditionals satisfy the principle of Conditional Excluded Middle (CEM) so that from $\sim(If$

⁵ Concluding the reasoning: asserting $If A, B$ would implicate $\sim(If S_w, B)$, which entails that there is a world that verifies S_w & $\sim B$. But since only w verifies S_w , then w must verify $\sim B$. Since w was an arbitrary world that does not verify A , it follows that every $\sim A$ -world is a $\sim B$ world.

D, B) one might infer *If D, ~B* and (ii) that every relevant possibility is included in some competitor or other. We think that this second approach fits best with the rest of von Fintel’s theoretical framework—as von Fintel’s (1997, section 7) argues that **Strict** truth-conditions for *If* can be made compatible with CEM by hypothesizing that conditionals come with a homogeneity presupposition.⁶

Whatever the status of the Competitors assumption, von Fintel’s account predicts that conditional perfection should arise precisely when the other assumptions in the above reasoning are satisfied. We take **Strict** to be a valuable working hypothesis, so the key assumptions to focus on, as we move to the experimental part of our paper are (i) that there is some principled way in which the relevant competitors to A are generated; (ii) that *If A, B* is understood as an exhaustive answer to [CONS?] questions; and (iii) that the speaker is relevantly informed.

3. Designing experimental tests of perfection inferences.

Before going through the battery of experiments we ran, it’s useful to describe informally how we set about experimenting with perfection. There are many decisions to be made in setting up such an experiment, and small variants might result in significant changes.

One guiding idea that motivated us from the outset is that if perfection arises, we should see unusually high endorsement rates for the two conditional fallacies of *Affirming the Consequent* (AC) and *Denying the Antecedent* (DA).

(AC) $B, \text{ If } A, B. \text{ Therefore: } A$

(DA) $\text{ not } A, \text{ If } A, B. \text{ Therefore: not } B.$

The idea here is that if, in context, *If A, B* conveys *If B, A* then, barring interference, the endorsement rate for AC should approach the endorsement rate for Modus Ponens. Similarly, if *If A, B* conveys *If not A, not B*, then DA should also approach Modus Ponens.

We have chosen to test endorsement rates for conditional inferences partly because we could rely on established and very robust data concerning people’s endorsement of these patterns. Figure 1 summarizes endorsement rates for MP, MT, AC, and DA. Incidentally,

⁶ Of course, the canonical way of validating CEM is to adopt Stalnaker’s semantics for conditionals (Stalnaker 1968, 1981): *If A, B* is true at w iff B is true at the selected A -world. Yet another option, one that we have some stake in, starts with the argument in Cariani & Santorio (forthcoming) that *will* is a ‘selectional’ modal (that its contribution is to select a world out of a modal base). They note that combining a restrictor semantics in the style of Kratzer (1991, 2012) with selectional modals gives something roughly like Stalnaker’s semantics for conditionals of the form *If A, will B*—specifically, a semantics that validates CEM. One might extend this insight to a broader class of conditional sentences by postulating that conditionals can sometimes restrict covert selectional modals (this would replace the current default hypothesis, according to which, absent overt modals, conditional antecedents restrict covert necessity modals).

it reveals one of the important discoveries in the psychology of reasoning: The endorsement rate of Modus Ponens is higher than the endorsement rate of Modus Tollens (even for bare, non-modalized conditionals).⁷

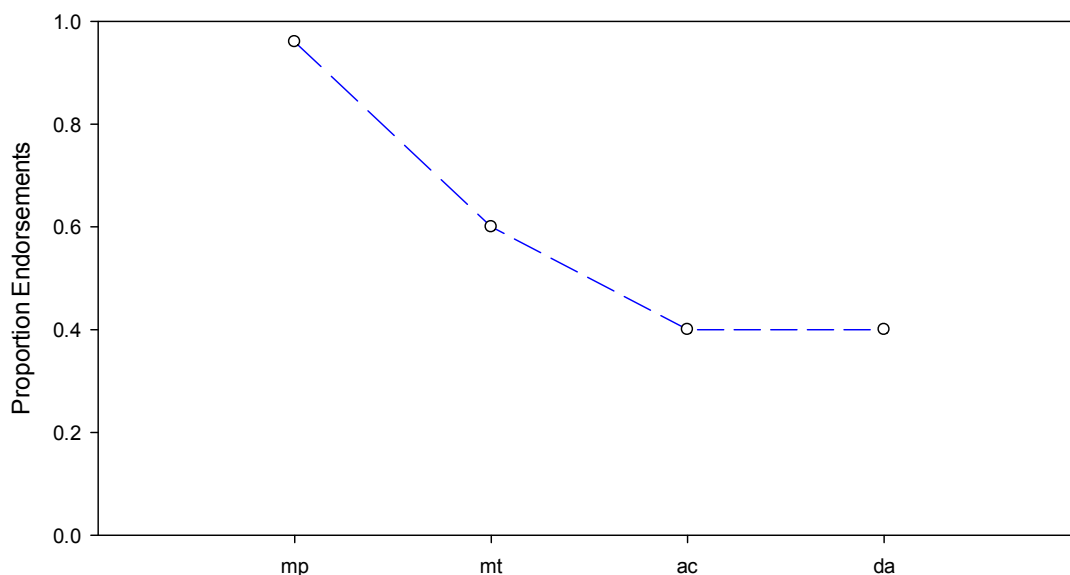


Figure 1. Standard endorsement rates for the four inference patterns modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da) across previous experiments (data from Evans, Newstead, & Byrne, 1993, Table 2.4 and are weighted averages from seven earlier experiments).

We could have chosen a different approach had we decided to test whether people endorse the inference from *If A, B* to *If not A, not B*. While our data are primarily of the multi-premise kind (the kind we described in the previous couple paragraphs), we recognize both kinds of data as significant to an account of conditional perfection (see, e.g., Fillenbaum, 1978, for an experiment of this latter sort).⁸

⁷ See the references mentioned in Note 2 for reviews of this evidence. For the specific studies from which these results come, see Evans, Newstead, and Byrne (1993, Table 2.4). Recall that our approach is to test the endorsement rates of AC and DA. When perfection is triggered, these inferences aren't fallacies at all, but actually valid applications of modus ponens or modus tollens. Thus, when we think about, say, AC, there are two possibilities that might lead to different endorsement rates:

- i. people infer from *If A, B* to *If B, A* and then apply MP to *If B, A* and *B*.
- ii. people infer from *If A, B* to *If not A, not B* and then apply MT to *If not A, not B* and *B*.

