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'Must' implies 'can'

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Abstract

An open question in the semantics of modality is what relations there are among different modal flavours. In this article, we consider the thorny issue of whether ascribing to an agent the *obligation* to φ implies that it is *possible* for the agent to φ. Traditionally, this issue has been interpreted as whether 'ought' implies 'can'. But another linguistic interpretation is available as well, namely, whether 'must' implies 'can' (MIC). We show that 'must' does imply 'can' via a convergent argument. The first strand of the argument is theoretical: it consists in proving MIC from a well-established theory of modality in natural language, i.e., that proposed by Kratzer. The second strand is empirical: we present novel acceptability judgment studies showing that MIC predicts and explains the linguistic behaviour of native English speakers.

Keywords: Modality, Obligation, *Ought* implies *Can*, Semantics, Experimental Philosophy

1. Introduction

Those who doubt that there is ever progress in philosophy should pause to think of what has happened in the domain of modality over the last six decades. Starting from Kripke's (1963) models for modal languages, philosophical ideas about modality have generated a whole host of results in logic, computer science, and linguistics (Blackburn, van Benthem, & Wolter, 2007). For the latter discipline, mainly due to the work of Kratzer (2012), we now have a theory that explains how one and the same modal expression can have different flavours in different contexts—for example, how 'must' can express different types of necessity in (A)-(C):

(A)   *Epistemic*:

        [Context: We are looking for Sandro, but he is not at the gym.] He must be at the park.

(B)   *Deontic*:

        [Context: Sandro didn't pay his taxes.] He must go to jail.

(C)   *Teleological*:

        [Context: Sandro wants to win the marathon.] He must train harder.

In spite of this progress, there are aspects of modality that still need to be properly accounted for. A particularly fascinating open problem concerns what relations there are among

different modal flavours. This domain of inquiry we call *multimodal semantics*. How can one uncover such relations? Surprisingly enough, ethics can be a source of inspiration. Many philosophers have argued that if an individual has an *obligation* to do something, then it must be *possible* for her to do it (Kant, 1793/1998; see also: Haji, 2002; Vranas, 2007; Zimmerman, 1996). Traditionally, this idea has been interpreted in terms of 'ought' implying 'can' (Moore, 1922). After many years of debate, it remains unclear whether 'ought' does imply 'can' (Leben, 2018; Kurthy, Lawford-Smith, & Sousa, 2017; Streumer, 2019) or does not (Henne et al., 2016; Buckwalter & Turri, 2015; King, 2019).

In this article, we take a fresh perspective on the issue and discuss another linguistic reading of the idea that obligation implies possibility—a reading which has been almost entirely neglected in the literature so far. What we want to know is whether 'must' implies 'can'. And we claim that it does. On the other hand, we remain agnostic as to whether 'ought' implies 'can'.

One might be surprised by our position. After all, aren't 'must' and 'ought' synonyms when interpreted as expressing obligation? They aren't. Consider this sentence (after von Fintel & Iatridou, 2008):

(1)   After using the bathroom, customers ought to wash their hands; employees must.

If 'must' had the same meaning as 'ought', (1) should express the same proposition as (2):

(2)   Both customers and employees ought to wash their hands after using the bathroom.

But it doesn't. The reason is that 'must' expresses *strong* obligation, while 'ought' *weak* obligation (McNamara, 1996; von Fintel & Iatridou, 2008). The present article defends the claim that strong obligation implies possibility, while remaining silent as to whether weak obligation does.

2. What does it mean that 'must' implies 'can'?

The claim that 'must' implies 'can' is open to many interpretations. Here is how we read it:

> MIC: For any context c that assigns deontic flavour to 'must' and circumstantial flavour to 'can', the proposition expressed by a sentence 'S must φ' in c entails the proposition expressed by the corresponding sentence 'S can φ' in c.

2.1 Deontic 'must' and circumstantial 'can'

MIC needs a fair bit of unpacking. To begin with, why is it formulated in terms of a quantification over contexts? The first reason is that words like 'must' and 'can' are massively polysemous: *depending on the context*, they can have different flavours (Leech, 2004; Palmer, 1990). The principle we are after says that (strong) obligation implies possibility; this is why MIC specifies that the context assigns deontic flavour to 'must'.

With 'can', things are slightly more complicated. It may be natural to assume that when philosophers say that obligation implies possibility, they have in mind that obligation implies ability. For the most part, this assumption would be mistaken (Graham, 2011; Vranas, 2007). Consider this case. Sandro, a virtuoso violinist, has promised that he will play the violin tonight at a charity concert. Right before the concert, his arch-enemy Elio ties him to a chair, making it impossible for him to keep his promise. We have the intuition that Sandro is no longer under the obligation to play the violin tonight. Still, Sandro hasn't lost his ability to play the violin (a

tied-up virtuoso is still a virtuoso). What 'impossible' here means is rather that the circumstances prevent Sandro from manifesting his ability. Accordingly, we take the 'can' in '*must* implies *can*' to express ability plus favourable circumstances, i.e., circumstances that don't prevent the manifestation of the relevant ability. We follow linguists (Kratzer, 1991) in calling this type of possibility 'circumstantial'.

Hereafter, when we discuss sentences such as 'Elio must help the children' and 'Sandro can print the flyer', we assume that they are uttered in contexts in which 'must' is interpreted deontically and 'can' circumstantially.

2.2 Time

The second reason why MIC invokes contexts is that contexts also fix the time of the modals. Let us explain. Obligation and circumstantial possibility are time-dependent. Sandro *now* has the obligation to pick up Beth at the airport, since he has just promised to do it, but he did not have this obligation five minutes ago. Possibilities also come and go. It was possible for Mary to participate in next week's marathon, but it is no longer possible for her to do that now since she has broken her legs.

When philosophers say that obligation implies possibility, they mean the following: if someone has the obligation *at a certain time* to do something, then they have the possibility *at that same time* to do it. MIC captures this because 'must' and 'can' are present tense modals and, when interpreted in a context *c*, the time of such modals is always the time of *c* (Abusch, 1997). For example, when uttered right after the release of the "smoking gun" tape, (3) said that Nixon had the obligation to resign *then*:

(3)   Nixon must resign.

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Notice that the time of the obligation may diverge from the time of the action (the same applies, *mutatis mutandis*, to circumstantial possibility). For example, if uttered now, (4) says that Sandro *now* has the obligation to pick up Beth at the airport *tomorrow*:

(4)   Sandro must pick up Beth at the airport tomorrow.

2.3 Implication as entailment

At this point, it should be clear that MIC expresses the claim that proposition (P1) implies proposition (P2):

(P1)   *that S has at time t the strong obligation to φ*

(P2)   *that it is circumstantially possible at time t for S to φ*

To be accurate, MIC says more than this, since it also specifies how to interpret 'implies'. There are two main options in the literature:

(i)   'implies' is read pragmatically (Hare, 1963; Sinnott-Armstrong, 1984);

(ii)   'implies' is read semantically (Vranas, 2007).

In (i), the idea is either that (P1) *presupposes* (P2), or that by expressing (P1), a speaker *conversationally implicates* (P2). We follow King (2017) in rejecting both pragmatic interpretations.[1] King argues that it is not the case that (P1) presupposes (P2) because the latter

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[1] As a matter of fact, King makes this point with respect to 'ought' and 'can', but the idea carries over to the relation between 'must' and 'can'.

proposition fails a crucial test for presuppositionality, namely, constancy under negation (Chierchia & McConnell-Ginet, 1990).[2] As to the idea that 'must' conversationally implicates 'can', the main problem raised by King is that the inference of (P2) from (P1) doesn't have either of the two hallmarks of conversational implicatures, namely, cancelability and calculability (Chierchia & McConnell-Ginet, 1990; Grice, 1989; Streumer, 2003).[3]

This leaves the semantic interpretation of 'implies' as the only option, and that is why MIC is formulated in terms of *entailment*. Accordingly, the main idea behind MIC can also be expressed in this way: (P1) entails (P2). It follows that *if MIC is true*, discourse (5) expresses a logical contradiction, while conditional (6) a logical truth:

(5)   Nixon must resign, but he cannot.

(6)   If Nixon must resign, then he can.

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[2] While it is clear that 'Sandro stopped smoking' and 'Sandro didn't stop smoking' both imply 'Sandro had been smoking', it doesn't seem right that 'Elio must help the children' and 'It isn't true that Elio must help the children' both imply 'Elio can help the children'—it seems perfectly consistent and felicitous to say 'It isn't true that Elio must help the children since he cannot do it anymore'.

