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# Indicatives, Subjunctives, and the Falsity of the Antecedent

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## Abstract

It is widely held that there are important differences between indicative conditionals (e.g., “If the authors are linguists, they have written a linguistics paper”) and subjunctive conditionals (e.g., “If the authors had been linguists, they would have written a linguistics paper”). A central difference is that indicatives and subjunctives convey different stances toward the truth of their antecedents. Indicatives (often) convey neutrality: for example, about whether the authors in question are linguists. Subjunctives (often) convey the falsity of the antecedent: for example, that the authors in question are not linguists. This paper tests prominent accounts of how these different stances are conveyed: whether by presupposition or conversational implicature. Experiment 1 tests the presupposition account by investigating whether the stances project—remain constant—when embedded under operators like negations, possibility modals, and interrogatives, a key characteristic of presuppositions. Experiment 2 tests the conversational-implicature account by investigating whether the stances can be cancelled without producing a contradiction, a key characteristic of implicatures. The results provide evidence that both stances—neutrality about the antecedent in indicatives and the falsity of the antecedent in subjunctives—are conveyed by conversational implicatures.

*Keywords:* Conversational implicature; Falsity of the antecedent; Indicative conditionals; Presupposition; Subjunctive conditionals

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## 1. Introduction

Consider these sentences:

1. “If the authors are linguists, they have written a linguistics paper.”<sup>1</sup>
2. “If the authors had been linguists, they would have written a linguistics paper.”

What, if anything, do they convey about the authors’ profession? Sentence (1) seems to be silent on this issue: the authors may or may not be linguists. Sentence (2), in contrast, seems to convey that the authors are not linguists. This difference underlies a major distinction between types of conditional sentences (sentences of the form “If A, (then) C”). Sentences like (1) are typically known as *indicative* conditionals; sentences like (2), as *subjunctive* or *counterfactual* conditionals. Conditionals in general are essential to everyday language and reasoning; counterfactual conditionals, in particular, to causal and moral thinking (Byrne, 2016). The relationship between these two types is one of the mysteries about conditionals (Bennett, 2003; Quelhas, Rasga, & Johnson-Laird, 2018).

It is widely accepted that indicatives and subjunctives convey different stances toward the truth or falsity of the antecedent (the “A” clause” of “If A, then C”). But it is not clear how. Classically, researchers have distinguished between two general ways to convey meaning: semantics and pragmatics. These terms have competing definitions, but a reasonable working definition is that semantics can be understood as literal, context-independent, noninferential, and truth-conditional meaning; and pragmatics can be understood as nonliteral, context-dependent, inferential, and nontruth-conditional meaning<sup>2</sup> (Birner, 2014).

This paper seeks to identify how conditionals’ stances toward the antecedent are conveyed. In doing so, it addresses an important debate in linguistics, the philosophy of language, and the psychology of reasoning on the status of these stances. The paper investigates whether the stances are conveyed by a presupposition (for presupposition accounts, see, e.g., Declerck & Reed, 2001; Fillenbaum, 1974; Khemlani, Byrne, & Johnson-Laird, 2018; Levinson, 1983) or a conversational implicature (for conversational implicature accounts, see, e.g., Iatridou, 2000; Ippolito, 2003; Leahy, 2011, 2018; Mittwoch, Huddleston, & Collins, 2002). We will explain these phenomena fully in the introductions to Experiments 1 and 2, respectively. Here, it suffices to note that, if the stances were conveyed by a presupposition, a good case could be made for these stances being part of the conventional, semantic meaning of the conditionals. But if the stances were conveyed by a conversational implicature, the stances would clearly be a pragmatic phenomenon, and not part of the conventional meaning of the conditionals.

Important though these theoretical debates are, this is an issue with far wider relevance. For instance, whether the stance is conveyed semantically or pragmatically—and, if pragmatically, *how*—bears on how strongly the speaker is committed to that stance. Recent theories have held that, since speakers are less committed to pragmatic meanings, such meanings are plausibly deniable (e.g., Fricker, 2012; Lee & Pinker, 2010; Pinker, Nowak, & Lee, 2008). Imagine a court case in which a key issue is whether a witness had ever had a Swiss bank account. Imagine, further, that the prosecuting attorney failed to follow a clear line of questioning and, commenting later, the witness states “If I *had* had a Swiss bank account, I would have answered a direct question about it.” This utterance appears to suggest that the witness

did not have a Swiss bank account. But how strongly did the witness commit to that? And if he really *did* have a bank account, was his statement a lie? Experimental data suggest that participants prefer indirect to direct meanings when committing problematic acts when the hearer is likely to be antagonistic and when the potential costs are high (Lee & Pinker, 2010). Data also suggest that participants prefer to trust speakers who implied (more technically, “implicated”), rather than explicitly said or presupposed, false information (Mazzarella, Reinecke, Noveck, & Mercier, 2018). Moreover, how the stance is conveyed may have implications for individual differences. For instance, researchers have been interested in the relationship between pragmatic reasoning and autism (Geurts, Kissine, & van Tiel, 2020).

Our question bears on another key debate: whether there can be a single, unified semantic theory of indicative and subjunctive conditionals. This debate has long proved controversial, with some researchers advancing a unifying account (e.g., Edgington, 2008; Johnson-Laird & Byrne, 2002; Over, Hadjichristidis, Evans, Handley, & Sloman, 2007; Pfeifer & Tulkki, 2017; Quelhas et al., 2018; Spohn, 2013; Stalnaker, 1968, 1975; Starr, 2014; Williamson, 2020), while others argue against it (e.g., Bennett, 2003; Lewis, 1973, 1976). This paper contributes to the debate by investigating salient semantic and pragmatic accounts of one key difference in meaning between indicative and subjunctive conditionals, the stances toward the antecedent, and ascertaining whether these stances belong to the conventional, context-independent, semantic meaning of the conditionals or their nonconventional, context-dependent, pragmatic meaning. In the rest of the introduction, we first outline the range of stances a conditional can be used to convey toward its antecedent, before previewing the experiments.

### 1.1. *The truth/falsity of the antecedent: Defining indicatives and subjunctives*

Theoretical and corpus-linguistic work suggests that conditionals are, in fact, compatible with a range of stances toward their antecedent. They can convey that the speaker takes the antecedent to be true, false, or somewhere in between. To illustrate, consider the following examples from Declerck and Reed (2001). These examples illustrate categories from their extensive typology, which relates the grammatical (morphosyntactic) form of a conditional to its stance toward the antecedent.

3. “If I had a problem, I always went to my grandmother” (ibid., p. 50).

This conditional conveys that its antecedent is known to be true. Conditionals like this, with factual antecedents, often describe past repetitive habits (ibid.). Compare example (3) with the next example:

4. “I hope Liverpool won their home match yesterday. If they did, they still have a chance of winning the championship” (ibid., p. 54).

This conditional conveys that its antecedent is an open—a real—possibility. Compare example (4) with the next example:

5. “I would have been happy if we had found a solution” (ibid., p. 54).

This conditional conveys that the antecedent is false in the actual world: it is counterfactual.

What sets the counterfactual-antecedent (5) apart from the others<sup>3</sup> is a distinctive use of verbal morphology in the antecedent.<sup>4</sup> The morphology appears to be standard past perfect, “had found.” But this morphology does not simply situate the antecedent in a particular time: it is, in a sense, a “fake tense” (Iatridou, 2000). The counterfactual-antecedent refers to the past but uses the extra layer of past tense—the past-perfect “had”—to indicate that the antecedent situation did not actually obtain. This use of morphology has led von Fintel (2012) to refer to counterfactuals as “additional-past conditionals.” But counterfactual-antecedent conditionals can also occur in the following form, referring to the present:

(6) “If he were rich, he would be smart” (Iatridou, 2000, p. 232).

Here, the antecedent conveys counterfactuality through “were,” which some class as being in the subjunctive mood (e.g., Starr, 2019) and others as being in a distinct “irrealis” mood (Huddleston, 2002; Mittwoch et al., 2002).

Following convention, we will focus on the distinction between indicative and subjunctive, or counterfactual, conditionals here, although the label “subjunctive” has well-known problems (see, e.g., Starr, 2019; von Fintel, 2012). We take it, moreover, that by “indicative” most researchers would mean conditionals like (4) above, which we will call “open-antecedent conditionals” to indicate that usually the speaker does not know whether the antecedent or consequent are true or false (Mittwoch et al., 2002). We take it, also, that by “subjunctive” or “counterfactual” most researchers would mean conditionals like example (5) with the distinctive extra-layering of “fake past” in the antecedent and a modal auxiliary “would” or “would have” in the consequent.

## 1.2. Previous findings

There are experimental data to support the theoretical and intuitive distinctions between indicative (open-antecedent) and subjunctive conditionals. For instance, in Thompson and Byrne (2002), when participants indicated “What, if anything, you think [the speaker] meant to imply?” by indicative and subjunctive conditionals, different patterns emerged for indicatives and subjunctives. Some 54% of participants took the speaker of an indicative to imply nothing; of the remaining participants, 24% took the speaker of an indicative to imply the truth of the antecedent and 44% the truth of the consequent. These data suggest that, at least for many participants, indicatives are compatible with either the truth or falsity of the antecedent (and consequent). For subjunctives, in contrast, around half (48%) of participants took the speaker of a subjunctive to imply the falsity of the antecedent and around half (47%) the falsity of the consequent, a far higher rate than for indicatives (respectively, 2% and 1%).

