On the felicity conditions of epistemic modals[*,†]

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Abstract In recent work (von Fintel & Gillies 2010, Matthewson 2015, Lassiter 2016), epistemic modals have been claimed to have felicity conditions that require the evidence for the prejacent to be indirect. In contrast, I argue that epistemic modals have felicity conditions that require the epistemic modal base not to entail or contradict the prejacent (cf. Giannakidou & Mari 2016). New linguistic data is produced in support of my position. The proposed account is shown to explain the new evidence better than accounts that rely on indirectness. Moreover, the proposed account is claimed to better explain the weakness or non-confidence intuitions that arise from epistemic *must* utterances. In light of these findings, future prospects are explored. In particular, I suggest that this proposal paves the way for the felicity conditions of epistemic *must* to be derived as a conversational implicature. Furthermore, I demonstrate that a purported counterexample to the proposal, *must* statements in the conclusions of deductions, is a problem for indirectness accounts as well.

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1   Introduction

In this paper, I argue that epistemic modals have felicity conditions that require the epistemic modal base not to entail or contradict the prejacent (cf. Giannakidou & Mari 2016). This is in contrast to von Fintel & Gillies (2010), who claim that epistemic modals have felicity conditions that require the evidence for the prejacent to be indirect. In section 1, a discussion of Karttunen (1972), Kratzer (1991) and von Fintel & Gillies (2010) provides the necessary background. In section 2, new evidence is produced that bears on the debate over the felicity conditions of epistemic modals between von Fintel & Gillies (2010) and Giannakidou & Mari (2016). In section 3, the

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proposed account is put forward, and is shown to explain the new evidence better than accounts that rely on indirectness. Through the lens of Lewis's (1996) theory of knowledge, I explore how perceptual evidence produces the known facts or information that determines the epistemic modal base. In section 4.1, I suggest that this proposal paves the way for the felicity conditions of epistemic *must* to be derived as a conversational implicature, delivering on an expectation expressed by von Fintel & Gillies. In section 4.2, I demonstrate that a counterexample to the proposal, *must* statements in the conclusions of deductions, is a problem for indirectness accounts as well. In section 5, I conclude.

1.1 The apparent weakness of epistemic *must*

Does an utterance of epistemic *must* ϕ entail ϕ or not? Karttunen (1972) reports the intuition that (1a) does not entail (1b), and claims more generally that *must* ϕ does not entail ϕ. Stated differently, Karttunen claims that epistemic *must* is weak.

(1) a. John must have left. (*must* ϕ)
     b. John has left. (ϕ)

Of (1), Karttunen (p. 12) writes, "(1a) seems to say that the truth of *John has left* in some way logically follows from other facts the speaker knows and some reasonable assumptions that he is willing to entertain." Kratzer (1991) proposes a weak semantics for epistemic *must* that captures the spirit of Karttunen's observation in that known facts and reasonable assumptions are combined to infer ϕ. The context c provides a function that takes as input any world w and outputs a set of propositions, *Epi*. *Epi* can be thought of as representing the known facts, the relevant information, or a body of evidence in w. Since the propositions in *Epi* are known facts, each of them is true in the world of evaluation w. The conjunction of this set, $\bigcap Epi$, is therefore realistic, that is, it contains w. $\bigcap Epi$ is the epistemic modal base, the set of worlds epistemically accessible from w.[1] To represent reasonable assumptions, Kratzer proposes another function provided by c that takes w as input and returns another set of propositions, those that hold true in situations that follow the normal course of events in w, i.e. those propositions that are stereotypical, *Norm*. The stereotypical propositions in *Norm* are reasonable to assume, though there

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1 The function provided by c, which I have left unnamed, is Kratzer's conversational background f. Therefore, $f(w) = Epi$, and $\bigcap f(w) = \bigcap Epi$. Since *Epi* is relative to both c and w, it might officially be represented as $Epi_{c,w}$ to remind us of this fact, however I will leave such subscripts off for ease of presentation.

is no guarantee that they are true in w itself. After all, propositions that are usually true can sometimes turn out to be false.[2] We can use $Norm$ to establish an ordering on $\bigcap Epi$. The idea is that there is a subset of worlds in $\bigcap Epi$ such that each member of this subset makes more propositions in $Norm$ true than any world outside of this subset in $\bigcap Epi$. These are the most stereotypical worlds in $\bigcap Epi$, the set of which I will call $Best$.[3] With ways of representing known facts, reasonable assumptions, and their interaction in place, Kratzer proposes the following semantics for epistemic $must$.[4, 5]

(2) $[\![must\ \phi]\!]^{c,\,w} = 1 \Leftrightarrow \forall w' \in Best : [\![\phi]\!]^{c,\,w'} = 1$