[3] As for cancelability, consider the following dialogues (dialogue (ii) is adapted from King):

(i)   Speaker A: My car is broken.
        Speaker B: There is a garage around the corner.
        Speaker A: It is closed.

(ii)   Speaker C: You must save that drowning child.
        Speaker D: I can't—the child is fifty miles away.

In dialogue (i), what speaker B conversationally implicates by saying that there is a garage around the corner is that the garage is open. By denying this implicature, Speaker A does not deny that there is a garage around the corner. But when Speaker D in dialogue (ii) denies that she can help the drowning child, she is implicitly denying that she must do it.

2.4 Looking ahead, or the shape of the argument

But is MIC true? The remainder of this article is devoted to arguing that it is. Our argument has two components: first, we derive MIC from Kratzer's semantic analysis of deontic 'must' and circumstantial 'can' (Section 3); second, we present novel empirical evidence showing that MIC predicts and explains the linguistic behaviour of native English speakers (Section 4). In this section, we briefly explain the logic behind this convergent argument.

Suppose that a well-confirmed theory (say, quantum mechanics) predicts phenomenon P. Regardless of whether you have tested P, quantum mechanics gives you a good reason to believe that P is the case. The first strand of our argument for MIC has the same structure. Kratzer's semantics is a well-established theory of natural language modals—it is the default theory in linguistics (Portner, 2009). Kratzer's analysis of deontic 'must' and circumstantial 'can'—we shall show—predicts MIC. Therefore, one has a good reason to believe that 'must' implies 'can'. This is an understatement. Typically, when one says that a theory predicts a phenomenon, one means that the theory makes it *probable* that the phenomenon in question obtains. Our claim is stronger: Kratzer's theory *entails* MIC. Indeed, we shall *prove* the latter from the former. Therefore, if Kratzer's theory is true, MIC *must* be true.

By deriving MIC from Kratzer's semantics, one gets a further explanatory benefit. As we saw above, linguistic analysis provides little reason to maintain that the relation between 'must' and 'can' is pragmatic. The problem for the hypothesis that 'must' *entails* 'can' is that no account in line with a well-grounded semantics of modals has been proposed so far. By proving MIC from Kratzer's analysis of 'must' and 'can' not only do we present one such account, but we also explain what grounds MIC: it is in virtue of the very meaning of deontic 'must' and circumstantial 'can' that the former entails the latter.

But one person's *modus ponens* is another's *modus tollens*. MIC follows from Kratzer's semantics? So much the worse for Kratzer, one might conclude if otherwise convinced that 'must' doesn't entail 'can'. To address this worry, after presenting our derivation of MIC from Kratzer's semantics, we report a series of acceptability judgment studies involving sentences that ascribe strong obligation in the face of circumstantial impossibility. We shall argue that MIC predicts and best explains the results of these empirical studies. Taken together, these two argumentative strands constitute very robust evidence in favour of MIC.

3. MIC—Kratzer style

Kratzer's (2012) starting point is a traditional idea from modal logic: modals are quantifiers over possible worlds that are accessible from the world of evaluation; necessity modals ('must', 'have to', etc.) are universal quantifiers, possibility modals ('can', 'may', etc.) are existential quantifiers. Therefore, a sentence like 'Elio must φ' is true if and only if Elio φs in all the accessible worlds, while a sentence like 'Elio can φ' is true if and only if Elio φs in some accessible worlds. Kratzer's main innovation is to capture how different contexts can determine different accessibility relations even for the very same modal expression, thus giving rise to different modal flavours.

In this section, we illustrate how this approach applies to deontic 'must' (Section 3.1) and circumstantial 'can' (Section 3.2). With this at hand, we develop Kratzer's semantics in a direction that has been so far overlooked: we show that it is possible to derive MIC from it (Section 3.3). Our discussion of Kratzer's semantics will make use of the Kaplanian view of *truth in context* (Kaplan, 1989), according to which a sentence S, uttered in a context c, is true in c if and only if the proposition S expresses in c is true in the world of c—we shall call this world '@'. The notation '$[[S]]_{c,\,@} = 1$' will be read as: 'the proposition expressed by S in c is

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true in @'. However, we depart from Kaplan in that we adopt the by now standard *referential analysis of tense* (Abusch, 1997; King, 2007): tenses are variables that receive a value under the contextual assignment, hence there is no need to relativize the truth of propositions to times. Recall that, in the case of 'must' and 'can', their "tense value" is the time of the context. We shall use the symbol 't_c' to refer to this time.

3.1 'Must'

Suppose that you come to know that Elio stole money from the orphanage, so you say to Mary:

(7)   Elio must go to jail.

In this context—call it 'c'—'must' clearly gets deontic flavour. One might suggest that it thus quantifies over all the worlds that conform to the normative standards holding in the world and at the time of c, and that your sentence says that in all such worlds Elio goes to jail. In other words, one might propose that (7) is true in c at the condition in (8):[4]

(8)   [[Elio must go to jail]]$_{c, @}$ = 1 *iff* for every w' such that w' conforms to the normative standards in @ at t_c, Elio goes to jail in w'.

But here is the catch: there is no possible world that conforms to plausible normative standards in which people steal money from the orphanage. Therefore, the analysis predicts that (7) is

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[4] In this section, we proceed in a semi-formal fashion. See the Appendix for a fully-fledged formalization of the analysis.

true only if Elio goes to jail in worlds in which he didn't steal any money—a clearly inadequate prediction.

To fix this issue, Kratzer (2012) proposes that the meaning of 'must'—in fact, the meaning of *any* modal—depends on two features of the context, which she calls *conversational backgrounds*. These jointly determine the set of worlds the modal quantifies over:

i. a modal base function f, fixing a set $f(w, t)$ of possible worlds that are accessible from a world w at a time t;[5]

ii. an ordering source function g, ordering the worlds in $f(w, t)$ according to how close they come to some normative ideal holding in w at t.

In the case of deontic 'must', the idea goes like this. First, when applied to a world w and time t, the modal base function determines a set $f(w, t)$ of worlds that are compatible with relevant circumstances obtaining in world w at time t. For your utterance of (7) in c, this is the set of worlds compatible with Elio's circumstances in @ at t_c—basically, the set of worlds in which Elio stole money from the orphanage. Second, the ordering source ranks the worlds in the set $f(w, t)$ according to how close they come to the normative standards holding in w at t. As a result, 'must' ends up quantifying over the best among the worlds that are compatible with the relevant circumstances in w at t. Kratzer's analysis hence assigns the following truth-condition to (7) in c:

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[5] In Kratzer's analysis, the modal base function f doesn't simply fix a set of worlds, but a set of propositions, i.e., a set of sets of worlds (see the Appendix). Given our aims, we can leave this complication aside. Moreover, the idea to specify the conversational backgrounds as functions from worlds and times, rather than just worlds, comes from an extension of Kratzer's original framework to deal with the interaction between time and modality (Condoravdi, 2002). This world-time structure is now standard among formal semanticists. We adopt it to capture the fact that the times of the obligation and circumstantial possibility matter to MIC (see Section 2.2).

(9) $[[$ Elio must go to jail $]]_{c, @} = 1$ *iff* for every w' in the set $f(@, t_c)$ (that is, w' is compatible with Elio's circumstances in $@$ at t_c), there is a w'' in $f(@, t_c)$ such that: (*a*) w'' is at least as good as w' in light of the normative ideal $g(@, t_c)$ (that is, the normative standards holding in $@$ at t_c) and (*b*) Elio goes to jail in all the worlds in $f(@, t_c)$ that are at least as good as w'' in light of $g(@, t_c)$.

This analysis solves the issue we encountered before: the truth of (7) in c is no longer predicted to require that Elio go to jail in worlds in which he didn't steal any money, since such worlds are not in the set $f(@, t_c)$. Notice moreover that truth-condition (9) guarantees that (7) cannot be true vacuously. First, it is impossible that there is no world compatible with Elio's circumstances—after all, $@$ is one such world. Second, the analysis requires that for (7) to be true, there be at least one best world among the worlds compatible with Elio's circumstances in $@$ at t_c such that Elio goes to jail in it—this follows from the existential quantification over w'' and the fact that the ordering relation 'to be at least as good as' is reflexive (hence w'' itself is a world in which Elio goes to jail).

3.2 'Can'

Let's now consider how Kratzer's semantics deals with circumstantial possibility modals. Suppose that you and I have just finished designing a flyer. You ask me: "Who can print it?" And I respond:

(10)   Sandro can print the flyer.