A distinction emerges between indicatives and subjunctives in other tasks investigating conditional inferences (Byrne & Tasso, 1999; Thompson & Byrne, 2002). Moreover, in Quelhas et al. (2018), participants selected among different paraphrases of indicative and subjunctive conditionals. Participants tended to choose a paraphrase of indicative conditionals to the effect that antecedent and consequent were both possible, and a paraphrase of subjunctive conditionals to the effect that both antecedent and consequent once were possible but no longer are. A substantial minority also selected a paraphrase for the subjunctives to the effect that antecedent and consequent were both possible. Given this range of data, and further

evidence from processing studies (e.g., de Vega, Urrutia, & Rizzo, 2007; Ferguson & Sanford, 2008; Santamaría, Espino, & Byrne, 2005; Stewart, Haigh, & Kidd, 2009), we can grant that indicative and subjunctive conditionals can convey different stances toward their antecedent, with subjunctives often conveying the falsity of their antecedents. But just how, and when, are these stances conveyed?

### 1.3. Entailment

A first semantic possibility is that conditionals semantically entail their stances toward the antecedent: for instance, that subjunctives semantically entail the falsity of the antecedent. One sentence entails a second if the second sentence is true in every model satisfying the first sentence. The sentence “There is a polar bear in the zoo enclosure” entails “There is a mammal in the zoo enclosure”: the first cannot be true without the second also being true. Famous examples like (7) and (8) below, however, suggest that this constraint is too strong for accounting for the falsity of the antecedent of subjunctive conditionals:

(7) “If Jones had taken arsenic, he would have shown exactly those symptoms which he does in fact show” (Anderson, 1951, p. 37).

Since a speaker of this conditional could use (7) to argue that Jones had, in fact, taken arsenic, the sentence does not entail that the opposite is true—that is, that Jones did not take arsenic (Stalnaker, 1975, 2014; von Stechow, 1997, 2012). Such conditionals are commonly referred to as “Anderson conditionals”; they will feature in our experiments below.

A similar case is example (8):

(8) “If the butler had done it, we would have found blood on the knife. The kitchen knife was clean; therefore the butler did not do it” (Iatridou, 2000, p. 232).

The second sentence, here, does not seem redundant: the *modus tollens* argument does not seem to beg the question. But if the first sentence had already entailed that the butler did not do it, the argument would have been superfluous (Iatridou, 2000, Stalnaker, 1975, 2014). Similarly, if subjunctives “A > C” are given the truth conditions of being true if a base conditional (“if A, C”) is true *and* the antecedent is false, we immediately run into trouble with modus ponens (MP), modus tollens (MT), affirmation of the consequent (AC), and denial of the antecedent (DA):

$$\begin{array}{ccc}
 & \text{If } A, C & \text{If } A, C \\
 A > C & \frac{\neg A}{A} & A > C \quad \frac{\neg A}{\neg C} \\
 MP : \frac{A}{\therefore C} = \frac{A}{\therefore C} & & MT : \frac{\neg C}{\therefore \neg A} = \frac{\neg C}{\therefore \neg A} \\
 \\
 & \text{If } A, C & \text{If } A, C \\
 A > C & \frac{\neg A}{C} & A > C \quad \frac{\neg A}{\neg A} \\
 AC : \frac{C}{\therefore A} = \frac{C}{\therefore A} & & DA : \frac{\neg A}{\therefore \neg C} = \frac{\neg A}{\therefore \neg C} \quad (1)
 \end{array}$$

In MP inferences, we see that the conclusion is now inferred from an inconsistent premise set, in MT, one of the premises presupposes what the conclusion is supposed to establish, in

AC, the conclusion is inconsistent with one of the premises, and in DA, one of the premises is redundant. Normally, AC and DA are considered invalid forms of inferences, but not due to these problems.

To account for the stances toward the antecedent, we need other, more flexible linguistic phenomena. In this paper, we consider two such phenomena: presupposition and conversational implicature. We will define these terms below.

#### 1.4. *The experiments*

Two experiments, below, use classic diagnostics for being a presupposition (Experiment 1) or a conversational implicature (Experiment 2) to address the question of how conditionals convey the stances toward the antecedent. For these experiments, novel stimulus materials were developed which manipulate participants' belief states (i.e., neutrality, belief, or disbelief) via occluded pictures. These stimulus materials were pretested to investigate whether participants made the appropriate belief-state assumptions as a function of the picture shown, and whether they rank-ordered indicative and subjunctive conditionals accordingly.<sup>5</sup>

## 2. Experiment 1: Presupposition

It is a common idea that there is some difference in status between the stances of indicative and subjunctive conditionals toward the antecedent and other content of the conditional. Within mental models theory (MMT), for instance, it has been common to speak of the falsity of antecedent and consequent as part of the default meaning (e.g., Khemlani et al., 2018) but also of the “presupposed facts” (see, e.g., Byrne, 2005, 2016, 2017; Espino & Byrne, 2018). This notion of presupposed facts connects with a long tradition in linguistics and philosophy according to which counterfactual conditionals presuppose the falsity of their antecedents (see, e.g., Declerck & Reed, 2001; Fillenbaum, 1974; Levinson, 1983). Presupposition is a linguistic category that is often used for capturing further aspects of content that are not directly represented in a sentence's truth conditions, which, however, make up a precondition for the sentence being true, or appropriately assertable.

To presuppose information is to linguistically mark it as taken for granted (Beaver & Geurts, 2014) or to act as if it could be made an uncontroversially part of the shared common ground between speaker and interlocutor (Potts, 2007, 2015). Precise definitions of the term “presupposition” are contested. But on a common view, presuppositions are marked, linguistically, with presupposition triggers.<sup>6</sup> Triggers include, for example, the following:

9) factive verbs, such as “know”

“The reader knows that this paper is fantastic” presupposes that the paper in question is fantastic.

10) aspectual verbs, such as “continue”

“The reader continued to enjoy the paper” presupposes that the reader was enjoying the paper.

11) definite descriptions, such as “The [Noun Phrase]”

“The broken glass glittered in the sunlight” presupposes that there was broken glass.

In some lists, one would also see the antecedent of counterfactual conditionals (e.g., Levinson, 1983) but, as we will see, their inclusion is contentious. Some researchers also argue that the openness of the indicative conditionals is due to a presupposition (see, e.g., Byrne & Johnson-Laird, 2019, Declerck & Reed, 2001). If presuppositions convey the different stances of indicatives and subjunctives toward their antecedent, then the presuppositions attach to some element of the antecedent: presumably, the morphological form of the main verb in the antecedent. How well, then, does a presupposition account for intuitions and linguistic data? To answer this question, we must consider a characteristic known as “projection.” This characteristic is at work in examples (12) and (13):

(12) “The East German ambassador laughed.”

(13) “The East German ambassador did not laugh.”

Here, there is a presupposition trigger, the definite description “The East German ambassador,” which presupposes the existence of the said ambassador at the relevant time. In (13), this trigger is embedded under negation, but the presupposition survives: it *projects* under negation. Such projection behavior is a hallmark of presuppositions, and it is not one that is found with semantic entailments (Simons, 2006). Indeed, it is a classic diagnostic test for being a presupposition to see whether information projects under various operators (Beaver & Geurts, 2014). In the so-called “family of sentences test” (see, e.g., Kadmon, 2001), one considers whether a candidate for being a presupposition survives in a set of related sentences: in negation, questioning, embedding under modals, and embedding in the antecedent of a conditional. Table 1 illustrates this test for the East German ambassador examples, and how the test might apply to indicative and subjunctive conditionals.

A range of existing empirical work has used such embedding to test for projection. For instance, studies have shown projection under negation for the presuppositions of factive verbs “realize” and “know”—that is, the truth of the complement (Chemla & Bott, 2013); for the presupposition of “stop”—that is, that “stop X” presupposes “used to X” (Romoli & Schwarz, 2015); and for the presuppositions of “the” and “win”—that is, “the X” presupposes X’s existence, and “win X” presupposes competing for X (Smith & Hall, 2011).

However, it turns out that presuppositions do not always survive; presuppositions that project can sometimes, nevertheless, be directly denied (Kadmon, 2001; Simons, 2006). For instance, example (14) directly denies the presupposition in example (13):

(14) “The East German ambassador did not laugh. There is no East German ambassador, because East Germany no longer exists.”