This difference might matter to our project and we should be mindful of it in interpreting our results.

⁸ We have, however, done some preliminary experiments of the latter kind as well. Though we will not formally discuss them here, they did not suggest different picture from what came out of the multi-premise experiments.

Experimenting with (Conditional) Perfection / 8

We note that psychological research provides many examples in which college-aged participants endorse AC and DA at rates greater than those that appear in Figure 1. The Figure 1 experiments used conditionals for which people do not have strong beliefs in the necessity of the antecedent for the consequent. A typical conditional in such experiments might be *If John understood Chapter 5, then John did well on the test*, where participants' previous beliefs do not suggest that John's understanding of Chapter 5 is necessary for his doing well. (Perhaps John could do well simply by bribing his instructor.) But if prior beliefs *do* suggest (causal) necessity, participants find AC and DA more congenial (e.g., Cummins, Lubart, Alksnis, & Rist, 1991; Marcus & Rips, 1979; Staudenmayer, 1975; Thompson, 1994). For example, a conditional like *If the butter is heated, then it melts* accords with people's belief that heating is both necessary and sufficient for the butter melting. It's difficult to think of other ways to melt butter aside from heating it. So an AC or DA argument with such a conditional appears correct to many participants (e.g., *If the butter is heated, then it melts; the butter melts; therefore, the butter was heated*). Effects of this sort are similar to those of conditional perfection in that they encourage a reading like that of *A iff B*, but they arise for reasons other than the pragmatic considerations that we have discussed so far. Because our intent in these experiments is to test the pragmatic account of Section 2, we chose conditionals with antecedents that don't already suggest necessity (e.g., conditionals like the one about John doing well rather than the one about butter melting).

A more pertinent set of studies have examined conditional promises (e.g., (6)-(7)) and threats (e.g., *If you continue to disrupt the class, you'll have to leave the room*). These studies have shown greater acceptance of AC and DA for promises and threats than for ordinary indicatives (e.g., *If there is an electrical failure, school will be closed*, Markovits & Lesage, 1990; *If the student is doing economics then he is a socialist*, Newstead, Ellis, Evans, & Dennis, 1997). Similarly, participants are more willing to accept the inference from *If A, B* to *If not A, not B* under the same circumstances (Fillenbaum, 1978). The goal of a promise or threat is usually to get the addressee to perform some action (e.g., mow the lawn) or to refrain from one (disrupting the class). In order for these speech acts to be effective, speakers presumably intend not to provide the promised reward if the action is not taken and not to carry out the threatened punishment if the infraction is not committed. These presumptions can be overridden in the right circumstances, as we've already noted in Section 2. But by default, promises and threats convey an exhaustive interpretation, as the experiments we've just cited suggest. Our aim in the present experiments is to manipulate participants' impression of exhaustivity by means of [CONS?] questions, so we picked conditionals for our experiments that (unlike promises and threats) don't by themselves convey exhaustivity.

The second guiding idea in shaping our experimental tasks was that we needed to create matched items. One version of each item used [CONS?] questions. In the other version, we either used no question at all, or we used [ANT?] questions—depending on the experiment. We will call this variable *question type* in what follows. An example of one of

Experimenting with (Conditional) Perfection / 9

our [CONS?] items was the following (the exact wording differed across experiments, as we will clarify in the next section):

John has taken a test on Chapters 4-6 that has not been graded yet.
[You ask Mary, "Did John do well on the test?"]
Mary says, "If John understood Chapter 5, then John did well on the test."
Assume that Mary's response is true and that John did well on the test.
Given this information, then, does Mary's statement imply that John understood Chapter 5?

When the [CONS?] question was a polar question (i.e., a yes/no question), the matching item did not have a question at all (so it is simply the result of removing the bit in square brackets).

Other experiments involved more complicated [CONS?] questions, such as for example:

You ask Mary, "What are all the ways John could manage to do well on the test?"

In these cases, the matching item replaced the line in which we asked the [CONS?] question with a line in which we asked the [ANT?] question:

You ask Mary, "What are all the things that would happen in case John understood Chapter 5?"

Note also that the sample item above is testing for Affirming the Consequent. For each vignette (there were 16 of them), we had four items that tested for Modus Ponens, Tollens, Affirming the Consequent, and Denying the Antecedent.

In total, this means that we associated each vignette with eight possible items (four inferences for each of the two possible questions). Participants saw only one item based on a particular vignette. In discussing the experiments, we will refer to this distribution of items (16 vignettes, four inference types, and two question types) as a *standard set*. Participants saw the vignettes presented one-at-a-time on a computer screen, in a new random order for each participant. They responded by clicking on one of two options (e.g., "implies" vs. "does not imply"). Participants were college students enrolled in an introductory psychology course, and they completed the experiment as part of a course requirement. No participant took part in more than one experiment.

Note that the [CONS?] question "What are all the ways in which *B*?" is less natural than other possible [CONS?] questions, such as "How might *B* happen?" or "Under what conditions would *B* happen?". In most of our experiments, we have privileged the more cumbersome question because it reduces the permissibility of partial (aka *mention-some*) answers. Consider the question:

(9) Q: Where can I buy Stephen King novels?

A: At Powell's Books.

In (9), we do not expect the answer to be an exhaustive catalog of the places where the questioner can buy Stephen King novels. The reason it is important to avoid this interpretation is that the account of conditional perfection we sketched in the previous section breaks down if the answer is understood to be partial.

To have a better chance of ruling out *mention-some* answers (that is: for the question to set up the presumption that any answer would be exhaustive), we might ask a different sort of question, such as:⁹

(10) Q: What are all the places where I can buy Stephen King novels?

A: At Powell's Books.

This is why most of our experiments use "What are all the ways in which *B*?" as the [CONS?] question.

While this is a good reason to run experimental tests with the more artificial phrasing, it is not a good reason *not to* test the more natural [CONS?] questions. It is for this reason that our leading experiment involves a simple polar question, as in our initial example above (in which "you" ask Mary, "Did John do well on the test?").¹⁰

4. The sequence of experiments.

A quest for perfection drives the experiments we report here. In each of them, we present participants with a series of problems, variations on the standard set that we described earlier. These problems vary the inference type (Modus Ponens, Tollens, Affirming the Consequent, and Denying the Antecedent) and question type ([CONS?] and [ANT?]) in the hope that a demand for an exhaustive set of reasons for the consequent—[CONS?] but not [ANT?]¹¹—will lead participants to perfect the conditional. According to the von Fintel-style hypothesis, perfection should be manifested by increased endorsement of the "fallacies," Denying the Antecedent and Affirming the Consequent. As we've mentioned, these arguments switch from invalid to valid under a perfected conditional, which should

⁹ Perhaps, even the question in (10) might, in certain circumstances, permit a *mention-some* answer. We discuss the implications of this point for our project in Section 5 below.