'Can' takes circumstantial flavour in this context. How can one express this flavour in terms of conversational backgrounds determining a set of accessible worlds? Exactly as in the case of deontic 'must', the modal base function determines a domain $f(w, t)$ of worlds that are compatible with relevant circumstances obtaining in w at t—for my utterance of (10), a set of worlds compatible with Sandro's circumstances in the world of the context @ at the time of the context t_c. If, for example, Sandro doesn't have enough money to print the flyer, the domain $f(@, t_c)$ will reflect this.

What about the ordering source $g(@, t_c)$? It clearly cannot be normative, since this is not a deontic use of 'can'. As pointed out by Kratzer (1991), circumstantial 'can' has an empty ordering source, i.e., one which doesn't restrict the domain selected by the modal base function f in any way. The reason is simple: it would be pointless in this case to rank the worlds in the domain selected by f in terms of some criterion or other. With respect to the truth or falsity of (10) in the reading in question, all those worlds are equally good: if Sandro is printing the flyer in any of them, then it is true that Sandro can print the flyer; otherwise, it is false.

The truth-condition for (10) in the context above is thus as follows:

(11)   [[Sandro can print the flyer]]$_{c, @}$ = 1 *iff* for some w' such that w' is in $f(@, t_c)$ (that is, w' is compatible with Sandro's circumstances in @ at t_c), Sandro prints the flyer in w'.

Hence, my utterance of (10) is predicted to be true just in case Sandro prints the flyer in some world that is compatible with his circumstances in the world and at the time of the context.

3.3 Why 'must' implies 'can'

In the previous two sections, we detailed the analyses of (deontic) 'must' and (circumstantial) 'can' proposed by Kratzer. We now show that, from those analyses, MIC follows naturally. We proceed as follows: (i) we consider an arbitrary sentence 'S must φ' and a context c for it that assigns deontic flavour to 'must'; (ii) we show that, given Kratzer's analyses of deontic 'must' and circumstantial 'can', the truth of 'S can φ' in c—where 'can' is assigned circumstantial flavour in c—follows from the truth of 'S must φ' in c.

Suppose that Gina has got Alzheimer's. Her only son, Elio, promises her that he will assist her until her last day. After Elio's promise, Mary utters (12):

(12) Elio must help his mother.

'Must' expresses deontic necessity in the context of Mary's utterance—call it 'c'. Accordingly, (12) has truth-condition (13) in c:

(13) $[[$ Elio must help his mother$]]_{c,\,@} = 1$ *iff* for every w' in $f(@, t_c)$ (that is, w' is compatible with Elio's circumstances in $@$ at t_c), there is a w'' in $f(@, t_c)$ such that: (a) w'' is at least as good as w' in light of the normative ideal $g(@, t_c)$ (that is, the normative standards holding in $@$ at t_c) and (b) Elio helps his mother in all the worlds in $f(@, t_c)$ that are at least as good as w'' in light of $g(@, t_c)$.

Assume that (12) is indeed true in c. Given truth-condition (13), it follows that there is a world compatible with Elio's circumstances in $@$ at t_c in which Elio helps his mother—as we said in Section 3.1, the set of worlds compatible with these circumstances cannot be empty,

since at least @ is one such world, and (13) entails that there is a world w'' in this set, at least as good as @, in which Elio helps his mother.[6] But from this it follows that (14), on the reading in which 'can' is assigned circumstantial flavour, is also true in c:

(14)   Elio can help his mother.

Here is why. On the reading in question, (14) receives truth-condition (15) in c:

(15)   [[Elio can help his mother]]$_{c, @}$ = 1 *iff* there is a world w' such that w' is in $f(@, t_c)$ and Elio helps his mother in w'.

Hence, (14) is true in c if and only if Elio helps his mother in some world compatible with his circumstances in @ at t_c. But, as we have just seen, the truth of (12) in c requires that there be a world compatible with Elio's circumstances in @ at t_c in which Elio helps his mother.

We conclude that if (12) is true in c, (14) must also be true in c. Therefore, this section constitutes a proof of MIC from Kratzer's semantics of deontic 'must' and circumstantial 'can'.

4. Going empirical

The fact that MIC follows from Kratzer's semantics of modals only gets one so far, since Kratzer's theory might be wrong. This is why, in this section, we present the results of a series

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[6] To be accurate, (13) entails that Elio helps his mother in all the worlds at least as good as w'', but w'' is certainly a world at least as good as itself.

of acceptability judgment studies which—so we maintain—provide robust empirical evidence for MIC. Needless to say, these results also count as evidence for Kratzer's theory.[7]

4.1 Study 1: Present vs. past

Suppose that a subject, S, contracts the strong obligation to φ, but it subsequently becomes circumstantially impossible for S to φ. Which of these two sentences would native English speakers consider to be the *better* description of S's current situation?

(i)   S must φ, but S cannot φ.

(ii)   S was supposed to φ, but S cannot φ.

MIC entails that (i) expresses a contradictory proposition in this context. In contrast, since there is nothing in MIC that prevents one to have a *past* obligation that cannot be fulfilled in the *present*, (ii) is *not* predicted to express a contradictory proposition in this context.

On the natural assumption that competent speakers are typically reluctant to endorse contradictory propositions—call this '*No contradiction*'—MIC thus predicts that native English speakers will favour (ii) over (i) as the better description of S's situation.[8] Our first empirical study tested this prediction. To assess the robustness of this prediction, taking our cue from the literature on 'ought' implies 'can' (Zimmerman, 1996), we investigated whether

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[7] In this section, our focus is limited to a subset of the data. Beyond what is discussed below, we also collected open-ended qualitative data on participants' explicit reasoning, as well as the time subjects took to answer the main probe. Since these additional data don't affect the overall conclusion presented here, we have decided not to discuss them for reasons of space. Our complete design and datasets are available at: https://osf.io/uqe4x and https://osf.io/k2gce/.

[8] Here we read 'endorse' along the following lines: S endorses proposition *p* if and only if (1) S grasps *p* and (2) S assents to *p*. Accordingly, a person cannot endorse a proposition without understanding it.

sentence choice is influenced by type of impossibility (externally imposed vs. self-imposed) or by blame ascription. We accordingly included two conditions that differ in terms of how the impossibility occurs—due to an accident (externally imposed) or because of one's decision (self-imposed)—and we also measured participants' blame attribution.

4.1.1 Method

205 native English speakers (102 male, 102 female, 1 other, mean age = 38.11, SD = 12.17, range = 20-72) were recruited via Amazon Mechanical Turk to fill in a short questionnaire.[9] Participants were assigned to either of two scenarios (*The Stairs* and *The Hammer*) in which a person promises to perform a certain action, which is subsequently rendered impossible. The two scenarios differ only in how the impossibility occurs—italics below indicate the differences.

> *The Stairs*
>
> A group of children is stuck deep in the mountains. It's now too dark for an expedition to set off to rescue them today. If the children don't get rescued by the end of the day tomorrow, they will die, so the expedition will leave at the earliest possible time tomorrow morning.
>
> Adam, the most skilled mountaineer in the area, promises to go on the expedition. However, while preparing for it, he *accidentally falls down the stairs and breaks his legs, which renders him* completely incapable of walking

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[9] The original sample consisted of 338 participants. Of these, 116 were eliminated due to failed control questions and further 17 participants were eliminated due to failing the *Impossibility probe* (see below). More information regarding elimination procedures can be found at https://osf.io/mgz26/ (pp. 9-10).

for at least a month. Now it is impossible for Adam to go on the expedition tomorrow.

The Hammer

A group of children is stuck deep in the mountains. It's now too dark for an expedition to set off to rescue them today. If the children don't get rescued by the end of the day tomorrow, they will die, so the expedition will leave at the earliest possible time tomorrow morning.

Adam, the most skilled mountaineer in the area, promises to go on the expedition. However, while preparing for it, he *realizes how dangerous the expedition will be. For this reason, he breaks his own legs, rendering himself* completely incapable of walking for at least a month. Now it is impossible for Adam to go on the expedition tomorrow.

Participants were then asked the following question: "Which one of the following two statements do you think better describes Adam's current situation?

(A)   Adam must go on the expedition tomorrow, but he cannot.