Importantly, though, direct denial only seems to work when the presupposition trigger is embedded under an operator (Beaver & Geurts, 2014). Compare the successful denial in

Table 1  
Family of sentences test

Test sentence	Projects? <i>There was laughter</i>	<i>There is an East German ambassador</i>	<i>Speaker is open to the possibility that the East German ambassador will laugh</i>	<i>Speaker doubts that the East German ambassador laughed</i>
The East German ambassador did not laugh.	No	Yes	It is not the case that if the East German ambassador laughs...	It is not the case that if the East German ambassador had laughed....
Did the East German ambassador laugh?	No	Yes	Will the guest be offended, if the East German ambassador laughs?	Would the guest have been offended, if the East German ambassador had laughed?
Possibly, the East German ambassador laughed	No	Yes	Possibly, if the East German ambassador laughs...	Possibly, if the East German ambassador had laughed...
Diagnosis	<i>Entailment</i>	<i>Presupposition</i>	<i>Unclear</i>	<i>Unclear</i>

(14), where the presupposition trigger is embedded under negation, with the attempted but infelicitous denial that follows (15):

(15) “The East German ambassador laughed. There is no East German ambassador.”

These rather specific contexts, then, do not undermine the use of projection as a diagnostic test. Can projection behavior, then, account for the stances toward the antecedent conveyed by conditionals? With indicative conditionals, there seems to be no great problem. If we ultimately want a theory that can allow all stances toward the antecedent, we might wonder whether presuppositions can do the required work: whether there are distinct triggers for the different stances. But there are promising differences in form between conditionals that convey different stances on the truth of the antecedent which might serve as triggers (see, e.g., Declerck & Reed, 2001). But with subjunctive conditionals, there seem to be considerable difficulties. As we have seen, presuppositions can be cancelled through direct denial when they are embedded under an operator. But a presupposition account predicts that the falsity of the antecedent should be conveyed when there is no embedding. Examples (7) and (8) already challenges this notion via their cancellation of the falsity of the antecedent of the respective subjunctives (though see Stalnaker, 2014 and Zakkou, 2019 for further discussion).

In Experiment 1, we test the presupposition account more systematically. Experiment 1 explores whether the stances toward the antecedent—neutrality for indicatives, and disbelief for subjunctives—exhibit the projection behavior of presuppositions. To investigate this, we apply the family of sentences test (Kadmon, 2001) to see whether these belief-state assumptions project past negation operators (“it is not the case that...”), possibility-modals (“possible, ...”), and interrogatives (“Martin, do you think that ... ?”). More specifically, we test:



(1) for standalone indicatives, whether neutrality toward the antecedent projects past these three operators; (2) for standalone subjunctives, whether disbelief toward the antecedent projects past the operators; and (3) for Anderson conditionals, whether belief in/neutrality toward the antecedent projects past the operators.

Translated into a statistical model, the presupposition hypothesis holds that there should be no differences across the various types of operator (referred to as the “DV type factor” below). This model (M5) is tested against a collection of other models, which allow for differences between the operators, as explained below.

## 2.1. Method

### 2.1.1. Participants and sampling procedure shared for all experiments

The experiment was conducted over the Internet to obtain a large and demographically diverse sample. A total of 118 people completed the experiment. The participants were sampled through the Internet platform Mechanical Turk from the USA, UK, Canada, and Australia. They were paid a small amount of money for their participation. The following a priori exclusion criteria were used: not having English as native language, completing the task in less than 240 s or in more than 3600 s, failing to answer at least one of two simple SAT comprehension questions correctly in a warm-up phase, and answering “not serious at all” to the question “how serious do you take your participation” at the beginning of the study. The final sample consisted of 78 participants. Mean age was 37.41 years, ranging from 21 to 65. 38.46% of participants identified as female; 61.54% identified as male. 79.49% indicated that the highest level of education that they had completed was an undergraduate degree or higher.

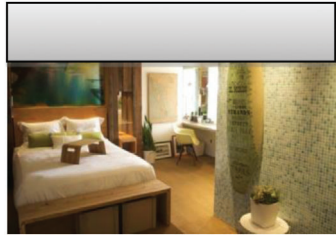
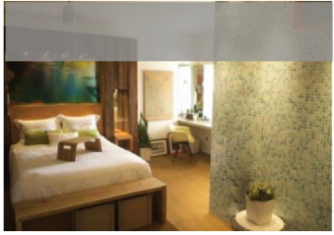
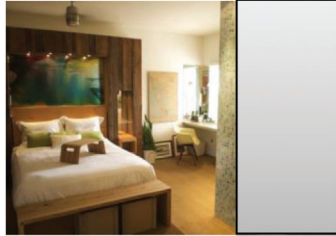
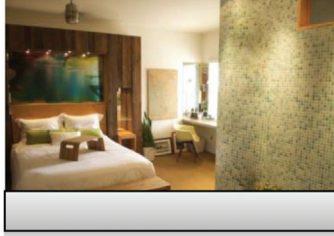
### 2.1.2. Design

The experiment had a within-participants design with the following factors varying within participant: DV type (assert vs. negation vs. possible vs. question), Prior (high probability (H) vs. low probability (L)), and Conditional type (indicative vs. subjunctive). To allow for four trial replications for each cell of the design, each participant in total went through 64 within-subject conditions.

### 2.1.3. Materials and procedure for all the experiments

For a pilot study,<sup>7</sup> a pool of 24 different pictures was created, and 16 pictures selected for further studies based on which pictures had the highest rate of inducing the intended belief-state assumptions consistently across the four conditions. In all the experiments reported below, the various within-participants conditions were thus randomly assigned to a pool of the 16 different pictures. Random assignment was performed without replacement such that each participant saw a different picture for each condition. This ensured that the mapping of condition to picture was counterbalanced across participants preventing confounds of condition and picture content.

Table 2  
Stimulus materials and experimental conditions

<i>Indicative, occluded</i>	<i>Subjunctive, not occluded</i>
<p><i>Here is a pendant lamp in the bedroom) = H</i>                      IF there is a pendant lamp in the bedroom, THEN it hangs above the bed.</p>	<p>IF there had been a pendant lamp in the bedroom, THEN it would have hung above the bed, where indeed something is hanging.</p>
	
<p><i>Here is a surfboard in the bedroom) = L</i>                      IF there is a surfboard in the bedroom, THEN it stands against the wall.</p>	<p>IF there had been a surfboard in the bedroom, THEN it would have stood against the wall.</p>
	

*Note.* “H” = high prior probability; “L” = low prior probability. Note that the upper right corner is an example of the so-called “Anderson conditional.”

To reduce the dropout rate during the experiment, participants first went through three pages stating our academic affiliations, posing two SAT comprehension questions in a warm-up phase, and presenting a seriousness check asking how careful the participants would be in their responses (Reips, 2002). Moreover, to ensure that the pictures were displayed properly if the participants completed the study on a smartphone, participants were asked to turn their smartphone in horizontal orientation, if they were using one.

The 16 possible pictures all implemented the four conditions indicated in Table 2. The pictures feature familiar places like bedrooms, cafés, and kitchens, where we stereotypically have expectations about likely objects (e.g., a pendant lamp in a bedroom) and unlikely objects (e.g., a surfboard in a bedroom). As Table 2 shows, the pictures additionally featured gray boxes that manipulate the assertability of indicative and subjunctive conditionals. These boxes operationalize the Occlusion variable (see also Baratgin, Over, & Politzer, 2013).

To create a situation in which indicative conditionals are assertable (left column), we used a gray box to hide the location specified by the consequent of the conditional. For instance, due to the gray box in the lower left picture, participants cannot verify for certain whether there is a surfboard standing against the wall, but they are expected to deem it unlikely. Our pilot study confirmed that participants make these judgments of high versus low prior probability.

To create a situation in which subjunctive conditionals are assertable (right column), we either placed a transparent gray box where the object was supposed to be (upper right corner), or a nontransparent gray box in an irrelevant location that had no bearing on the presence of the object mentioned in the conditional (lower right corner). For instance, when assessing the conditional “If there had been a surfboard, then it would have stood against the wall” based on the picture in the lower right corner, participants can see for certain that there is no surfboard standing against the wall, and thus maintain disbelief in the presence of a surfboard on the picture. In contrast, the transparent<sup>8</sup> gray box in the upper right corner was introduced to create a situation for asserting so-called Anderson conditionals (e.g., “If there had been a pendant lamp in the bedroom, then it would have hung above the bed, where indeed something is hanging”), which take the subjunctive form but are asserted without doubting the antecedent. Due to the transparent gray box, participants can verify that there is an object that appears to fit the description at the place mentioned in the consequent. Nevertheless, the lack of full transparency is intended to make the guarded form of the subjunctive mood for the conditional assertion sound more natural.

A feature of the conditionals in Table 2 is that the consequent depends for its truth on the antecedent. The conditionals were designed in this way, because it enabled us to manipulate belief states based on the pictures and the gray boxes in a way that would also permit the formulation of Anderson conditionals. Since Experiments 1 and 2 only concern belief states targeting the antecedent, this feature does not matter for their purpose.

#### *2.1.4. Procedure specific to experiment 1*

The experiment was split into 16 blocks, each implementing one of the four trial replications of the four Prior  $\times$  Conditional type within-subject conditions. For each block, a picture was randomly assigned from the pool of 16 pictures used. The order of the blocks was randomized and there were no breaks between blocks. Within a given block, participants were presented with the four DV types on separate pages in random order with the same picture.