¹⁰ Note that the reason why we did not use an [ANT?] question as a comparison in this case is that it does not seem plausible to target the antecedent with one such question (say, "Did John understand Chapter 5?"). Except for some *recherché* contexts, the conditional "If John understood Chapter 5, then John did well on the test" is not an acceptable answer to the question: "Did John understand Chapter 5?".

increase the likelihood that participants will accept them. The same manipulation, however, should have only a weak effect, if any, on the endorsement of Modus Ponens and Modus Tollens, since these inferences are already valid under the “unperfected” reading of the conditional. This, then, is the perfection pattern of our quest: Greater endorsement of Affirming the Consequent and Denying the Antecedent under [CONS?] questions but not [ANT?] questions, but little change in endorsement of Modus Ponens and Modus Tollens.

Experiment 1: Polar Questions

We start here with one of the simplest examples we ran.¹¹ As described in the previous section, this experiment straightforwardly contrasted a polar [CONS?] question with the same item with the question removed.

John has taken a test on Chapters 4-6 that has not been graded yet.

[You ask Mary, “Did John do well on the test?”]

Mary says, “If John understood Chapter 5, then John did well on the test.”

Assume that John did not do well on the test.

Given this information, does Mary’s statement imply that John did not understand Chapter 5?

The proportion of “yes” responses, based on 32 participants, showed however no difference between the [CONS?] question and no question at all. As Figure 2 illustrates, we did find the typical decrease in endorsements as a function of inference type, $F(3,504) = 17.67, p < .001$. As the figure suggests, however, we found no reliable overall difference due to the [CONS?] question ($F(1,504) < 1$), and no differential effect of the [CONS?] question on the rate of endorsement for the individual inference types ($F(3,504) < 1$).¹²

¹¹ Although we lead with this experiment, it is not temporally the first experiment we ran. It was suggested to us by Kai von Fintel as a simplification of some later experiments.

¹² The statistical tests in this and the following experiments are based on a generalized linear mixed model for binomial data. Participants and vignettes are random effects in these analyses. The analyses used the Satterthwaite approximation for degrees of freedom.

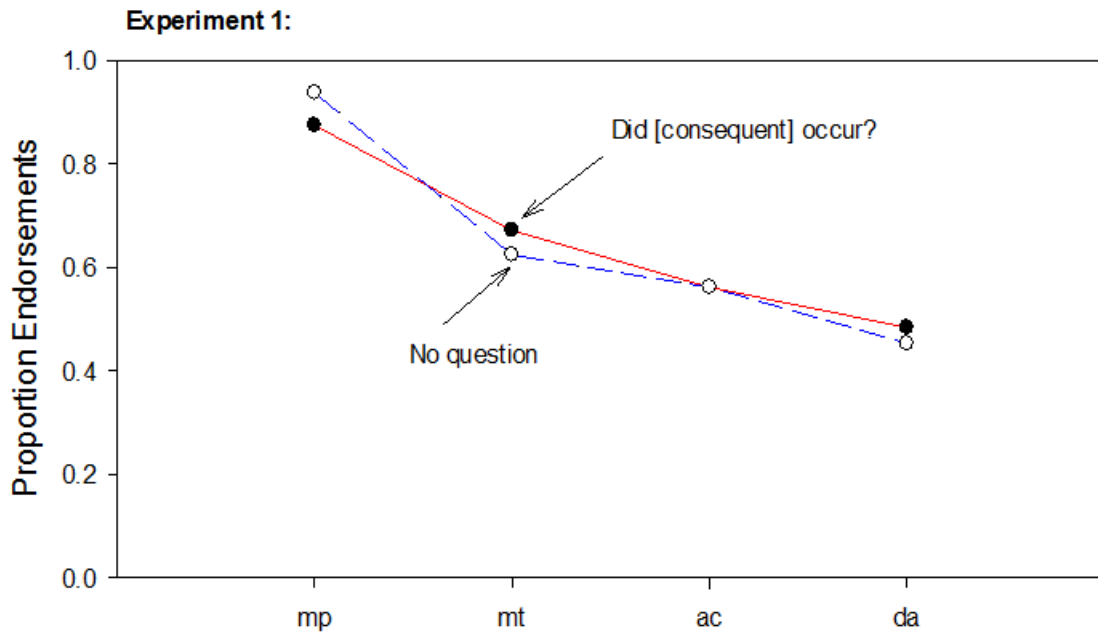


Figure 2. The effect of polar question vs. no question on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 1.

Experiment 2: Explicit Demands for Exhaustive Answers

Experiment 2 involved the more complicated [CONS?] questions, ones that attempt to emphasize the demand for exhaustivity in the question to Mary:

John has taken a test on Chapters 4-6 that has not been graded yet.

You ask Mary, "What are all the ways John could manage to do well on the test?"

Mary responds, "If John understood Chapter 5, then John did well on the test."

Assume that John did well on the test.

Given this information, does Mary's statement then imply that John understood Chapter 5?

As we mentioned earlier, the [CONS?] question was intended to make *mention-some* answers as impermissible as possible. The [ANT?] question was also introduced to make [ANT?] items parallel to the [CONS?] items, controlling for the length and complexity of the vignettes. Specifically, in the "Chapter 5" case, we used the [ANT?] question: "What are all the things that could happen in case John understood Chapter 5?".