(B)   Adam was supposed to go on the expedition tomorrow, but he cannot."[10]

Having chosen a sentence, participants were presented with the following question (*Blame probe*): "To what extent do you think Adam is to blame for failing to go on the expedition?" Responses were recorded on a 7-point scale (1: "No blame", 4: "Moderate

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[10] In the absence of a past tense form of 'must', 'S was supposed to φ' was chosen as past tense counterpart of 'S must φ' (to indicate that S's obligation holds in the past). The quasi-modal construction 'S had to φ' wouldn't have worked, since it has the implication that S *did* φ. We also wanted to avoid modal *periphrases*, e.g., 'S had the obligation to φ', since their syntactic structure differs too much from the one of 'S must φ'.

blame", 7: "Full blame"). This probe was followed by an *Impossibility probe* to determine whether participants agreed that the performance of the relevant action had become impossible for Adam after he broke his legs ("Do you agree that, after breaking his legs, it is impossible for Adam to go on the expedition?"). Participants who disagreed were not included in the analysis.[11]

4.1.2 Results and discussion

Out of 205 participants, 168 (82%) preferred the 'was supposed to but cannot' to the 'must but cannot' option (37; 18%). A binomial test shows this to be significantly different from a chance distribution, $p < .01$, 95% CI [0.76, 0.87]. As revealed by a chi-square test of independence, this general result was not significantly affected by scenario type (i.e., condition): 86 out of 103 participants (83%) chose the 'was supposed to but cannot' variant in *The Hammer* condition, while 82 out of 102 (80%) did so in *The Stairs* condition; $\chi^2(1, 205) = 0.33$, $p = .56$, OR = 1.23, 95% CI [0.91, 1.18] (see Figure 1).

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[11] Obviously, to test MIC one needs to look at the behaviour of subjects who consider the performance of the action *impossible*. Nevertheless, excluding the negative responses does not affect our results (this applies across all the studies).
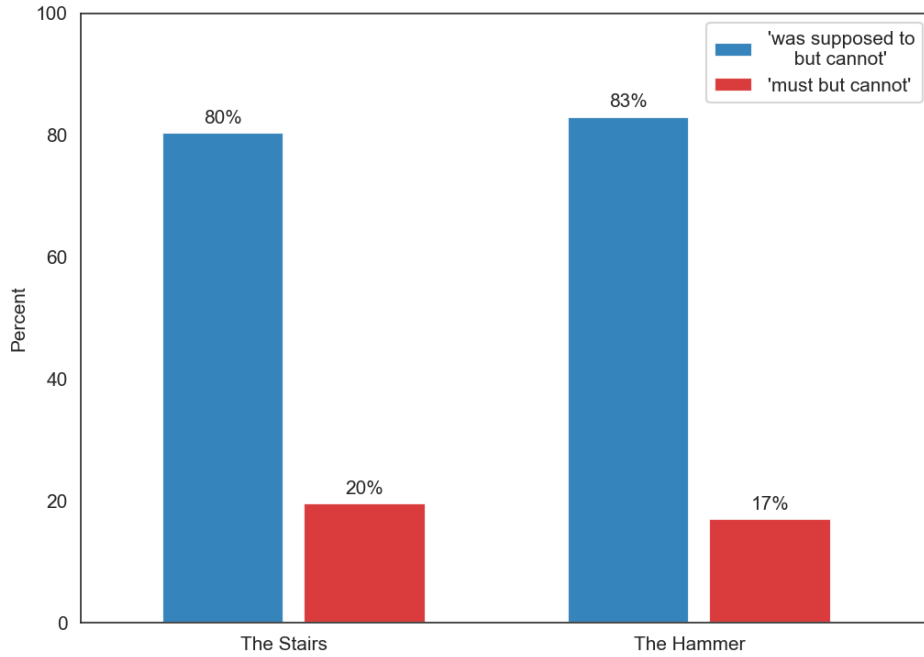
Figure 1. The distribution of sentence choices ('was supposed to but cannot' vs. 'must but cannot') per condition (*The Stairs* vs. *The Hammer*). The ordinate represents within-condition percentages.

As indicated by an independent samples *t*-test, blame ascription to Adam was significantly higher in *The Hammer* condition (mean blame = 5.95; *SD* = 1.64; mode = 7) than in *The Stairs* condition (mean blame = 2.43; *SD* = 1.76; mode = 1), $t(203) = 15.26$, $p < .01$, mean difference = 3.52, 95% CI [3.05, 3.99], d = 2.05 (see Figure 2). To directly test whether blame influenced sentence choice, we conducted a logistic regression analysis, which included blame as well as age, gender, and response time as predictors of sentence choice. Unlike the null model ($p < .01$), the regression model was not significant, $\chi^2(4) = 4.723$, $p = .32$. In particular, blame was not a significant predictor of sentence choice, $p = .4$, OR = 0.94, 95% CI [0.81, 1.09].
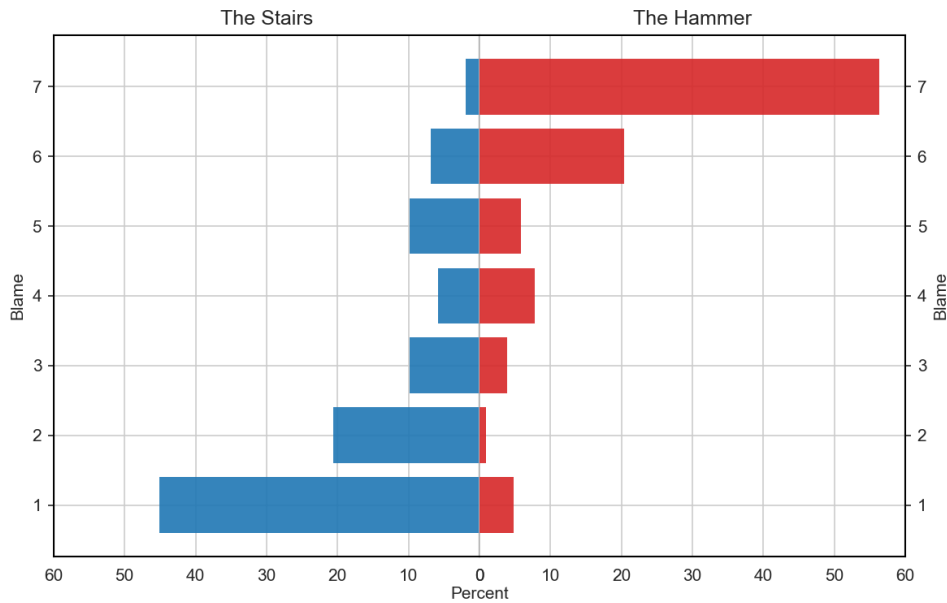
Figure 2. The distribution of blame scores as a function of condition.

When presented with a scenario in which a subject (i.e., Adam) contracts the strong obligation to go on an expedition tomorrow but then the performance of the action becomes impossible, native English speakers judge sentence (B) 'Adam was supposed to go on the expedition tomorrow, but he cannot' to be a better description of the situation than sentence (A) 'Adam must go on the expedition tomorrow, but he cannot' (82% vs. 18%). In combination with *No Contradiction*, MIC explains and predicts these results. If MIC is the case, (A) expresses a contradictory proposition. In contrast, no contradiction obtains when the time of the obligation and the time of the impossibility differ, as they do in the proposition expressed by (B). Therefore, if competent speakers tend to avoid endorsing contradictory propositions, these results are expected.

The results also indicate that the preference for 'was supposed to but cannot' over 'must but cannot' is completely uninfluenced by the source of the impossibility or blame: the fact that the impossibility is self-imposed or externally imposed doesn't have any impact on participants' responses, nor is blame a reliable predictor of sentence choice: compared to

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having no information about blame attributions, having this information does not enable one to predict with improved accuracy what sentence participants will choose. This is exactly what MIC predicts: speakers should favour 'was supposed to but cannot' over 'must but cannot' *regardless of the source of impossibility or what they think of Adam's blameworthiness*, because only the former sentence expresses a consistent proposition.

4.2 Study 2: Strong vs weak obligations

While 'Adam must go on the expedition tomorrow' ascribes to Adam a *strong* obligation in the present, 'Adam was supposed to go on the expedition tomorrow' ascribes to him a *weak* obligation in the past (Palmer, 1990). Therefore, the following question arises: isn't it the case that, in Study 1, 'Adam was supposed to go on the expedition tomorrow, but he cannot' is preferred over 'Adam must go on the expedition tomorrow, but he cannot' just because Adam was *never* seen as being under a strong obligation to begin with? That is, couldn't participants think that, in virtue of promising to go on the expedition, Adam is "only" supposed to go, rather than that he must go? If this were the case, one could explain their preference for 'was supposed to but cannot' over 'must but cannot' in Study 1 without invoking MIC.