Before beginning with the actual experiment, participants completed four practice trials with one of the excluded pictures, where it was emphasized that it was important to pay attention to subtle differences between the wordings on the various pages. To complete these trials, participants were given the following instruction:

In the following, you are going to see pictures and statements made by Dennis concerning the pictures shown. Your task is to indicate which assumptions you would make concerning what Dennis believes based on what he says.

On each page, participants were then presented with a statement by Dennis in response to the selected image, corresponding to the within-subject condition displayed at the moment.

For instance, a participant might first have seen the following image.



Together with the following statement:

- Dennis: Possibly, IF there is a monitor in the office, THEN it stands on the table. (*possible*)

The task of the participants was to indicate which of the following three statements best describes Dennis' state of mind when reading his statement:

- Dennis disbelieves that there is a monitor in the office.
- Dennis neither believes nor disbelieves that there is a monitor in the office.
- Dennis believes that there is a monitor in the office.

On the three pages that followed, participants were given the same task with the following three statements in random order:

- IF there is a monitor in the office, THEN it stands on the table. (*assert*)
- It is NOT the case that IF there is a monitor in the office, THEN it stands on the table. (*negation*)
- Martin, do you think that IF there is a monitor in the office, THEN it stands on the table? (*question*)

## 2.2. Results

Table 3 reports descriptive statistics for participants' belief-state ascriptions.

Given the design, there were replicates for each participant and picture. Hence, it was not appropriate to assume that the data were independently and identically distributed. Accordingly, linear mixed-effects models with crossed random effects for intercepts and slopes by participants and pictures were used (Baayen, Davidson, & Bates, 2008).<sup>9</sup> This analysis was conducted using the statistical programming language R (R Core Team, 2013) and the package brms for mixed-effects models in Bayesian statistics (Bürkner, 2017) with a multinomial likelihood and a logit link function for categorical regression. The following family of models was fit to the data, which vary in their fixed effects:

Table 3  
Descriptive statistics

	Assert	Negation	Possible	Question
Indicative, HH	50.96% Neutral	50.32% Disbelief	63.46% Neutral	73.40% Neutral
Indicative, LL	57.69% Neutral	48.08% Disbelief	63.46% Neutral	70.19% Neutral
Subjunctive, HH	37.18% Belief	55.45% Disbelief	37.50% Neutral	42.95% Neutral
Subjunctive, LL	45.83% Disbelief	55.45% Disbelief	47.12% Neutral	54.17% Neutral

*Note.* Due to the categorical nature of the response variable, the descriptive statistics is reported as percentages of the modal values. “HH” = high prior probability of antecedent and consequent; “LL” = low prior probability of antecedent and consequent.

(M1) a maximal model that treats participants’ selections as a function of the DV type factor (assert vs. negation vs. possible vs. question), the Prior factor (high vs. low), the Conditional factor (indicative vs. subjunctive) and their three and two-way interaction.

(M2) a model that is obtained from the maximal model (M1) by removing the three-way interaction.

(M3) a model that is obtained from (M2) by removing the two-way DV type:Prior interaction.

(M4) a model that is obtained from (M3) by removing the two-way Conditional:DV type interaction.

(M5) a model that is obtained from (M4) by completely removing the DV type factor. (M5) thereby implements the presupposition model.

Hypotheses concerning the presence/absence of effects are tested here and below by setting coefficients of the maximal model (M1) equal to zero. In this way, evidence in favor of, for example, the  $H_0$  that there is no simple effect of the DV type factor can be quantified in terms of Bayes factors, where classical significance testing would only have permitted us to conclude that  $H_0$  could not be rejected (Wagenmakers, Marsman, Jamil, Ly, & Verhagen, 2018). To be able to quantify the strength of evidence both against and in favor of  $H_0$ , we rely on the following qualitative interpretation of Bayes factors (Lee & Wagenmakers, 2014): (Anecdotal evidence for  $H_1$ )  $\frac{1}{3} < BF_{H_0H_1} < 1$ , (Moderate evidence for  $H_1$ )  $\frac{1}{10} < BF_{H_0H_1} < \frac{1}{3}$ , (Strong evidence for  $H_1$ )  $\frac{1}{30} < BF_{H_0H_1} < \frac{1}{10}$ , (Very Strong evidence for  $H_1$ )  $\frac{1}{100} < BF_{H_0H_1} < \frac{1}{30}$ , (Extreme evidence for  $H_1$ )  $BF_{H_0H_1} < \frac{1}{100}$ . Values above 1 indicative evidence in favor of  $H_0$  since this scale is mirrored by applying the following ratio:  $BF_{H_0H_1} = \frac{1}{BF_{H_1H_0}}$ . Table 4 reports the performance of the models as quantified by the leave-one-out cross validation criterion and WAIC.

The information criteria showed a preference for M1–M3 and clearly rejected the model (M5) corresponding to the presupposition hypothesis of no effect of embedding indicative

Table 4  
Model comparison

	LOOIC	$\Delta\text{elpd}$	SE	WAIC	Weight
M1	8150.2	0	–	8147.7	0.611
M2	8152.3	–1.1	3.7	8149.8	0.213
M3	8152.6	–1.2	5.3	8150.3	0.177
M4	8202.8	–26.3	10.1	8200.5	0.000
M5	8795.1	–322.5	27.6	8793.2	0.000

*Note.* LOOIC = leave-one-out cross-validation information criterion. WAIC = Watanabe-Akaike information criterion. Weight = Akaike weight of LOOIC. “elpd” = expected log predictive density is a measure of the expected out-of-sample predictive accuracy.

and subjunctive conditionals under negation, possibility, and interrogation operators. Since the differences between M1 and M3 were modest, Fig. 1 plots the posterior predictions of all three models as weighted by their respective model weights from Table 4.

The results indicate that there was a contrast between “assert” and the other DV types across conditions. In particular, strong evidence could be obtained that use of “Negation” increased the posterior probability of Disbelief ( $b_{\text{Negation\_Disbelief}} = 2.21$ , 95% CI [1.72, 2.72],  $\text{BF}_{\text{H0H1}} < 0.001$ ) and that embedding under “Possible” and “Question” both increased the posterior probability of “Neutral” ( $b_{\text{Possible\_Neutral}} = 0.77$ , 95% CI [0.35, 1.18],  $\text{BF}_{\text{H0H1}} = 0.02$ ;  $b_{\text{Question\_Neutral}} = 1.58$ , 95% CI [1.13, 2.03],  $\text{BF}_{\text{H0H1}} < 0.001$ ). There was, moreover, weaker evidence of a three-way interaction in particular based on the following contrast, which indicates a higher posterior probability of selecting the “Neutral” category for a specific level of the Condition and Prior factors ( $b_{\text{Subjunctive:PriorLL:Question\_Neutral}} = 1.21$ , 95% CI [0.29, 2.12],  $\text{BF}_{\text{H0H1}} = 0.37$ ).

### 2.3. Discussion

As a manipulation check, we can gauge the belief-state attributions of standalone assertions for their plausibility across conditions. What we find is a general tendency to attribute doxastic neutrality toward the antecedent for indicative conditionals (across prior levels), disbelief/neutrality in the counterfactual conditionals (subjunctive, low prior), and an elevated posterior probability of selecting “belief” with the Anderson conditionals (subjunctive, high prior) compared to the counterfactual conditionals (Table 3 and Fig. 1). Since these belief-state attributions overall match prior theoretical expectations, the results from Experiment 1 can be used to test the presupposition hypothesis. Translated into a statistical model, the presupposition hypothesis holds that there should be no differences across the various levels of the DV type factor. Accordingly, if the presupposition hypothesis had accounted for the data, we would expect M5 to be the winning model. In contrast, M5 turned out to be the worst fitting model. What we find instead is that the DV type factor enters into an interaction with the Conditional factor, and that participants attribute somewhat different belief states depending on whether the conditional is embedded under an operator. Negation increases the probability