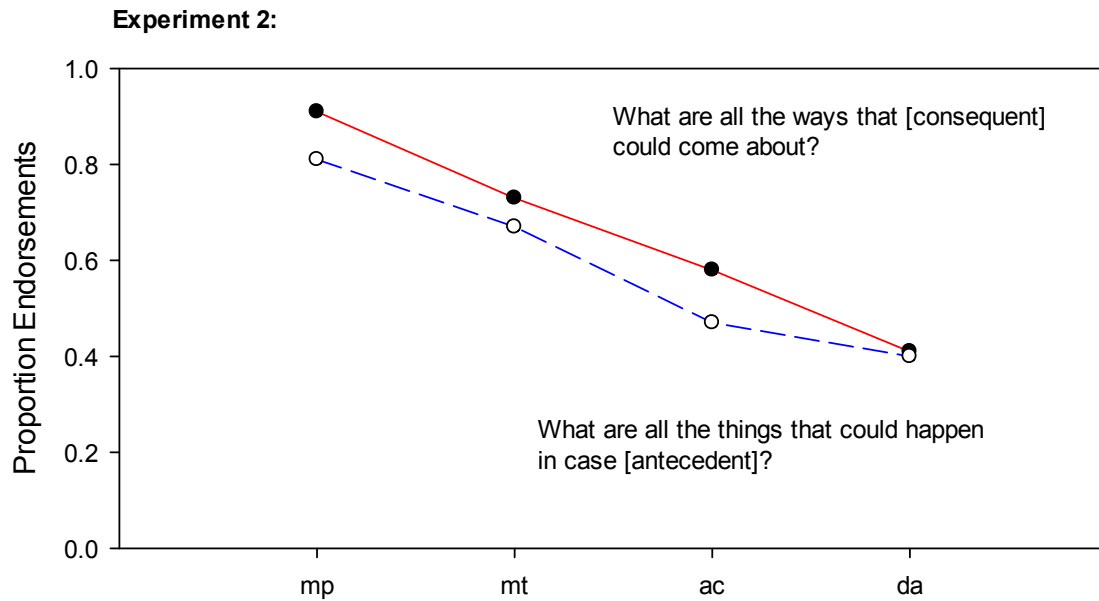


Figure 3. The effect of [CONS?] versus [ANT?] questions on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 2.

None of these changes, however, led our participants to perfect the conditionals. Figure 3 graphs the data from 32 participants and shows the usual decrease in endorsement rates from Modus Ponens to Tollens to Affirming the Consequent to Denying the Antecedent, $F(3,504) = 20.34, p < .001$. We also found a marginal difference favoring problems with [CONS?] over those with [ANS?] ($F(1,504) = 3.16, p = .076$), but no significant difference appeared in the shape of these two functions, $F(3,504) < 1$. That is, we did not find that demands for an exhaustive answer to how the consequent could come about elevated Affirming the Consequent and Denying the Antecedent to a greater extent than it did Modus Ponens or Modus Tollens.

Experiment 3: Checks for Memory for the Questions

Could it be that our participants were ignoring the question? After all, one could perform the task while skipping the question “you” are asking Mary and reading just the conditional and the minor premise. If that was happening, it would explain our difficulty in obtaining the perfection pattern.

To follow this line of inquiry, we ran a version of Experiment 2 with an additional twist. After answering each item, participants viewed a new screen that prompted them to recall which question, [CONS?] or [ANT?], they had seen earlier, and they picked one of them by clicking on it. For the sample vignette, the choice was between “What are all the ways John could manage to do well on the test?” and “What are all the things that could happen in case John understood Chapter 5?” If participants could not remember what question had been asked, we inferred that the question did not play a role in their reasoning. And even though one might imagine that they could correctly recognize the question without using it in reasoning, a correct answer would at least suggest that the question was available for them to reason with. In addition, since participants saw multiple items, this

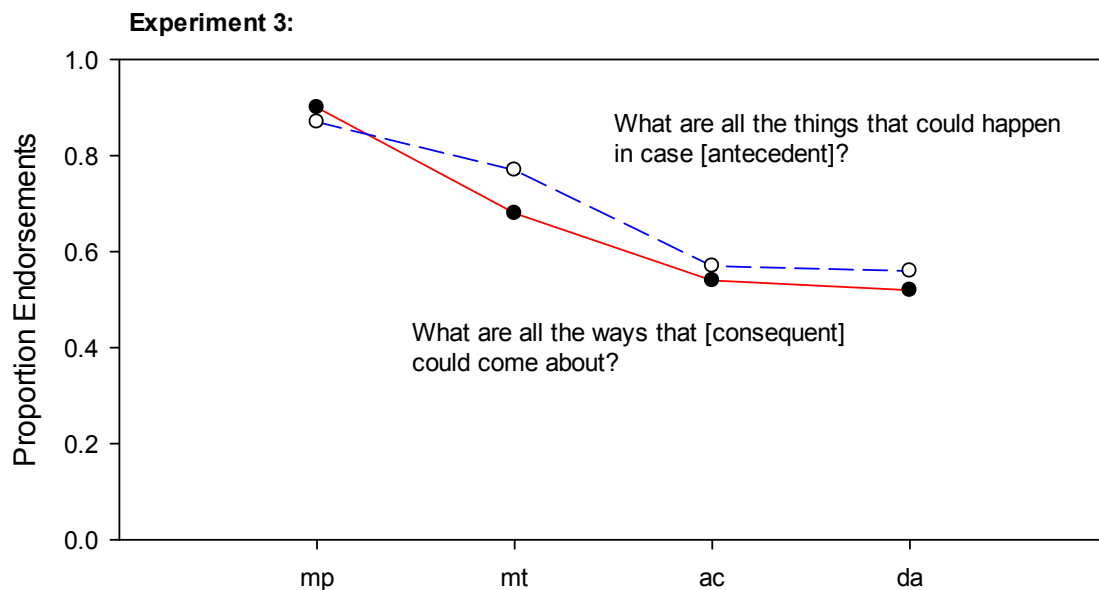


Figure 4. The effect of [CONS?] versus [ANT?] questions on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 3, with memory checks.

forced choice encouraged them to attend to the question as they were working through the later items in their allotted sequence.

Alas, the results did not fit the perfection pattern. Figure 4 plots the proportion of endorsements from 33 participants after we removed all trials on which the participants made a memory error (i.e., selected the [CONS?] question when they had actually seen [ANT?] or the reverse error). These errors ranged from 9% to 18% across the eight conditions shown in the figure. As the figure suggests, we found the usual effect of inference types, $F(3,452) = 13.75$, $p < .001$. But neither the effect of the question nor the interaction between the question and the inference types was statistically reliable (both F 's < 1).

Given the above results, one might become quite skeptical. Either there is a problem in the theoretical proposal or in the particular way we had sought to test it.

Experiment 4: Explicit Specification of the Antecedent as the Only Condition

Experiment 3 showed that people generally recalled the questions. Even tossing out the cases in which they didn't, did not make a difference to the resulting pattern of judgments. Are there cases where we do get the perfection pattern using a similar experimental set up? The next idea, then, was to get very close to forcing a biconditional reading by semantic means. In the items for the new experiment, Mary does not just answer the question with the conditional: she adds what basically amounts to biconditional information (to make things easier, we underlined the new bit below: it was not underlined in the original stimuli).