(2) predicts that $must\ \phi$ will be true in those worlds w that, in conjunction with c, produce a modal base $\bigcap Epi$ and an ordering source $Norm$ such that the $Best$ worlds in $\bigcap Epi$ are all worlds in which ϕ is true. Note that even though the modal base is realistic and therefore w is in $\bigcap Epi$, this does not guarantee that ϕ is true in w itself since w is not guaranteed to be in $Best$. If w is non-stereotypical, then it won't be a $Best$ world, and $must\ \phi$ can be true in w even if ϕ is false in w. This captures Karttunen's intuition that (1b) does not follow from (1a), and that it does not follow because the speaker of (1a) may be relying on assumptions that, though reasonable, could be wrong.

1.2   The apparent indirectness of epistemic $must$

There is a challenge for Kratzer's proposal, which is that there are sentences that it predicts to be felicitous and true, but which are intuitively infelicitous.

(3)   [Adapted from von Fintel & Gillies (2010: p. 353):] The speaker is looking out the window at the pouring rain.

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2 Similar to the discussion in footnote 1, the function that provides $Norm$ is Kratzer's g, $g(w) = Norm$, and I leave subscripts off for ease of presentation.

3 Here are the mechanics for an ordering given an epistemic modal base $\bigcap Epi$ and an ordering source $Norm$: $\forall w, w' \in \bigcap Epi$: $w \leq_{Norm} w' \Leftrightarrow \{p \in Norm : w \in p\} \supseteq \{p \in Norm : w' \in p\}$. (Being lower on the ordering means being more optimal with respect to the propositions in $Norm$.) The $Best$ set is defined as follows: $Best_{\bigcap Epi,\ \leq_{Norm}} = \{w \in \bigcap Epi : \forall w' \in \bigcap Epi\ [w' \leq_{Norm} w \rightarrow w \leq_{Norm} w']\}$.

4 I am making "the limit assumption" by assuming that there is such a set of $Best$ worlds as established by the ordering source $Norm$. Kratzer (1991) does not make this assumption, so her denotation for $must\ \phi$ (p. 644) is more complex than that in (2). See von Fintel & Heim (2011: p. 61-2) for some discussion and references on the limit assumption.

5 To determine $Best_{\bigcap Epi,\leq_{Norm}}$, $\bigcap Epi$ and $\leq_{Norm}$ are required, which in turn are only made available thanks to the functions provided by c and a world of evaluation w to act as input to those functions. So $Best_{\bigcap Epi,\leq_{Norm}}$ is dependent on c and w for its content. However, I will leave these subscripts off and just refer to $Best$ in the body of the text.

a. # It must be raining.

It seems safe to assume that a context in which the speaker sees pouring rain is one in which the proposition *that it is raining* is a known fact, and therefore that proposition will be in *Epi*.[6] Since all worlds in $\bigcap Epi$ will be worlds in which it is raining, so will those in *Best*. (2) doesn't say anything about felicity conditions for *must*, therefore it predicts (3a) to be felicitous and true even though it is intuitively infelicitous. An initial guess at the cause of the infelicity intuition is that epistemic *must* conveys that reasonable assumptions play a *necessary* role in the inference to ϕ. In other words, for *must* ϕ to be felicitous, there must necessarily be a non-*Best* world in which ϕ is false, so that $\bigcap Epi$ does not entail ϕ by itself. This idea is in fact proposed by Giannakidou & Mari (2016), and we will return to it below in section 3.

von Fintel & Gillies (2010: vF&G) offer a different explanation, which starts with the fact that the felicity judgments for (4a) contrast with those for (3a).

(4)   [Adapted from vF&G (2010: p. 353):] The speaker sees people entering the building holding and wearing wet rain gear, but she cannot see outside herself.

a.   It must be raining.

vF&G say that perhaps the crucial factor is that while the speaker has direct evidence for the prejacent ϕ in (3), her evidence is merely indirect in (4). To account for the asymmetry between (3) and (4), as well as for Karttunen's weakness intuition in (1), they develop what I will call "the indirectness account". The idea is that certain propositions in *Epi* are known only through direct observation or trustworthy report. I'll call this special subset of directly known propositions *Dir*.[7] vF&G propose that epistemic *must* ϕ comes with a presupposition that no single proposition ψ in *Dir* entails or contradicts ϕ. If this condition is met, then *must* ϕ is true if and only if every world in the conjunction of *Dir* is a world in which ϕ is true.