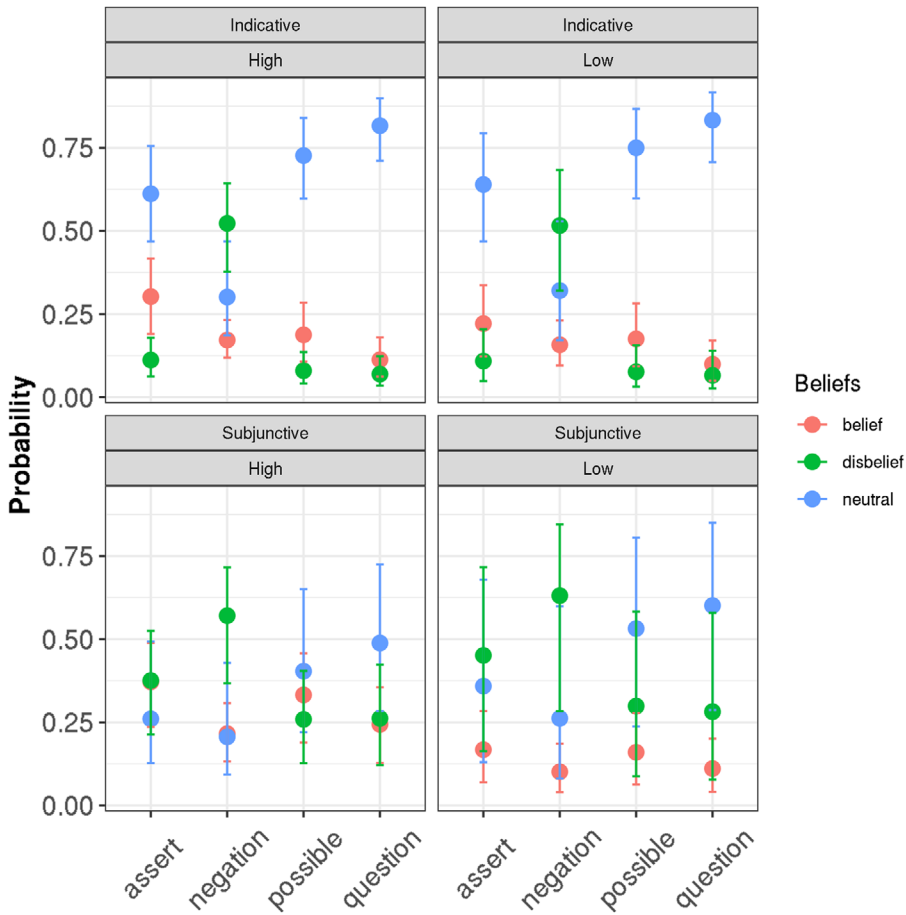


Fig. 1. Posterior predictions based on M1–M3. The posterior predictive probabilities of selecting belief/neutrality/disbelief across within-subject conditions are displayed. “High” = high prior probability of antecedent and consequent. “Low” = low prior probability of antecedent and consequent. Error bars represent 95% credible intervals.

of attributing disbelief; Possible and Question increase the probability of attributing neutrality. The results thus speak against the presupposition hypothesis.

That these effects were found most strongly with projection past the negation operator is not surprising, since embedding under a possibility modal and an interrogative has the same valence as the bare assertion case, when the latter expresses neutrality. But, in fact, it was found that both the possibility modal and the interrogative contributed to attenuating the expression of doxastic neutrality.

As Experiment 1 shows, presupposition as defined by the classic family of sentences test is not a flexible enough phenomenon to handle the different stances toward the antecedent. This finding naturally prompts us to investigate a more flexible phenomenon: conversational implicature.

### 3. Experiment 2: Conversational implicature

Conversational implicatures are the paradigm case of natural-language pragmatics. They arise when a speaker implicitly and intentionally communicates something other than the conventional meaning of the utterance.

Take the following example: “I ate most of the pizza” (Birner, 2013, p. 45). The speaker literally states only that they ate most of the pizza but appears to convey—to conversationally implicate—that they did not eat all of it. Implicatures, it is said, arise because of how we expect conversations to go: we expect speakers to behave cooperatively. The classical account, here, is Grice (1989): we expect speakers to say enough, but not too much; to avoid saying false or unevicenced things; to be relevant; to avoid obscurity and ambiguity; and to be brief and orderly. Implicatures can arise when these expectations are observed or flouted—ostentatiously *not* observed. Let us assume that the speaker is cooperative and, in particular, has said enough, but not too much (has respected the *Maxim of Quantity*). Our cooperative speaker did not make the stronger statement “I ate all of the pizza,” and so—we presume—does not believe that the stronger statement is true. As hearers, we, therefore, conclude that the speaker did not eat all of the pizza.

Different theories account for implicatures with different theoretical constructs (see, e.g., Horn, 1984; Levinson, 2000; Sperber & Wilson, 1995), but a central property is that implicatures are defeasible: they can be cancelled without producing a contradiction (Blome-Tillmann, 2003). Hence, the speaker above could legitimately say “I ate most of the pizza—in fact, all of it.” That implicatures are so cancellable makes them an attractive option for explaining the different stances conveyed by indicatives and subjunctives. For indicative conditionals, some have proposed that it is an implicature that conveys the “open possibility” sense of the antecedent (Mittwoch et al., 2002), a proposal that obviates the need for distinct presupposition triggers for each stance on the antecedent. More commonly, researchers have proposed that it is an implicature that conveys the “not known” sense of the antecedent (e.g., Grice, 1989; Mittwoch et al., 2002). After all, if the speaker of “If *A*, *C*” had known that both “*A*” and “*C*” were true, they could have said simply “*A* and *C*”; that the speaker did not do so suggests that they do not know (Grice, 1989).

For subjunctives, the implicature account plays an important role. On this account, speakers can use subjunctive conditionals to conversationally implicate, in context, that the antecedent is false. With this account, we can accept, for instance, that example (6)—“If he were rich, he would be smart”—can sometimes, perhaps often, suggest that the “he” in question is not rich (or smart), but the sentence need not give rise to this implicature. Implicature-based accounts differ in detail, but have attracted numerous supporters (e.g., Iatridou, 2000; Ippolito, 2003; Leahy, 2011, 2018; Mittwoch et al., 2002).

The cancellability of conversational implicatures offers a diagnostic test: if information is conveyed by a conversational implicature, then it should be cancellable. Skovgaard-Olsen, Collins, Krzyżanowska, Hahn, and Klauer (2019) designed a cancellation task that applied this diagnostic test. In this cancellation task, the candidate for being an implicature is uttered by a fictional character. For the current research question, a character, Samuel, might say:



Samuel: “If there had been a pendant lamp in the bedroom, then it would have hung above the bed.”

Samuel then attempts to cancel the potential implicature: that there is not, in fact, a pendant lamp in the bedroom. A second character, Louis, accuses Samuel of contradicting himself, and participants are asked whether they agree with Louis. If this information is an actual implicature, then it should be possible for Samuel to cancel it: participants should disagree with Louis.

Alongside the candidate implicature are two baselines. The first baseline is an uncontroversial implicature: Samuel might say that it is “possible” that there is such a lamp, but deny suggesting that it is not highly likely. This baseline is an instance of a modal scalar implicature: when a speaker uses a weaker modal term, “possible,” they may implicate, or be mistaken for implicating, that a stronger modal term would be inappropriate. Hence, the speaker here would be suggesting that it is possible but not highly likely that there is such a lamp. Scalar implicatures are readily cancellable. The second baseline is an entailment: Samuel states that “this is a picture of a bedroom AND ...” before going on to deny suggesting that it is a picture of bedroom. This should not be cancelable.

The cancellation task allows us to ask whether cancelling the stance toward the antecedent is more like cancelling a scalar implicature or cancelling an entailment. It, therefore, allows us to experimentally test whether indicatives and subjunctives convey their stances toward their antecedents with a conversational implicature.

### 3.1. Method

#### 3.1.1. Participants

The same sampling procedure and exclusion criteria were used as in Experiment 1. A total of 120 people completed the experiment. Since some of the exclusion criteria were overlapping, the final sample consisted of 93 participants. Mean age was 34.46 years, ranging from 19 to 68. 50.54% of participants identified as female; 48.39% identified as male; and 0.11% preferred not to respond. 65.59% indicated that the highest level of education that they had completed was an undergraduate degree or higher.<sup>10</sup>

#### 3.1.2. Design

The experiment had a within-subject design with three factors: Occlusion (with two levels: occluded vs. not-occluded), Prior (with two levels: high (H) vs. low (L)), and Cancellation type (with three levels: scalar vs. entailment vs. belief state). To allow for four trial replications for each cell of the design, each participant in total went through 48 within-subject conditions.

#### 3.1.3. Materials and procedure

The experiment was split into 16 blocks of three pages, one block for each level of the Occlusion  $\times$  Prior factors and their four trial replications. Each block contained one page for each of the three levels of the Cancellation type factor. Sixteen different pictures were

randomly assigned to each of the 16 blocks. The order of the blocks was randomized anew for each participant and there were no breaks between the blocks. The three pages within each block were randomized and showed one within-subject condition from the pool of 16 selected pictures with different types of cancellations.

We cued participants to the intended interpretation of the cancellations with instructions and practice trials. For Experiment 2, the participants were given the following instructions together with four sample items:

In the following you will see several pictures of familiar settings (e.g. bathrooms, kitchens). As you will notice, different parts of the pictures are hidden by grey boxes. Note that some of these boxes are transparent.

The responses we will ask you to make relate to a picture shown and a corresponding dialogue between Samuel and Louis. In the dialogues, Samuel will say what he thinks is true – what he believes. Sometimes he will indicate what he thinks is false – what he disbelieves. And sometimes he will indicate that he doesn't have a view – that he is open to either believing or disbelieving it. Louis in turn accuses Samuel of contradicting himself. It will be your task to evaluate Louis' objection. Is he right?