To adjudicate between these two interpretations of Study 1, in Study 2 we investigated which type of obligation competent speakers ascribe to Adam *before the impossibility is introduced*.

4.2.1 Method

We recruited 113 English native speakers (69 male, 44 female, mean age = 36.05, *SD* = 11.29, range = 20-76) via Amazon Mechanical Turk.[12] They were presented with the following story:

> *The Promise*
>
> A group of children is stuck deep in the mountains. It's now too dark for an expedition to set off to rescue them today. If the children don't get rescued by the end of the day tomorrow, they will die, so the expedition will leave at the earliest possible time tomorrow morning. Adam, the most skilled mountaineer 0in the area, promises to go on the expedition.

The main probe was the same as in Study 1 ("Which one of the following two statements do you think better describes Adam's current situation?"), but the options were as follows:

(A')   Adam must go on the expedition tomorrow.

(B')   Adam is supposed to go on the expedition tomorrow.

4.2.2 Results and discussion

Out of the 113 participants, 83 (73%) preferred the 'must' to the 'is supposed to' option (30; 27%). A binomial test shows this distribution to be significantly different from chance, $p < .01$, 95% CI [0.65, 0.81]. Furthermore, comparing the results of the current study with those of Study 1, a planned chi-square test of independence showed that the distribution of the

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[12] The original sample consisted of 182 participants recruited with the same procedures as in Study 1 (repeated participation was not allowed here or in any of our further studies). 69 of them were eliminated due to failed control questions.

'supposed to' vs. 'must' variants was significantly affected by design type, $\chi^2(1, 318) = 95.16$, $p < .01$, OR = 12.56, 95% CI [7.26, 21.74].
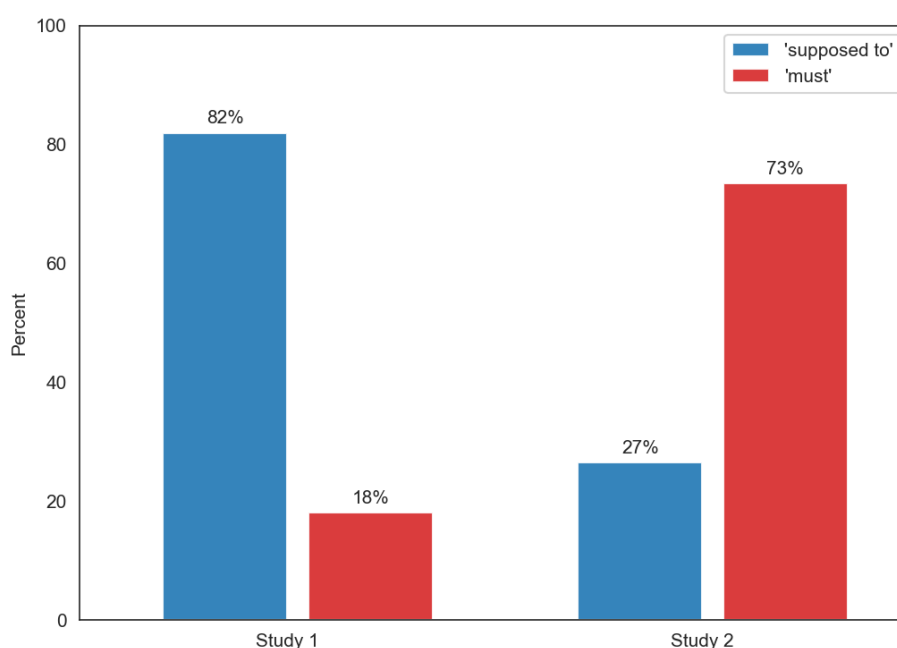

Figure 3. Comparison between studies in terms of sentence choice ('must' vs. 'is/was supposed to'). The ordinate represents within-study percentages.

When presented with *The Promise,* native English speakers choose 'Adam must go on the expedition tomorrow' rather than 'Adam is supposed to go on the expedition tomorrow' (73% vs. 27%) as the best characterization of Adam's situation after he promises to go on the expedition (when it is not impossible for him to fulfil the promise). Accordingly, this study indicates that Adam is seen as having a *strong* rather than a *weak* obligation. This rules out an interpretation of Study 1 according to which, after the impossibility is introduced, competent speakers prefer 'was supposed to but cannot' to 'must but cannot' because they think Adam never contracted a strong obligation in the first place.

The combination of Study 1 and Study 2 offers strong evidence in favour of MIC (see Figure 3). The results of Study 2 show that 'was supposed to but cannot' is a suboptimal

description of Adam's situation in Study 1: it ascribes to Adam a *weak* obligation in the past, while in fact participants think that Adam contracted a *strong* obligation. This makes Study 1 a particularly stringent test for MIC, given that 'must but cannot' ascribes to Adam the right type of obligation and thus has a *prima facie* advantage over 'was supposed to but cannot'. In Study 1, however, subjects preferred the latter option to the former. This means that they were willing to sacrifice the strength of the obligation, as long as this allowed them to locate the obligation in the past. MIC explains this: by locating the obligation in the past, participants can avoid endorsing a contradictory proposition.

4.3 Study 3: Against the Blame Hypothesis

In conjunction with *No Contradiction*, MIC makes two predictions. The first one was tested and confirmed in Study 1: when presented with a scenario in which a subject, S, contracts a strong obligation to φ which then becomes impossible to fulfil, native English speakers will typically *favour* sentence (ii) over sentence (i)—the sentences are repeated below.

(i)   S must φ, but S cannot φ.

(ii)   S was supposed to φ, but S cannot φ.

The second prediction is that competent speakers will generally find (i) *unacceptable*. This contrasts with what we may call the *Blame Hypothesis*, according to which competent speakers will tend to judge that an agent has the obligation to perform an impossible action *when the agent is to blame for the impossibility*—this latter hypothesis was formulated by Chituc et al. (2016) with respect to 'ought'. The guiding motivation behind the *Blame Hypothesis* is that the relation between a judgment of obligation and a judgment of possibility

is pragmatic rather than semantic—more precisely, it is a conversational implicature and as such it can be cancelled (cf. Sinnott-Armstrong, 1984 about 'ought' and 'can'). One context in which it is cancelled—the *Blame Hypothesis* holds—is when the speaker wants to blame the agent. In such a context, speakers are thus expected to accept (i).

Here is a slightly different, but related, way to conceive of the contrast between the *Blame Hypothesis* and MIC. According to the former, the acceptability of (i) is a continuous function of blame: the more a speaker finds an agent blameworthy, the greater the degree of acceptance of (i). In contrast, MIC has it that the relation between 'must' and 'can' is semantic, and it therefore predicts that there is no relation between degrees of blame and degrees of sentence acceptance: competent speakers will tend to reject (i) *regardless of whether the agent is to blame for the impossibility*. The aim of this study was to compare these two competing hypotheses.

4.3.1 Method

We recruited 253 English native speakers (142 male, 110 female, 1 other, mean age = 38.56, SD = 11.28, range = 19-74) via Amazon Mechanical Turk.[13] Save for one additional step, this study is identical to Study 1: participants were assigned to the same conditions (*The Hammer* vs. *The Stairs*) and were presented with the same question as before (i.e., they had to choose between 'was supposed to but cannot' and 'must but cannot'). This time, however, participants were presented with an additional question (*Graded follow-up probe*):

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[13] The original sample consisted of 329 participants recruited using the same procedures as before, 56 of whom were eliminated due to failed control questions. A further 20 participants were eliminated due to failing the *Impossibility probe*.

"We would now like to know what you think of […] the statement with 'must':

Adam must go on the expedition tomorrow, but he cannot.

How good/bad is this statement as a description of Adam's current situation?"

The options ranged from "very bad" through "bad", "good" and "very good" on a four-point scale (although the options were not numerically marked). The rest of the questionnaire was as in Study 1, including the *Blame probe* and the *Impossibility probe*.

4.3.2 Results and discussion

Out of 253 participants, 205 (81%) preferred 'was supposed to but cannot' to 'must but cannot' (48; 19%), replicating our previous results in relation to sentence choice, discussed in section 4.1.2. Even though blame was significantly different between the two conditions (*The Hammer*: mean blame = 6.27; *SD* = 1.39; mode = 7; *The Stairs*: mean blame = 2.35; *SD* = 1.55; mode = 1, $t(251)$ = 21.05, $p < .01$, mean difference = 3.92, 95% CI [3.55, 4.28], d = 2.18), the result was once again not affected by scenario type: 101 out of 119 participants (85%) chose the 'was supposed to but cannot' variant in *The Hammer* condition, while 104 out of 134 (78%) did so in *The Stairs* condition; $\chi^2(1, 253)$ = 2.16, p =.14, OR = 1.62, 95% CI [0.85, 3.09].