John has taken a test on Chapters 4-6 that has not been graded yet.
You ask Mary, "What are all the ways John could manage to do well on the test?"
Mary responds, "If John understood Chapter 5, then John did well on the test.
That is the ONLY way John could have done well on the test."
Assume that John did well on the test.
Given this information, does Mary's statement imply that John understood Chapter 5?

In the [ANT?] variant, in addition to the usual difference in question (i.e., "What are all the things that could happen in case John understood Chapter 5?"), Mary's response changes to:

Mary responds, "If John understood Chapter 5, then John did well on the test.
That is the ONLY thing that could have happened if John understood Chapter 5."

Note that the continuation in these [ANT?] variants does not go any distance towards conveying biconditional information (for it does not rule out that John's doing well on the test might have come about by some other means).

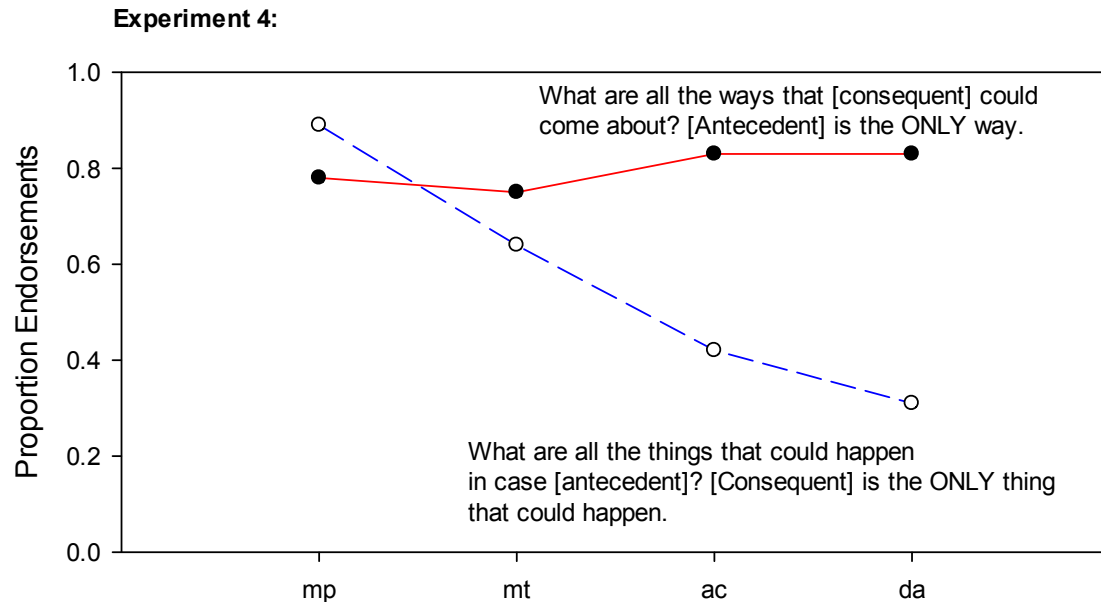


Figure 5. The effect of [CONS?] versus [ANT?] questions on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 4, with explicit indication of exhaustivity.

At last, these explicit changes did yield a perfection pattern, as shown in Figure 5 (based on 32 participants). Not only did we find a significant effect of inference type ($F(3,504) = 6.29$, $p < .001$), we also found a significant effect of question type ($F(1,504) = 22.65$, $p < .001$), and crucially an interaction of the two ($F(3,504) = 10.85$, $p < .001$). This last effect is the perfection result, apparent in the difference in the shape of the curves in the figure.

Essentially, if we explicitly provide the strengthenings that are supposed to be conveyed by pragmatic means, we get precisely the pattern we would expect. This suggests that our procedure is sensitive to (at least some kinds of) information that can get participants to interpret a conditional as a biconditional.

Experiment 5: Speaker's Knowledge of the Answers and Willingness to Relate Them

The biconditional interpretation (predictably) arises if we have an explicit continuation with *only*, as in Experiment 4. So why were we unable to find a similar pattern in Experiments 1-3? We have already attempted to rule out the possibilities that the questions were not sufficiently clear in their demand for an exhaustive answer and that participants were inattentive to the questions. One further possibility is that we have not completely eliminated a "mention some" answer. Although our [CONS?] question asks Mary for all the ways the consequent could come about, her response may reflect only her

partial knowledge of these ways or her limited willingness to produce them. Participants may have interpreted Mary's statement in a way that allows for these constraints, and if so, they may have doubted whether her answer does indeed convey all the ways the consequent could happen.

To encourage participants to think that Mary's response was exhaustive, we tried "loading up" the context. The items in Experiment 5 looked like this (we underlined the new bit; it was not underlined in the text that participants saw):

John has taken a test on Chapters 4-6 that has not been graded yet.
 You ask Mary, "What are all the ways John could manage to do well on the test?"
In fact, Mary knows all the ways and is willing to relate them. Mary responds, "If John understood Chapter 5, then John did well on the test."
 Assume that John did well on the test.
 Given this information, does Mary's statement imply that John understood Chapter 5?

The same underlined information was also inserted in the [ANT?] version of the problem.

We expected that stipulating that Mary knows all the ways in which John might do well on the test and is willing to relate them would have a similar effect to saying explicitly that [Consequent] is the ONLY thing that could happen.

This expectation turned out to be (only) partially vindicated by our findings.