The task of the participants was to indicate the extent to which they agreed or disagreed with Louis' statement on a five-point Likert scale {strongly disagree, disagree, neutral, agree, and strongly agree}. Before beginning the experiment proper, participants moreover saw three practice trials, where we emphasized that it was important to pay attention to both subtle differences between the wordings of the various types of cancellations used in the experiment and the varying placement of the gray boxes.

On the following three pages, participants were presented with one of the three types of cancellation in random order (perceived contradiction of cancellation of entailment, scalar implicature, and belief-state assumptions). The task of the participants was always to assess the extent to which they agreed with Louis' claim that Samuel contradicted himself. Using the bedroom picture from Table 3, the three types of cancellation were implemented across the four conditions as shown in Table 5.

The goal of the experiment was to find out whether cancellations of assumptions concerning belief states of indicative and subjunctive conditionals are more like cancellations of entailments or cancellations of scalar implicatures.

### 3.2. Results

Some initial descriptive statistics are reported in Table 6.

In the analysis below, we have collapsed across the levels of the Priors factor to focus on the contrast between indicative conditionals (investigated in the occluded conditions) and subjunctive conditionals (investigated in the not-occluded conditions), which is the contrast of most direct importance.

Table 5  
Cancellation types in experiment 2

Entailment	Scalar implicature	Belief state
<i>Indicative, occluded H</i>		
<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a pendant lamp in the bedroom, THEN it hangs above the bed                      ...but I am not suggesting that this is a picture of a bedroom.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a pendant lamp in the bedroom, THEN it is possible that it hangs above the bed                      ...but I am not suggesting that if so, it isn't highly likely that it hangs above the bed.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a pendant lamp in the bedroom, THEN it hangs above the bed                      ...but I am not suggesting that I am open to believing or disbelieving that there is a pendant lamp in the bedroom.</p>
<i>Indicative, occluded L</i>		
<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a surfboard in the bedroom, THEN it stands against the wall                      ...but I am not suggesting that this is a picture of a bedroom.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a surfboard in the bedroom, THEN it is possible that it stands against the wall                      ...but I am not suggesting that if so, it isn't highly likely that it stands against the wall.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there is a surfboard in the bedroom, THEN it stands against the wall                      ...but I am not suggesting that I am open to believing or disbelieving that there is a surfboard in the bedroom.</p>
<i>Subjunctive, not occluded H</i>		
<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a pendant lamp in the bedroom, THEN it would have hung above the bed, where indeed something is hanging                      ...but I am not suggesting that this is a picture of a bedroom.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a pendant lamp in the bedroom, THEN it is possible it would have hung above the bed, where indeed something is hanging                      ...but I am not suggesting that if so, it isn't highly likely that it would have hung above the bed.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a pendant lamp in the bedroom, THEN it would have hung above the bed, where indeed something is hanging                      ...but I am not suggesting that I doubt that there is a pendant lamp in the bedroom.</p>
<i>Subjunctive, not occluded L</i>		
<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a surfboard in the bedroom, THEN it would have stood against the wall                      ...but I am not suggesting that this is a picture of a bedroom.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a surfboard in the bedroom, THEN it is possible it would have stood against the wall                      ...but I am not suggesting that if so, it isn't highly likely that it would have stood against the wall.</p>	<p><b>Samuel:</b> This is a picture of a bedroom AND IF there had been a surfboard in the bedroom, THEN it would have stood against the wall                      ...but I am not suggesting that I doubt that there is a surfboard in the bedroom.</p>

*Note.* For the entailments, the conclusion of And Elimination was cancelled. “H” = high prior probability. “L” = low prior probability.

Table 6  
Descriptive statistics

	Entailment	Belief state	Scalar implicature
Indicative H	<i>Mdn</i> = 5, <i>MAD</i> = 0	<i>Mdn</i> = 2, <i>MAD</i> = 1.48	<i>Mdn</i> = 3, <i>MAD</i> = 1.48
Indicative L	<i>Mdn</i> = 5, <i>MAD</i> = 0	<i>Mdn</i> = 2, <i>MAD</i> = 1.48	<i>Mdn</i> = 3, <i>MAD</i> = 1.48
Subjunctive H	<i>Mdn</i> = 5, <i>MAD</i> = 0	<i>Mdn</i> = 2, <i>MAD</i> = 1.48	<i>Mdn</i> = 3, <i>MAD</i> = 1.48
Subjunctive L	<i>Mdn</i> = 5, <i>MAD</i> = 0	<i>Mdn</i> = 2, <i>MAD</i> = 1.48	<i>Mdn</i> = 3, <i>MAD</i> = 1.48

*Note.* Due to the ordinal nature of the perceived contradiction ratings, the descriptive statistics are reported via medians (*Mdn*) and median absolute deviations (*MAD*).

Given the design, there were replicates for each participant and pictures. Hence, it was not appropriate to assume that the data were independently and identically distributed. Accordingly, the appropriate analysis was to use linear mixed-effects models, with crossed random effects for intercepts and slopes by participants and pictures (Baayen et al., 2008). This analysis was conducted using R-package brms for mixed-effects models in Bayesian statistics (Bürkner, 2017). The following family of nested models was fit to the data:

(M6) a maximal model that treats participants' ratings of perceived contradiction as a function of the Cancellation factor (scalar implicature vs. entailment vs. belief state), Sentence Type (subjunctive vs. indicative), and their interaction.

(M7) a model that is obtained from the maximal model (M6) by removing the two-way interaction.

(M8) a model that is obtained from (M7) by removing the simple effect for the Sentence factor.

(M9) a model that is obtained from (M8) by removing the simple effect for the Cancellation factor.

Effects of the Cancellation type factor are of theoretical importance for testing the conversational implicature hypothesis. In selecting the class of models above, we investigated whether the effects of the Cancellation type factor vary across indicative and subjunctive conditionals. Since the responses obtained from the five-point Likert scale are ordinal responses, the responses were modeled as generated by thresholds set on a latent continuous scale via a cumulative model and a logit link function (Bürkner & Vuorre, 2019). Table 7 reports the performance of the models as quantified by the leave-one-out cross validation criterion and WAIC.

The modest differences between M6 and M8 indicate that the difference between indicative and subjunctive conditionals did not matter much for participants' perceived degree of contradiction. In contrast, the clear rejection of M9 indicates that strong differences in the

Table 7  
Model comparison

	LOOIC	$\Delta\text{elpd}$	SE	WAIC	Weight
M6	9271.5	0	–	9265.5	0.43
M7	9273.1	–0.8	1.9	9267.3	0.19
M8	9271.7	–0.1	1.9	9265.9	0.39
M9	9296.0	–12.3	2.6	9288.8	0.00

Note. LOOIC = leave-one-out cross-validation information criterion. WAIC = Watanabe-Akaike information criterion. Weight = Akaike weight of LOOIC. “elpd” = expected log predictive density is a measure of the expected out-of-sample predictive accuracy.

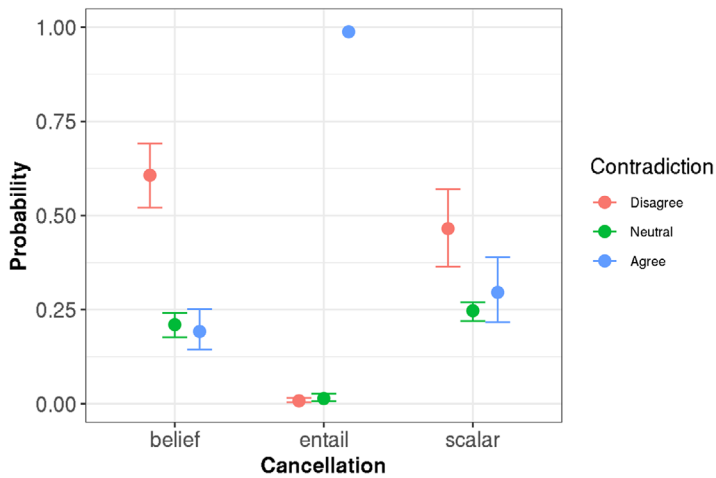


Fig. 2. Posterior predictions of M6–M8. Level of (dis)agreement that Samuel was contradicting himself, split by type of cancellation (of the belief state, entailment, and scalar implicature). This figure collapses across the levels of the Sentence factor. For each of the three types of cancellation, the “Strongly agree” and “Agree” ordinal categories were aggregated to “Agree” and “Strongly disagree” and “Disagree” were aggregated to “Disagree.” Error bars represent 95% credible intervals.

type of Cancellation were found. Since the differences between M6 and M8 were small, Fig. 2 plots the posterior predictions of all three models as weighted by their respective model weights from Table 7. Note that, as M8 excludes the interaction and the simple effect of Sentence type, the plot collapses across the Sentence factor. For purposes of plotting, we here aggregate “Disagree strongly”/“Disagree” and “Agree strongly”/“Agree,” although these response options were fitted separately above.