Out of 253 participants, 176 (70%) thought that the 'must' sentence was a 'bad'/'very bad' description of Adam's situation. A similar pattern emerged when we limited the analysis to those participants who selected the 'was supposed to' sentence: the majority of these participants (154 out of 205; 75%) thought that the 'must' sentence was 'bad' (126; 61%) or 'very bad' (27; 14%). As to the small minority of our sample who chose 'must but cannot', 22 of 48 (46%) judged this very sentence 'bad' (11; 23%) or 'very bad' (11; 23%).

Crucially, we found no evidence that sentence evaluation was influenced by condition: by dichotomising all the responses to the *Graded follow-up probe* into 'GOOD' ('very good' + 'good') vs. 'BAD' ('bad' + 'very bad') evaluations, we found that 'must but cannot' was judged as BAD by 86 of the 119 (72%) participants in *The Hammer* condition, and by 90 of the 134 (67%) participants in *The Stairs* condition, $\chi^2(1, 253) = .776$, $p = .38$, OR $= 1.27$, 95% CI [0.74, 2.19] (see Figure 4).
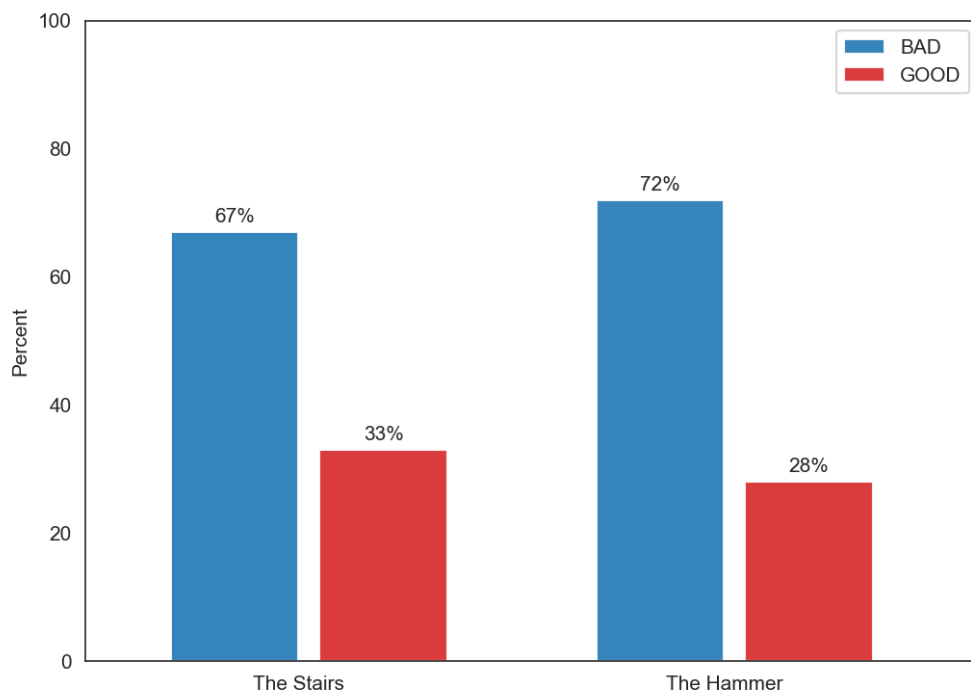

Figure 4. The distribution of sentence evaluations (BAD vs. GOOD) per condition (*The Stairs* vs. *The Hammer*). The ordinate represents within-condition percentages.

To directly test influence of blame attributions on sentence evaluation, we performed two types of analysis. In the first, we used the dichotomised scores for the *Graded follow-up probe.* We ran a logistic regression including blame, age, gender, and response time as predictor variables. Unlike the null model ($p < .01$), the regression model was not significant, $\chi^2(4) = 5.137$, $p = .27$. In particular, blame was not a significant predictor of sentence evaluation, $p = .9$, OR $= 1.01$, 95% CI [0.90, 1.13]. We also found that the distribution of

'GOOD' vs. 'BAD' evaluations was not significantly different when comparing subjects with high blame rating (i.e., levels of blame in the range of 5-7) to subjects with non-high blame rating (i.e., levels of blame in the range of 1-4): 'must but cannot' was judged BAD by 94 out of 130 (72%) of the "non-high blamers" and by 82 out of 123 (67%) of the "high blamers", $\chi^2(1, 253) = .95$, $p = .33$, OR = 1.31, 95% CI [0.76, 2.23]. In the second analysis, we correlated the raw responses to the *Blame probe* with the raw responses to the *Graded follow-up probe*, and we found that the correlation was not significant, $r(271) = .03$, $p = .61$.[14]

When they were presented with a scenario in which a subject (i.e., Adam) contracts a strong obligation to perform an action which subsequently becomes impossible, competent speakers tended to judge the sentence 'Adam must go on the expedition tomorrow, but he cannot' as a 'bad' or 'very bad' description of Adam's situation (70%). The fact that competent speakers generally found 'must but cannot' unacceptable is exactly what one should expect given MIC in combination with *No Contradiction*. Unsurprisingly, this pattern of judgment was also found when limiting the analysis to those subjects who chose 'was supposed to but cannot' in the initial probe (75% of these subjects found 'must but cannot' to be 'bad'/'very bad'). One can thus take subjects' preference for 'was supposed to but cannot' as a reliable indicator of their rejection of 'must but cannot', hence further corroborating the results of Study 1.

MIC states that 'must' *entails* 'can', thus it predicts that rejection of 'must but cannot' shouldn't vary depending upon blame ascription: competent speakers should rather reject this sentence across the board. In contrast, the *Blame Hypothesis* has it that sentence acceptance is a function of blame, and that subjects will tend to accept 'Adam must go on the expedition, but

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[14] One might think that a non-parametric analysis is better suited to our type of data. For this reason, we also ran a Spearman correlation test, the result of which was not significant either, $r_S(271) = .051$, $p = .39$.

he cannot' when they blame Adam for the impossibility. Our results clearly favour MIC over the *Blame Hypothesis*:

- Even though blame ascription was significantly higher in *The Hammer* (mean = 6.27; mode = 7) than in *The Stairs* (mean = 2.35; mode = 1), there was no significant difference between the two conditions in terms of how subjects evaluated the acceptability of 'must but cannot'.

- Even though blame ascription was almost ceiling in *The Hammer*, 72% of the subjects in this condition—including those who chose the 'must' sentence to begin with—judged 'Adam must go on the expedition, but he cannot' as 'bad'/'very bad'.

- Blame was not a reliable predictor of sentence acceptance: compared to having no information about blame attribution, having this information does not enable one to predict with improved accuracy whether a subject will judge 'must but cannot' as good or bad.

- The majority of subjects that ascribed high blame to Adam found 'Adam must go on the expedition, but he cannot' to be bad (67%)—a result not significantly different from that of "non-high blamers" making the same judgment (72%).

- The degree to which speakers found the agent blameworthy didn't correlate with the degree to which they accepted 'Adam must go on the expedition, but he cannot'.

Combined together, these results provide robust support for MIC over the *Blame Hypothesis*, in that they indicate that competent speakers tend to reject 'S must but S cannot' *regardless of whether S is to blame for the impossibility*.

4.4 Study 4: Explaining contradictions away

In this final study, we considered a possible objection concerning the validity of our previous results. All our studies so far involved an explicit comparison between a sentence with 'must' and an alternative sentence featuring 'supposed'. However, sentence production/evaluation in real life doesn't usually involve such comparisons. One might thus raise the worry that when presented with sentence (A) 'Adam must go on the expedition tomorrow, but he cannot' *with no competing alternatives*, competent speakers might be inclined to accept it as a correct description after all. If this turned out to be the case, it would raise a difficulty for MIC, since sentence (A) expresses a proposition which is a contradiction on MIC, i.e., proposition (P-A):

(P-A) *that Adam has at time t the strong obligation to go on the expedition tomorrow, but it is circumstantially impossible at time t for Adam to go on the expedition tomorrow*

In Study 4, we tested the hypothesis that if people accept sentence (A) when presented with it with no competing alternatives, they do so *not* because they are endorsing and trying to communicate the literal meaning of (A), but instead because they are reading (A) as conveying the related but distinct proposition (P-B)—where *t-1* is a time in the past of *t*:

(P-B) *that Adam has at time t-1 the obligation to go on the expedition tomorrow, but it is circumstantially impossible at time t for Adam to go on the expedition tomorrow*

In other words, our hypothesis is that if speakers indeed accept sentence (A), they do so to ascribe a *past* obligation that cannot be fulfilled anymore, rather than a *present*, unfulfillable obligation. If the hypothesis proved correct, then speakers' behaviour vis-à-vis sentence (A)

would not constitute a problem for MIC, since MIC is clearly consistent with someone having a past obligation which cannot be fulfilled in the present.