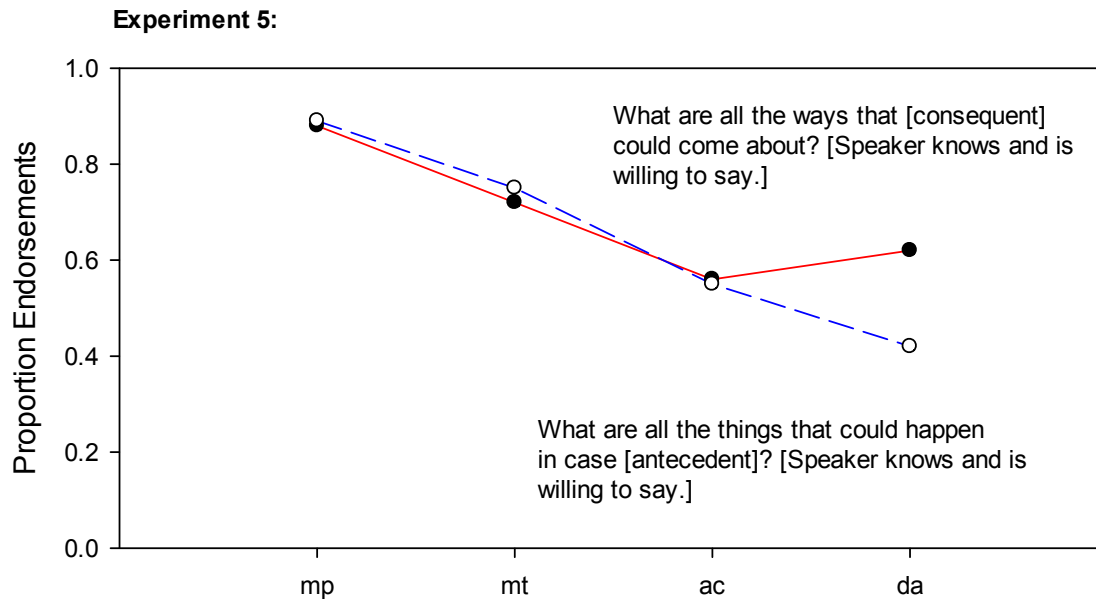


Figure 6. The effect of [CONS?] versus [ANT?] questions on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 5, with information about speaker's knowledge and willingness.

Experimenting with (Conditional) Perfection / 18

Endorsement rates for the four inference types again differed significantly ($F(3,504) = 15.47, p < .001$), based on data from 32 participants. But this time, the results show that the [CONS?] question alters this typical pattern by elevating endorsement rates for Denying the Antecedent. Although neither the overall difference between questions ($F(1,504) < 1$) nor the interaction between question and inference type ($F(3,504) = 1.59, p = .19$) are significant, there is a significant difference between questions for Denying the Antecedent, $F(1,504) = 5.70, p = .02$. By contrast, the [CONS?] question did not affect endorsement rates for Affirming the Consequent ($F(1,504) < 1$). Note, too, that even for Denying the Antecedent, the boost in endorsement rates, though significant, is smaller than what we have seen in the full-blown perfection of Experiment 4.

Experiment 6: Explicit Specification of Exhaustiveness

Once participants know that the speaker of a conditional is (a) under explicit pressure to produce an exhaustive answer to the question of how the consequent could come about, and (b) knows all the ways it could come about and is willing to relate them, they produce a weak perfection pattern. The weakness of this result may be due to a residual unwillingness on the participants' part to believe that the speaker really has produced all the ways. Although Mary may know all the ways and is willing to tell you about them, she may nevertheless give you just a sample, perhaps because the list is too long, too complex, or too unrelated to present concerns. These considerations suggest that we might be able to reinstate full perfection if Mary explicitly states that she is in fact giving all the ways when she asserts the conditional.

To check this prediction, we used the vignettes from Experiment 5, but added Mary's assertion that she was giving all the ways the consequent could come about:

John has taken a test on Chapters 4-6 that has not been graded yet.

You ask Mary, "What are all the ways John could manage to do well on the test?"

In fact, Mary knows all the ways and is willing to relate them. Mary responds, "Here are ALL of them: If John understood Chapter 5, then John did well on the test."

Assume that John did well on the test.

Given this information, does Mary's statement imply that John understood Chapter 5?

The corresponding [ANT?] version likewise included the "Here are ALL of them" prefix in Mary's answer.

The results from 32 participants appear in Figure 7 and show that the new "ALL of them" clause was sufficient to produce the perfected interpretation.

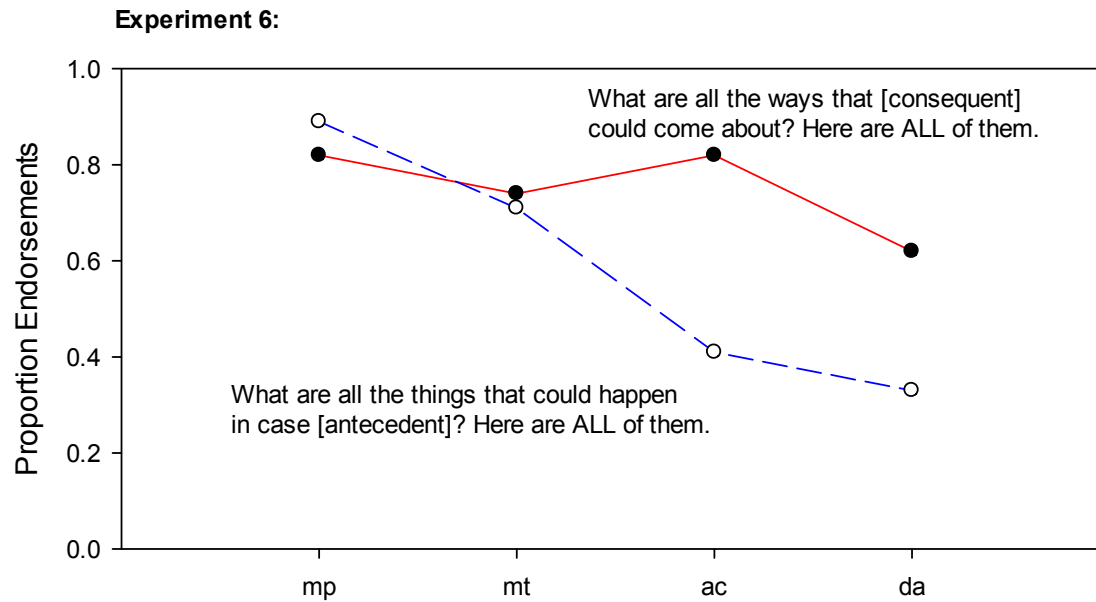


Figure 7. The effect of [CONS?] versus [ANT?] questions on endorsement of modus ponens (mp), modus tollens (mt), affirming the consequent (ac), and denying the antecedent (da), Experiment 6, with explicit exhaustivity.

When the speaker was asked to give all the ways the consequent could occur, and the speaker then made it clear that she was providing all the ways, participants were likely to endorse each of the inference types. When the speaker was asked about all the things that could happen if the antecedent occurred, however, we find the typical decreasing pattern across inference types. This produced significant effects of inference type ($F(3, 520) = 14.58$, $p < .001$), question type ($F(1, 520) = 10.43$, $p = .001$), and an interaction between the two ($F(3, 520) = 6.73$, $p < .001$). Unlike the results of Experiment 5, the difference due to the question is significant for both Affirming the Consequent and Denying the Antecedent ($F(1, 520) = 23.09$, $p < .001$ for Affirming the Consequent, and $F(1, 520) = 11.55$, $p < .001$ for Denying the Antecedent).