As a manipulation check, it can be observed across sentences that participants clearly distinguished between attempts to cancel a commitment to entailments and conversational implicatures, for both indicative and subjunctive conditionals. It was thus found that cancellations of entailments were viewed as more contradictory than cancellations of scalar implicatures for both indicatives ( $b_{\text{Entail} - \text{Scalar}} = 4.59$ , 90% CI [3.93, 5.30],  $\text{BF}_{\text{H1H0}} > 100$ ) and subjunctives ( $b_{\text{Entail} - \text{Scalar}} = 5.01$ , 90% CI [4.26, 5.77],  $\text{BF}_{\text{H1H0}} > 100$ ).

Next, the cancellations of belief states were compared to these two baselines. Strong evidence was found that cancellations of belief states were viewed as less contradictory than cancellations of entailments for both indicatives ( $b_{\text{Belief - Entail}} = -5.29$ , 90% CI [-5.99, -4.58],  $\text{BF}_{\text{H1H0}} > 100$ ) and subjunctives ( $b_{\text{Belief - Entail}} = -5.30$ , 90% CI [-6.08, -4.53],  $\text{BF}_{\text{H1H0}} > 100$ ).

In addition, moderate evidence was found that cancellations of belief states were viewed as less contradictory than cancellations of scalar implicatures for indicatives ( $b_{\text{Belief - Scalar}} = -0.70$ , 90% CI [-1.07, -0.30],  $\text{BF}_{\text{H1H0}} = 9.07$ ) but not for subjunctives ( $b_{\text{Belief - Scalar}} = -0.28$ , 90% CI [-0.65, 0.08],  $\text{BF}_{\text{H1H0}} = 0.18$ ), where indeed the  $H_0$  of no difference between the cancellation of belief-state assumptions and scalar implicatures was supported.

### 3.3. Discussion

The analysis validated our two baselines for the cancellation test by showing that there was very strong evidence that commitments to entailments were viewed as more cancellable than commitments to scalar implicatures. Next, our results showed that speakers can cancel, without contradicting themselves, the neutrality toward the antecedent of an indicative conditional and the disbelief toward the antecedent of a subjunctive conditional. Indeed, cancelling a commitment to the suggested belief state was viewed as *less* contradictory than cancelling a commitment to a scalar implicature for indicative conditionals. For subjunctive conditionals, strong evidence was found that the belief-state assumptions concerning the antecedent were just as cancellable as scalar implicatures. The data thus support the view that a conversational implicature is present in both indicative and subjunctive conditionals. Differences in the content of these conversational implicatures may accordingly help account for the meaning differences between indicative and subjunctive conditionals. Converging evidence for this conclusion was found in Experiment 1, where the posterior probability of selecting “Belief” was increased from subjunctives used to convey counterfactual conditionals to subjunctives used as Anderson conditionals.

## 4. General discussion

It is a familiar point that indicative and subjunctive conditionals differ with respect to the belief-state status of the antecedent, as illustrated by Adams’ (1970) Oswald–Kennedy pair, where one can consistently accept the first while rejecting the second:

(*indicative*) If Oswald did not shoot Kennedy, someone else did.

(*counterfactual*) If Oswald had not shot Kennedy, someone else would have.

The formulation of this minimal pair, with two conditionals differing in meaning, has led to a number of attempts to either provide a unifying account of indicative and subjunctive conditionals (Edgington, 2008; Spohn, 2013; Stalnaker, 1975; Starr, 2014; von Stechow, 2012; Williamson, 2020), argue why disjunct accounts are needed (Bennett, 2003; Lewis, 1973, 1976), or argue for a unifying account by questioning that this, indeed, constitutes a minimal pair (Quelhas et al., 2018). For proponents of the first approach, it is tempting to formulate one

Table 8  
Predictions

	Entailments	Presuppositions	Conversational implicatures
Project from embeddings	0	1	0
Cancellable when embedded	–	1	–
Cancellable when unembedded	0	0	1

*Note.* The horizontal lines indicate that Beaver and Geurts (2014) do not provide values for those cells.

semantics of conditionals and look to linguistic phenomena closer to pragmatics, like conversational implicatures or presuppositions, to account for the meaning differences between the two types of sentences above. Our findings cast light on the plausibility of such an approach.

#### 4.1. *Conversational implicatures and presuppositions*

Throughout Experiments 1 and 2, it was found that a conversational implicature best accounts for the diverging belief-state assumptions concerning the antecedents of indicative and subjunctive conditionals. Central to the evidence is the cancellability of the belief states: speakers could cancel the neutrality toward the antecedent in indicatives and the disbelief toward the antecedent in subjunctives without participants perceiving a contradiction.

According to the Stalnaker–Karttunen–Heim approach to presuppositions, a sentence carrying a presupposition can only be felicitously uttered in contexts that entail the presupposition (Kadmon, 2001, Ch. 5), or which can be updated so as to entail the presupposition (Simons, 2006). On this view, cancellation of presuppositions cannot be accounted for, if presuppositions are supposed to be entailed by the context on a classical, monotonic consequence relation. In contrast, on the so-called Cancellation Approach of Gazdar (1979) and Soames (1982), presuppositions are defeasible and can be cancelled by contextual assumptions or prior conversational implicatures (Kadmon, 2001, Ch. 6).

However, as Beaver and Geurts (2014) note, it appears that the main examples of cancellation of presuppositions concern cases, where the sentence carrying the presupposition has been embedded in a compound sentence. For instance, in examples like “If it’s *the* knave that stole the tarts, then I’m a Dutchman: there is no knave here,” the presupposition of the embedded sentence that there is a knave is cancelled. In contrast, cancelling unembedded presuppositions is typically seen to be as infelicitous as cancelling a commitment to an entailment (e.g., “It’s the knave that stole the tarts, but there is no knave”). Based on this observation, Beaver and Geurts (2014) formulate the generalization in Table 8.

This generalization fits with the further observation that, mostly, the presuppositions of unembedded affirmative statements are entailments (Simons, 2006). Accordingly, the presuppositions of unembedded affirmative statements should not be cancellable without contradiction. These observations about cancellation pose a challenge to the view that presupposition gives rise to the differing stances toward the antecedents conveyed by indicative and subjunctive conditionals, inasmuch as only further embeddings of the conditionals should permit cancellation. Yet, the results from Experiment 2 show that the stances toward the antecedent

were cancellable for both indicatives and subjunctives, and even more cancellable than a commitment to scalar implicatures.

The finding of this cancellation effect thus provides support for a conversational implicature account (Iatridou, 2000; Leahy, 2011, 2018) over a presupposition (Kutschera, 1974; Stalnaker, 1975, 2014; von Stechow, 1997) or entailment account. This rejection of a presupposition account is further strengthened by our results in Experiment 1, where it was found that the belief-state assumptions concerning the antecedents of indicative and subjunctive conditionals do not project through embedding under various operators.

#### 4.2. *The source of the conversational implicatures*

A challenge for a conversational implicature account is that it must be shown *in principle* <sup>11</sup> how the conversational implicature to the falsity of antecedent of subjunctive conditionals could be reconstructed based on general maxims of communication (Grice, 1989). In Leahy (2018), this conversational implicature is accounted for by applying the notion of scalar implicatures to the presuppositions of a sentence. Leahy further holds that the presuppositions of counterfactuals ( $\emptyset$ ) are logically weaker than the presuppositions of indicative conditionals (i.e., that the antecedent is epistemically possible). These constraints generate the expectation that the choice of the subjunctive means that the speaker was not warranted in making the stronger presuppositions of the corresponding indicative conditional. One difficulty with this view is, however, that, our data suggest that it is not, in fact, a presupposition of indicative conditionals that the antecedent is epistemically possible. In addition, participants considered the belief-state assumption of the antecedent to be more cancellable than scalar implicatures for both indicatives and subjunctives in Experiment 2.

Another possibility runs as follows: in the choice of a conditional construction (“if *A*, then *C*”) over a conjunction (“*A* & *C*”), the speaker signals that they are not warranted in making the stronger assertion of committing to the truth of *A*. Rather, by making a conditional assertion, the speaker can express their view about a relationship between *C* and *A* while remaining uncommitted about *A*. By further choosing the subjunctive mood (e.g., “if [past tense], would ...”), where past tense morphology is employed which does not have a literal past tense interpretation (Iatridou, 2000; Ippolito, 2003), further distance is expressed. If interpreted doxastically, there are only three possibilities for categorical beliefs: either the speaker *believes A*, the speaker is *neutral* about *A*, or the speaker *disbelieves A*. If the speaker had been in a position to believe *A*, a conjunction could have been used. Instead, the speaker chose a conditional construction. If the speaker wished to remain neutral about *A*, a conditional in the indicative mood could have been used. Instead, the speaker chose a more convoluted formulation employing fake past tense to express further distance. Given that the speaker does not believe *A*, and is not content with remaining neutral about *A*, their interlocutors are warranted in inferring that the speaker disbelieves, or doubts, *A*.