4.4.1 Method

We recruited 211 English native speakers (125 male, 85 female, 1 other, mean age = 38.82 *SD* = 12.69, range = 19-76) via Amazon Mechanical Turk.[15] Participants were presented with the same scenarios as in Studies 1 and 3 (i.e., *The Stairs* and *The Hammer*). However, unlike in Studies 1 and 3, they went through the following two-stage process. First, they were asked the following Yes-No question (*Must probe*): "Do you agree that the following statement correctly describes Adam's current situation? (Yes/No)

(A)   Adam must go on the expedition tomorrow, but he cannot."

Second, in the case of a positive answer in response to the *Must probe*, subjects were asked to express what they had in mind, by choosing between a 'has to but cannot' and a 'was supposed to but cannot' sentence variant (*Clarification probe*): "You agreed that Adam must go on the expedition tomorrow, even though he cannot. If you had to express what you had in mind in different words, which one of the following statements would you choose?

(A'')   Adam has to go on the expedition tomorrow, but he cannot.

(B)   Adam was supposed to go on the expedition tomorrow, but he cannot."

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[15] We used the same procedures as in Studies 1 and 3. The original sample consisted of 344 participants. Of these, 115 were eliminated due to failed control questions, and further 18 participants were eliminated due to failing the *Impossibility probe*.

4.4.2 Results and discussion

Of the 211 participants, 190 (90%) responded with "Yes" and 21 (10%) with "No" to the *Must probe*. We found no evidence that response to the *Must probe* was influenced by condition: 97 of the 106 (92%) participants in *The Hammer* condition, and 93 of the 105 (89%) participants in *The Stairs* condition agreed with the 'must but cannot' sentence, $\chi^2(1, 211) = .508$, $p = .48$, OR = 1.39, 95% CI [0.56, 3.45].

We conducted a logistic regression analysis, which included blame, age, gender, and response time as predictors, and response to the *Must probe* as the outcome variable. Unlike the null model ($p < .01$), the regression model was not significant, $\chi^2(4) = 3.862$, $p = .43$. In particular, blame was not a significant predictor of participants' response to the *Must probe*, $p = .93$, OR = 1.01, 95% CI [0.84, 1.21]).

Of the 190 participants answering "Yes", 160 (84%) chose the 'was supposed to but cannot' sentence and 30 (16%) chose the 'has to but cannot' sentence in response to the *Clarification probe* (Figure 5). Again, we found no evidence that this distribution was influenced by condition: 82 of the 97 (85%) participants in *The Hammer* condition, and 78 of the 93 (84%) participants in *The Stairs* condition chose the 'was supposed to but cannot' sentence, $\chi^2(1, 190) = .016$, $p = .9$, OR = 1.05, 95% CI [0.48, 2.29]. We conducted a second logistic regression analysis, including the same predictor variables as before, and response to the *Clarification probe* as the outcome variable. Unlike the null model ($p < .01$), the regression model was not significant, $\chi^2(4) = 9.115$, $p = .06$. In particular, blame was not a significant predictor of participants' response to the *Clarification probe*, $p = .6$, OR = 1.05, 95% CI [0.88, 1.24].
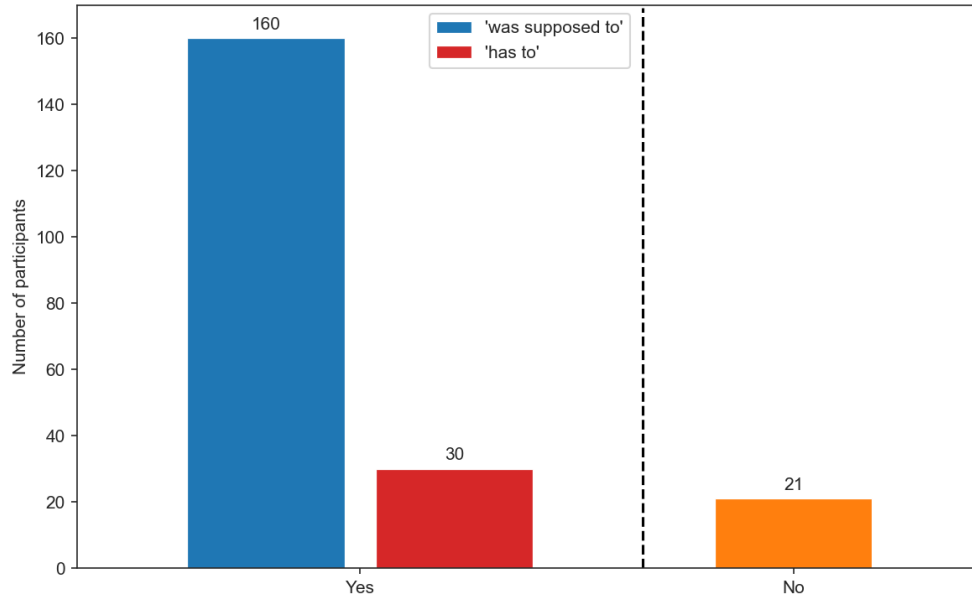
Figure 5. The distribution of responses. To the right of the dashed line are those who responded with "No", whilst to the left are those who responded with "Yes" to the *Must probe*. The latter subgroup is further divided according to participants' response to the *Clarification probe* ('was supposed to but cannot' vs. 'has to but cannot').

In the present study, speakers overwhelmingly accepted (90%) sentence (A) ('Adam must go on the expedition tomorrow, but he cannot') as a correct description of Adam's situation (*The Stairs*: 89%, *The Hammer*: 92%). This appears to be in striking contrast with the results of the previous studies. More importantly, the present result also appears to count as evidence against MIC, since the proposition expressed by (A), namely (P-A) (repeated below), is predicted to be a contradiction by MIC.

(P-A) *that Adam has at time t the strong obligation to go on the expedition tomorrow, but it is circumstantially impossible at time t for Adam to go on the expedition tomorrow*

There is, however, a crucial difference between Studies 1 and 3 and the present study: in Studies 1 and 3 participants could choose between (A) and 'was supposed to but cannot',

whereas in the present study (A) was the only sentence participants were given in the first part of the task. The following alternative hypothesis thus arises: participants in the present study accept (A) *not* because they endorse its literal meaning, i.e., proposition (P-A), but rather because they endorse, and are trying to communicate, a closely related but distinct proposition, namely (P-B) (repeated below), which doesn't find adequate linguistic formulation in the task at hand.

(P-B) *that Adam has at time t-1 the obligation to go on the expedition tomorrow, but it is circumstantially impossible at time t for Adam to go on the expedition tomorrow*

The results of our study confirm this alternative hypothesis. Given the near synonymy of 'must' and 'have to' as present tense strong necessity modals, we can safely assume that (A'') ('Adam has to go on the expedition tomorrow, but he cannot') expresses proposition (P-A), while (B) ('Adam was supposed to go on the expedition tomorrow, but he cannot') expresses proposition (P-B). When asked what they had in mind when they accepted (A) as a correct description of Adam's situation, speakers overwhelmingly favoured (B) over (A'') (84% vs. 16%), thus indicating that when they accepted (A) they were not endorsing (P-A), but rather (P-B).

Not only is this consistent with MIC; it is predicted and explained by it: when accepting sentence (A), speakers don't endorse the proposition literally expressed by (A), given that this proposition is a contradiction; rather, they accept (A) as a means to communicate a closely related but non-contradictory proposition. Yet again, this phenomenon obtains irrespective of both the source of impossibility and blame.

The apparent tension between the results obtained in Studies 1 and 3, on the one hand, and Study 4, on the other, suggests an important methodological consideration regarding the experimental study of modals in natural language. Given the massive polysemy of modal expressions, experimental participants might assign different interpretations to a modal even when experimenters carefully control for the contextual variables relevant for interpreting the modal. Our results indicate that this is particularly prone to happen when a modal sentence is presented with no competing alternative, since this gives participants more room for interpretation. This effect can be mitigated by presenting participants with two or more modal sentences, since participants can use the contrast to focus on the relevant modal interpretation.