5. Theoretical Discussion

The positive results in Experiments 4 and 6 suggest that true conditional perfection can, in fact, be linked to exhaustivity. However, the negative results in Experiments 1-3, and to some extent even in Experiment 5, require us to put this finding in perspective.

Specifically, a common assumption is that a strong relationship exists between questions and exhaustivity. This relationship includes at least the idea that some overt questions trigger exhaustive readings in conditionals. The experimental evidence we have considered suggests that this is not quite right. In order to trigger exhaustive readings of conditionals, we need more than just questions.

In closing, we briefly consider how our experiments qualify the relation among questions, exhaustivity, and perfection. But first we consider a similar experiment that raises some of the same issues.

5.1. Relation to a prior experiment

There is some similarity between the question-variations we used in our experiments and an earlier experiment by Farr (2011). Farr gave her participants vignettes like this:

Monika sells seafood on the market. She gets 1 euro for a crab, 2.50 euros for an eel, 15 euros for a lobster and 2.50 euros for a pike. Kerstin, an employee of Monika, cannot remember the prices. Since she does not want to ask Monika again, she asks Sahra, who also works for Monika. Sahra knows the prices exactly.

At this point, in Farr's experiment, there is a dialogue between Kerstin and Sahra. This dialogue starts with one of two questions:

what-if-p Kerstin: What happens if I sell an eel?
when-q Kerstin: When do I get 2.50 euros?
Sahra: If you sell an eel, you get 2.50 euros.

Participants are then asked:

Did Sahra answer Kerstin's question sufficiently? [Yes] [No]

One thing we want to note here is that, despite the similarities in the setup, Farr's experiment did not end up testing whether Sahra's conditional gets perfected. Instead, it ended up testing for the related question of whether Kerstin's question was answered "sufficiently." One way in which this difference is potentially problematic is that, in the right context, a question might be answered sufficiently even if it gets just a partial, *mention-some*, answer. But in such a case, we have no way of telling whether the conditional has been perfected. The connection among question type, exhaustiveness of answers (in the case of conditionals), and perfection is the issue we explore in the rest of this article.

5.2. How the Experiments Constrain Explanations of Perfection

At first sight, our experiments appear to refute the idea that questions trigger perfection. Even explicit questions that demand exhaustive answers about the consequent (e.g., *What are all the ways [the consequent] could come about?*) don't always yield a perfected conditional (*antecedent iff consequent*).

According to the von Fintel/Cornulier account that we have been pursuing, questions about some event *B* set up the expectation that a conditional answer of the form *If A, B* implies that *A* is the only way *B* could come about. Thus, *if ~A, ~B*. Together, *If A, B* and *If*

$\sim A$, $\sim B$, yield the perfected interpretation, A iff B . For example, questions like *Did John do well on the test?* or *What are all the ways John could do well on the test?* imply that the answer *If John understood Chapter 5, then he did well on the test* supplies all ways he could do well. So John did well if and only if John understood Chapter 5. Our experiments, however, failed to produce this pattern of reasoning. In principle, then, this failure could come about either (a) because participants failed to infer a perfected conditional from (what they perceived as) an exhaustive answer, or (b) because they failed to interpret the conditional as exhaustive, in the first place. Let's consider these two possibilities in turn.

5.2.1. Do people infer perfected conditionals from exhaustive answers?

Perhaps our negative results are partial evidence that people do not reason from (i) to (ii):

- (i) For each alternative D to the antecedent A , $\sim (If D, B)$
- (ii) $If \sim A, \sim B$

In the case of our experiments, failure to infer (ii) from (i) amounts to the idea that participants understood the antecedent (e.g., *John understood Chapter 5*) as the only way that the consequent (*John did well on the test*) could occur, and yet did not infer that if John did not understand Chapter 5, he did not do well.

But on the contrary, Experiments 4 and 6 show that given discourse that basically entails claims of the form of (i), people will reason their way to a claim of the form of (ii).¹³ This suggests that the failure to find the perfection pattern in the remaining experiments is due to participants failing to interpret the conditional (e.g., *If John understood Chapter 5, he did well on the test*) as an exhaustive answer to the question (*What are all the ways John could do well on the test?*).

To back up this possibility, we asked participants in a further experiment to decide whether the conditionals mentioned all the ways the consequent could come about.¹⁴ The experiment was very similar to Experiment 5 (in which Mary is said to know all the ways and is willing to relate them), but in addition to asking whether participants agreed with the inference, we also asked them, "Did Mary's response mention all the ways?" (Half the participants answered the inference question first and half answered the "all the ways" question first, though the order had no statistically reliable effect on the results.) For [CONS?] questions (e.g., *What are all the ways John could do well on the test?*), participants believed that the conditional response (*If John understood Chapter 5, he did well on the test*) mentioned all the ways on only 14.5% of trials.

¹³ Note, incidentally, that if one rejects the Competitor assumption we sketched in Section 2, this would be indirect, and admittedly very defeasible, experimental evidence that people reason with something like Conditional Excluded Middle.

¹⁴ We thank Bob Stalnaker for suggesting this experiment.

Of course, our results do not mean that questions *never* produce the presumption that a conditional answer is exhaustive. Rather, the results suggest that even very explicit questions of the proper sort don't always trigger an exhaustive reading. Something more is needed to ensure it.

5.2.2. Why don't people believe conditional answers to questions are exhaustive?

Questions don't always yield exhaustive answers. Still, we might be able to recover the spirit of the Cornulier/von Fintel proposal on conditional perfection by supposing that questions yield exhaustive answers by default and giving an independent explanation for why this default pattern did not emerge in Experiments 1-3 and 5.

Perhaps the explanation is that some property of the vignettes in these experiments encouraged a *mention-some* reading. Consider this dialogue:

(11) Q: Who are all the people who came to the party?

A: John came.