#### 4.3. *Anderson conditionals, modus tollens, and presuppositions*

In Anderson conditionals, the speaker complicates the interpretational task of his/her interlocutors even further. The speaker does this by combining a conditional construction with past



tense morphology that is not to be taken literally (“If Jones had taken arsenic, he would have shown exactly those symptoms...”) with a factive relative clause (“...which he does in fact show”), which cancels the doxastic distance introduced by the subjunctive mood. Here again, the hearer is faced with the challenge of figuring out why a cooperative speaker would use such a convoluted way of expressing him-/herself. If participants invest sufficient resources, they could generate the hypothesis that the speaker is using this complex construction as part of an argument that purports to dispel doubt about the antecedent. In the absence of alternative explanations for the patients’ symptoms, this subargument could in turn be used as part of a larger argument to establish the truth of the antecedent, via an inference to the best explanation along the following lines:

“I think the patient took arsenic; for he has such-and-such symptoms; and these are the symptoms he would have if he had taken arsenic” (Edgington, 2008, p. 6)

In Zakkou (2019), it is argued that, contrary to appearances, Anderson conditionals do not provide a counterexample against a presupposition account. As part of her argument, Zakkou points out that a speaker, who first asserts (7a) and then (7b) need not contradict herself:

(7a) “If Jones had taken arsenic, he would have shown the same symptoms he actually shows,” (7b) “So he took arsenic”

The contradiction attributed to the presupposition account is removed, it is argued, if the speaker only accepts that Jones did not take arsenic for the purpose of the conversation in asserting (7a) and accepts that Jones did take arsenic, because she believes that he did, in asserting (7b). While this is certainly possible, it still needs to be established empirically that ordinary speakers are just as sophisticated in keeping track of different attitudes. The simpler explanation is that the speaker is cancelling a conversational implicature.

Similarly, Zakkou (2019) suggests that the speaker in (16) accepts for the purpose of conversation that Jones did not take arsenic and asserts his own belief to the contrary via a relative clause:

(16) If Jones had taken arsenic—which he did—he would have shown the same symptoms he actually shows.

A more straightforward account would be that the speaker cancels a commitment to the conversational implicature that Jones did not take arsenic through the relative clause.

In both cases, further empirical work is needed to distinguish between these possibilities. But it is worth highlighting that while it was found that participants have the same posterior probability of attributing belief and disbelief to the antecedent of an Anderson conditional in Experiment 1, negating an Anderson conditional shifts the modal tendency toward disbelief. So, it was not found that the belief-state assumption concerning the antecedent of Anderson conditionals exhibits the standard behavior of presuppositions.

Table 9  
Mapping between indicative and counterfactuals, MMT

Row	Partition		Factual: <i>If A then C</i>	Counterfactual: <i>If A had happened, then C would have happened</i>
1	A	C	Possibility	Counterfactual possibility
2	A	Not-C	Impossibility	Impossibility
3	Not-A	C	Possibility	Counterfactual possibility
4	Not-A	Not-C	Possibility	Fact

*Note.* Quelhas et al. (2018) call indicative conditionals “factual conditionals.”

Zakkou (2019) also dismisses an argument against the presupposition account based on Stalnaker’s (1975, 2014) observation that the following MT argument does not beg the question and presuppose what it is supposed to establish (i.e., the butler’s innocence):

(8) “If the butler had done it, we would have found blood on the knife. The kitchen knife was clean; therefore the butler did not do it.”

To make the case, Zakkou considers related examples in which the speaker may use presuppositions in the technical sense and anticipate the conclusion of an MT argument, without begging the question by introducing the conclusion as a tacit premise. The discussion overlooks, however, that on a presuppositional account, the first premise of the MT argument can only be true, if its presuppositions are satisfied; otherwise, this premise is false or a truth-value gap (von Stechow, 2004). So, to have an argument with true premises, it is a requirement of an account that makes the falsity of the antecedent a presupposition of a subjunctive conditional that the conclusion is already true with the first premise, which is, indeed, question-begging.

In contrast, a conversational implicature account would fare better. For conversational implicatures are only plausible inferences about the speaker’s mental states, which the interlocutor is defeasibly warranted in making. This allows for the factual premises of the argument to be true irrespectively of the status of these inferences. Through the entailment, the MT argument ensures that the premises cannot be true without the conclusion being true. So, whereas an uncanceled conversational implicature of the first premise at most establishes that it is reasonable for the interlocutor to assume that the speaker believes that the butler is innocent, the conclusion of the MT argument shows that the butler *must* be innocent. The conversational implicature account, in other words, separates the truth and factual content of the premises from the conversational assumptions about the speaker’s belief states and thereby avoids begging the question about the factual truth of the conclusion.

#### 4.4. *Mental models theory*

Finally, we turn to the implications of our findings for MMT.

On the current revised version of MMT (Khemlani et al., 2018), the meaning of conditionals is explicated by Table 9.

Conditionals are here interpreted as conjunctive assertions about possibilities (i.e., “ $A \& C$  is possible and  $A \& \neg C$  is not possible...”). That not- $A$  is possible is a shared presupposition of true and false conditionals; what matters for their truth evaluation is just that the first two rows

get switched. In the case of counterfactual conditionals, the “ $\neg A \& \neg C$ ” possibility acquires the status of being a *fact* and the other possibilities change status to express “counterfactual possibilities,” which were once possible but did not obtain. That the “ $\neg A \& \neg C$ ” possibility is a fact is rendered a presupposition when proponents of mental model speak of “the presupposed facts” (see, e.g., Byrne, 2005, 2016, 2017; Espino & Byrne, 2018).

If MMT adheres to a classical definition of presupposition (as suggested in Ragni & Johnson-Laird, 2020), we take the theory to hold that the presuppositions project under various operators and are not cancellable as long as the conditionals are unembedded. On this understanding, the theory, therefore, stands in tension with our findings, which suggest that the stances toward the antecedent do not project and are cancellable.

## 5. Conclusion

In this paper, we present new experimental evidence on the doxastic status of subjunctive conditionals. Previous theoretical papers in linguistics (e.g., Iatridou, 2000; Ippolito, 2003) have discussed the possibility of conversational implicature and presupposition accounts of the assumed falsity of subjunctive conditionals, but without presenting empirical data that could help decide the issue. To this end, we developed new stimulus materials to selectively manipulate the belief states of participants when evaluating indicative and subjunctive conditionals and probed the conversational implicature account and the presupposition account across two experiments. As part of these studies, we additionally investigated how participants assess so-called Anderson conditionals, where the falsity of the antecedent is bracketed in subjunctive conditionals. It was found in a family of sentences test that operators like negation, possibility modals, and interrogatives have an effect on participants’ belief-state assumptions and that a presupposition hypothesis predicting that belief-state assumptions project past such operators could be rejected. Further, it was found in a cancellation task, that belief-state assumptions of indicative conditionals and subjunctive conditionals were either just as cancellable as scalar implicatures (subjunctive conditionals) or even more cancellable than scalar implicatures (indicative conditionals). This finding indicates that one of the central meaning differences between indicative and subjunctive conditionals can be attributed to a phenomenon which is uncontroversially pragmatic in nature; to wit, conversational implicatures.

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## Conflicts of interests

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## Notes

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- 2 We adopt this as a working definition as a way of defining *typical* (though not necessary) characteristics. Of these typical characteristics of pragmatic meanings, perhaps the most controversial is nontruth-conditionality, since some would argue that pragmatic meanings can be truth-conditional (Birner, 2014; Carston, 2002; Recanati, 2011).
- 3 See also tentative-antecedent examples, such as the following, which should be read as referring to the future: “I would be happy if we found a solution” (Declerck & Reed, 2001, p. 54). This conditional is tentative about the antecedent: it is possible, but unlikely, that the antecedent will prove true. There is “fake tense” here too, with the past-tense morphology conveying remoteness of possibility or tentativeness.
- 4 The verbal morphology in the consequent appears less distinctive. For example, speakers can use the modal auxiliary (Huddleston, 2002; Mittwoch et al., 2002)—some would say past tense (e.g., Iatridou, 2000)—“would” in factual-antecedent conditionals. We could paraphrase example (3) as “If I had a problem, I would always go to my grandmother.” “Would” can also appear without “have” in the consequent of counterfactual conditionals, as in this example: “If the colonial powers hadn’t invaded, the Americas would be very different” (Starr, 2019).
- 5 The pilot study can be found on the OSF repository: <https://osf.io/w8p97/>.
- 6 This is a simplification. Some theories take presuppositions to be more pragmatic: to be performed by the speaker, rather than triggered conventionally (Stalnaker, 1972, 1974, 2014). There is also debate about the extent to which presuppositions can be wholly conventional as attaching to particular lexical items or whether they can be reconstructed from general conversational principles (Simons, 2006; Beaver & Geurts, 2014).
- 7 See: <https://osf.io/w8p97/>.
- 8 Note that in their rendering on the computer screen, the pictures were larger and so the gray box really was transparent to the participants.
- 9 Conditional\*Prior was kept fixed as random effects by participants and pictures.
- 10 We are here ignoring the entry “2” for the age of one of the participants.
- 11 Note that the circumstance that rational reconstructions in terms of abductive reasoning like this can be carried out does not mean that they play a role for the underlying psychological processes, or that they could not have become conventionalized in time (for discussion, see Geurts, Kissine, & van Tiel, 2020).

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