5. Conclusion

The relation among different modal flavours is an understudied area of natural language semantics. In this article, we have contributed to this area by examining the question whether deontic 'must' entails circumstantial 'can'. We have given a convergent argument in support of a positive answer.

First, we have proven that MIC follows from a well-established theory of modality in natural language—Kratzer's semantics. Kratzer's analysis of deontic 'must' has it that the truth of 'S must φ' in a context c (assigning deontic flavour to 'must') entails that S φ-es in some of the worlds compatible with S's circumstances in @ at t_c. But this is sufficient for 'S can φ', read circumstantially, to be true in c. Therefore, in a context c that assigns deontic flavour to 'must' and circumstantial flavour to 'can', the proposition expressed by 'S must φ' entails the proposition expressed by 'S can φ'.

Second, we have tested MIC against the linguistic behaviour of native English speakers. When they are presented with a story in which a subject S contracts a strong obligation, which

becomes then impossible for S to fulfil, not only do competent speakers favour the linguistic ascription of a past obligation ('S was supposed to φ, but S cannot φ') over the ascription of a present obligation ('S must φ, but S cannot φ'), but they also evaluate the latter sentence as bad or very bad, and they do so regardless of whether they find S blameworthy for the impossibility in question. This is of course what one should expect given MIC plus the natural assumption that competent speakers are not willing to endorse contradictory propositions. In fact, our data show that even when they do accept sentences such as 'S must φ, but S cannot φ', speakers do so not because they endorse the contradictory proposition *that S has at time t the strong obligation to* φ, *but it is circumstantially impossible at time t for S to* φ, but rather because they endorse the MIC-consistent proposition *that S has at time t-1 the obligation to* φ, *but it is circumstantially impossible at time t for S to* φ.

By putting together this theoretical and empirical evidence, one has excellent reasons to conclude that 'must' implies 'can'.

APPENDIX: Formal derivation of MIC

This appendix provides a proof of MIC from Kratzerian semantic clauses for the modal operators of necessity and possibility, given a context in which necessity is deontic and possibility is circumstantial. The proof is casted in a formal system combining Kratzer's semantics for modals (Kratzer 2012) with a Kaplanian framework for utterance-truth (Kaplan, 1989). With respect to the main text, the following presentation follows Kratzer more closely in defining conversational backgrounds as functions whose values are sets of propositions (premise sets).

The propositional modal language L:

L is a triple <P, Conn, Op> where:

- $P = \{p_0, p_1, p_2, ...\}$ is an infinite set of propositional atoms.

- Conn = $\{\neg, \rightarrow\}$ is the set of propositional connectives.

- Op = {Nec, Pos} is the set of modal operators.

Well-formed formulas (wffs) of L are defined as follows:

- Propositional atoms are wffs

- If A, B are wffs, then ¬A, A→B, Nec(A), Poss(A) are wffs.

- Nothing else is a wff.

The model M for L:

M is a quadruple <W, T, C, [[.]]> where:

1. $W = \{w_0, w_1, w_2, ...\}$ is the set of possible worlds.

2. $T = \{t_0, t_1, t_2, ...\}$ is the linearly ordered set of times.

3. C = $\{c_0, c_1, c_2, ...\}$ is the set of contexts; each context c specifies a modal base function f_c and an ordering source function g_c, besides a time t_c and a world w_c; the functions f_c and g_c map world-time pairs $<w, t> \in W \times T$ to (possibly empty) sets of propositions X $\subseteq \wp(W)$.

4. [[.]] is a function mapping a well-formed formula φ of L, relative to a context parameter $c_i \in C$, onto a proposition $p \in \wp(W)$.

For deontic necessity modals and circumstantial possibility modals, $f_c(w, t)$ is a set of propositions representing the relevant circumstances in w at t. For deontic necessity modals, $g_c(w, t)$ is a set of "ideal" propositions entertained in w at t. For circumstantial possibility modals, $g_c(w, t) = \emptyset$.

The ordering $\leq_{g_c(w, t)}$ is defined as the following reflexive and transitive relation:

5. $w'' \leq_{g_c(w, t)} w'$ *iff* $\{p \in g_c(w, t): p(w') = 1\} \subseteq \{p \in g_c(w, t): p(w'') = 1\}$

The semantics of L is defined by clauses 6-10 (the modal operators in 9 and 10 correspond to Kratzer's technical notions of *necessity* and *possibility*, respectively):

6. $[[p_n]]_c \subseteq W$

7. $[[\neg A]]_c = \overline{[[A]]_c}$

8. $[[A \rightarrow B]]_c = \overline{[[A]]_c} \cup [[B]]_c$

9. $[[Nec(A)]]_c = \{w \in W$: for all w' in $\bigcap f_c(w, t_c)$ there is a w'' in $\bigcap f_c(w, t_c)$ such that $w'' \leq_{g_c(w, t_c)} w'$ and for all w''' in $\bigcap f_c(w, t_c)$ such that $w''' \leq_{g_c(w, t_c)} w''$, $A(w''') = 1\}$

10. $[[\ Poss(A)\ ]]_c = \{w \in W$: for some w' in $\cap f_c(w, t_c)$, for all w'' in $\cap f_c(w, t_c)$ such that w''

$\leq_{g_c(w,\,t_c)} w'$ there is a w''' in $\cap f_c(w, t_c)$ such that $w''' \leq_{g_c(w,\,t_c)} w''$ and $A(w''') = 1\}$

When $[[\ Poss(A)\ ]]_c$ is a purely circumstantial possibility, $g_c(w, t_c) = \emptyset$ and clause 10 reduces
to 10* (since $\leq_{g_c(w,\,t_c)}$ holds between any two worlds in $\cap f_c(w, t_c)$):

10*. $[[\ Poss(A)\ ]]_c = \{w \in W$: for some w' in $\cap f_c(w, t_c)$, $A(w') = 1\}$

A relation of entailment $\vDash$ between a set of propositions $X \subseteq \wp(W)$ and a proposition $p \in \wp(W)$
is defined as follows:

11. $X \vDash p$ *iff* p is true in all worlds in which all the propositions in X are true

Derivation of MIC

We prove the following claim:

(MIC) For any context c such that f_c is a circumstantial modal base (underlying the
       interpretation of *Nec* and *Poss*) and g_c is a deontic ordering source (underlying the
       interpretation of *Nec* only), the following entailment holds:

       $[[\ Nec(A)\ ]]_c \ \vDash \ [[\ Poss(A)\ ]]_c$

Let's assume that c is a context as specified in (MIC) and the proposition $[[\ Nec(A)\ ]]_c$ is true
in a world @, that is, $[[\ Nec(A)\ ]]_{c,\,@} = 1$. Hence, the following truth condition obtains:

(A)   for all w' in $\cap f_c(@, t_c)$ there is a w'' in $\cap f_c(@, t_c)$ such that $w'' \leq_{g_c(@, t_c)} w'$ and for all w'''

in $\cap f_c(@, t_c)$ such that $w''' \leq_{g_c(@, t_c)} w''$, $A(w''') = 1$

The following holds for the modal base $f_c(@, t_c)$—since $@$ itself is certainly a world in which

the circumstances picked up by f_c in $<@,\ t_c>$ hold:

(B)   there is at least a w' in $\cap f_c(@, t_c)$

Let w_1 be such a world w' as in (B). Then, it follows from (A) that

(C)   there is a w'' in $\cap f_c(@, t_c)$ such that $w'' \leq_{g_c(@, t_c)} w_1$ and for all w''' in $\cap f_c(@, t_c)$ such that

$w''' \leq_{g_c(@, t_c)} w''$, $A(w''') = 1$

Let w_2 be such a world w'' as in (C). Then, it follows from (C) that

(D)   for all w''' in $\cap fc(@, tc)$ such that $w''' \leq_{g_c(@, t_c)} w_2$, $A(w''') = 1$

By reflexivity of the ordering $\leq_{g_c(@, t_c)}$, it follows from (D) that

(E) $A(w_2) = 1$

Given the way w_2 has been introduced, it follows from (E) that

(F)   there is a w in $\cap f_c(@, t_c)$ such that $A(w) = 1$

At this point, it is enough to observe that (F) gives just the truth condition guaranteeing that

$[[\; Poss(A) \;]]_{c, @} = 1$ (as specified by clause 10* above).

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