Even though the question is phrased as demanding a complete list, a possible *mention-some* interpretation of the answer seems available. The respondent might be seen as simply rejecting the burden of providing a complete answer to the question and might volunteer instead whatever information she was able to provide (perhaps expecting that other conversational participants will be able to fill out the rest of the party-goers list). In the specific case of (11), this sort of interpretation might even be invited by the background knowledge that only extremely unusual parties have only one attendee. Similarly, it is possible that, when we ask, "What are all the ways in which [consequent] might come about?" the respondent's answer is given a *mention-some* reading.¹⁵

Though we do not think that this assessment is without merit, it has too many surprising consequences to be plausible. What we found is that, unless the respondent explicitly avows providing a complete answer, there is no significant pattern of perfection. Though there are slight increases in endorsement rates for the fallacies Affirming the Consequent and Denying the Antecedent in some experiments, they are typically not enough to meet standard significance thresholds. One might have expected that in the cases where a *mention-all* interpretation is possible but not mandated, we should have seen some participants reach for it. In Experiment 5 and in the experiment mentioned in the previous

¹⁵ Demands for exhaustive answers often call for memory searches that exceed people's abilities, especially in the context of an on-going conversation. In such situations, speakers may be thrown back on a satisfactory answer that is informative, but partial. Hearers may likewise make allowances for this kind of satisficing by leaving open the possibility that the speaker's answer is all she can come up with at the moment—that it is temporarily exhaustive, rather than exhaustive period. In the case of (11), for example, this interpretation is enhanced if the speaker indicates some hesitancy: "Well...John came." Viewed in this way, what our results suggest is that this temporarily exhaustive reading is more available than one might have expected.

subsection, we even tried as much as possible to “load” up the context so as to invite a *mention-all* answer, but without much success.¹⁶ This is especially striking because *mention-all* interpretations of answers to questions are not unusual. According to the received wisdom (see, for example, van Rooij & Schulz, 2003), they should be preferred unless they are contrary to expectations (as in (11)). More generally, much recent work on implicatures argues that the computation of implicatures happens by default (see e.g., Chierchia 2013).

Of course, it is still possible that participants read the [CONS?] questions as having open-ended answers that respondents were unlikely to answer exhaustively. In the case of our running example, participants may have taken the question, *What are all the ways John could manage to do well on the test?* as placing an impossible demand on the addressee, given the many ways John could do well (e.g., cheating, bribing the instructor, divine intervention, lucky guessing,...). However, some of the vignettes in our experiments were explicit in listing alternatives for the antecedent. For example, one of the vignettes began with the sentence *Someone has put a fertilizer, either Easy-gro or Bloom-builder, on the plants.* This was then followed by the [CONS?] question *What are all the ways the plants could manage to grow quickly?* and the conditional *If Easy-gro was put on the plants, then the plants grew quickly.* Although items like these are not completely immune to *mention-some* interpretations, they seem at least less open to these interpretations than those in which the alternatives are unspecified. The initial sentence seems to limit the relevant alternatives to just a few (in this case, Easy-gro or Bloom-builder); so the speaker of the conditional should find it less of a burden to provide an exhaustive list. However, a re-analysis of Experiment 1 shows that participants were *less* likely to endorse the inferences for the items with explicitly-provided alternatives (68% “yes” responses) than for the remaining open items (81% “yes” responses), and there were no reliable differences among inference types with respect to this effect.

It appears then that pragmatic reasoning based on background questions is not enough to trigger the relevant exhaustive readings. What turns out to be necessary—in our experiments, at least—is linguistic material that explicitly directs hearers towards an exhaustive interpretation.

A very austere development of this idea would be to claim that the biconditional interpretation requires that such material always be explicitly represented. This amounts to the claim that there is no distinctive pragmatic phenomenon of conditional perfection. Biconditional interpretations arise as entailments when an utterance of *If A, B* is conjoined with additional claims that are strong enough to entail their converses.

The immediate problem with this explanation is that several previous experiments have found evidence of perfection stemming from the conditional’s status as a promise or threat

¹⁶ Recall that in this case we obtained an increase in endorsement for DA.

(e.g., *If you disrupt the class, you'll have to leave the room*). (See the sources cited in Section 3.) These conditionals don't entail their obverses—they merely suggest them—so perfection is obtainable without explicit entailment of $If \sim A, \sim B$. What is the case is that questions, in particular, are not always enough to yield the obverse.¹⁷

Here's where we've got to: Questions that explicitly request exhaustive answers don't seem sufficient to produce perfection. That's the experimental finding. This seems to be because the answers aren't read as exhaustive rather than because an exhaustive answer doesn't yield perfection. Although it's possible that the question-to-exhaustive-answer link is the normal case and something about our experimental materials militated against it, the usual suspects—the respondent's lack of knowledge, uncooperativeness, and response burden—seem to be ruled out by the results. There may be some unusual suspects responsible for blocking the normal route to interpreting the answer as exhaustive, but what could these be? Instead, it seems more likely that an exhaustive interpretation of an answer requires more than just a question demanding one. This something more could be an explicit avowal that the response is exhaustive, but it seems likely that people could settle on exhaustive readings from weaker evidence, as in the case of promises and threats. Perhaps what listeners require is some reason to think that an exhaustive conditional answer is in the respondent's interest. Otherwise, the listeners' experience with their own communicative foibles may make them hesitant to think they've gotten the full story.

¹⁷ A more generous variant on this no-question-to-exhaustive-answer position would be to claim that perfection-like strengthening can happen even when there are no explicit exhaustification devices. This goes in the general direction of Herburger's (2015) "Whole Truth" account of conditional perfection. Her preliminary statement of the theory is:

Conditional Perfection and upper-bounding inferences arise as logical entailments when a sentence S is silently conjoined with *only S*, resulting in the conjunction S and *only S*. S and *only S* is then taken to express 'the truth and the whole truth'. (Herburger, 2015, p. 6)

Note that Herburger strikes through '*and only S*' to indicate the fact that it may not be pronounced. If it is possible to interpret utterances of $If A, B$ as utterances of $If A, B$ and *only If A, B*, then that's when we should expect perfection inferences to arise. According to this intermediate take, perfection inferences can arise due to overt or covert exhaustification.

This sort of approach is difficult to evaluate, experimentally at least, absent some systematic ideas about when we are allowed to supplement S with the silent *and only S*. Since it is part of the proposal that there are no systematic principles that connect which questions are made salient by the discourse and the availability of the strengthened interpretation, it is hard to see what such principles might look like.

But perhaps a non-experimental argument is available. If perfection is achievable with overt exhaustification devices (as our experiments demonstrate), and if there is precedent for covert exhaustification, we should expect that nothing prevents an exhaustified interpretation of conditionals. The remaining question, once again, is why we did not find much trace of these exhaustified interpretations in our first experiments.

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