(5)   a. $[\![must\ \phi]\!]^{c,w}$ is defined only if $\forall \psi \in Dir : \psi \not\subseteq \lambda w.[\![\phi]\!]^{c,w}$ and $\psi \cap \lambda w.[\![\phi]\!]^{c,w} \neq \emptyset$

        b.   If defined, $[\![must\ \phi]\!]^{c,w} = 1 \Leftrightarrow \forall w' \in \bigcap Dir : [\![\phi]\!]^{w'} = 1$

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6 In fact, this assumption is probably only safe when the speaker is your average layperson, and not, for example, a professional epistemologist, or someone who has come to doubt their own sanity. In general, there may be more nuance to how perception relates to the contents of *Epi*. This will be discussed further in section 3 below.

7 This is what vF&G call "the kernel". Note that they say *Dir* is provided by c.

The presupposition (5a) predicts (3a) to be infelicitous since Dir contains the proposition that it is raining, which entails the prejacent. Meanwhile, (4a) meets the presupposition, since no directly known proposition entails or contradicts the prejacent, that is, the proposition *that there is wet rain gear* does not entail (or contradict) the proposition *that it is raining*. Notice that (5b) predicts that *must* ϕ entails ϕ, and therefore that *must* ϕ is logically strong. This is because $\bigcap Dir$ is realistic, so it contains w. As for Karttunen's claim that *must* ϕ is intuitively weak, vF&G say that it is not weak, just indirect in that none of the directly known propositions in Dir directly settles the prejacent. For vF&G, *must* ϕ conveys that ϕ is only inferred indirectly from the conjunction of Dir, which they claim gives rise to a "non-confidence" intuition about ϕ that many researchers have confused for weakness. This is the source of the intuition about (1a), they say, and despite non-confidence, (1a) entails (1b).

Given the denotation in (5b), in order for (4a) to be true, Dir needs to contain another proposition besides *there is wet rain gear*, one that when combined with that proposition entails the prejacent, *that it is raining*. vF&G say that we have to assume that the speaker knows for sure that *if there is wet rain gear then it is raining*. Matthewson (2015) calls this kind of proposition a general reasoning conditional. Since these conditionals are claimed to be in Dir, and $\bigcap Dir$ is realistic, *must* ϕ is predicted to entail ϕ. vF&G point out (p. 358) that under a Kratzerian approach to epistemic modality, *if there is wet rain gear then it is raining* would be in $Norm$. In that case, while such a conditional would be reasonable to assume, it may nevertheless not be true in the world of evaluation, therefore any inference to ϕ that relies on it does not guarantee that ϕ is true. The location of the general reasoning conditional is what makes Kratzer's account weak while vF&G's is strong. Note however that the strength issue is logically independent from the indirectness presupposition. Since the general reasoning conditional plays no role in the account of the infelicity of (3), the presupposition in (5a) could stand even if we assumed that general reasoning conditionals were in $Norm$, and that *must* quantifies over a $Best$ set that may not contain the actual world w, as in (2). So vF&G's and Kratzer's semantics differ in two ways: the indirectness presupposition and strength. This paper focuses primarily on the presupposition, though I will ultimately argue that the analysis I adopt for the presuppositional component goes hand in hand with a weak truth conditions for epistemic *must*.

2   Problems for the indirectness account

Giannakidou & Mari (2016: G&M) claim that the felicity conditions of epistemic modals are not about directness, but are instead a requirement that the speaker

does not know the prejacent. This is encoded by requiring the modal base to contain at least one world in which the prejacent is false. Before adopting and defending this position in section 3, some new data that motivates G&M's claim and that challenges the indirectness account is needed. G&M provide two examples that they claim accomplish this. They argue that the indirectness presupposition predicts (6a) to be felicitous and (7a) to be infelicitous even though intuitions clearly run counter to these predictions.

(6)   [From G&M (2016):] You and your sister were out of touch for a couple of years. Today she calls you on the phone to catch up. She tells you that her daughter Maria plays the piano. Later, you tell your husband:

        a. #Maria must play the piano.

G&M claim that in (6), the evidence for the prejacent *that Maria plays the piano* is indirect since the speaker is told about it. Therefore, they say that the indirectness account does not explain the infelicity intuition. Furthermore, consider (7):

(7)   [From G&M (2016):] You and your sister were out of touch for a couple of years. Today you visit her for the first time. As she shows you around her apartment, you see that there is a piano. Later, you tell your husband:

        a.   Maria must play the piano.

G&M claim that in (7), the evidence for the prejacent is direct because the speaker sees the piano, therefore the indirectness account incorrectly predicts (7a) to be infelicitous. However, despite G&M's claims, I believe the presupposition of the indirectness account accurately predicts both (6a) and (7a). According to vF&G, trustworthy reports count as direct evidence, therefore the prejacent of (6a) is included in *Dir*, so (6a) is correctly predicted to be infelicitous. Moreover, the indirectness account would not treat (7) as providing direct evidence for the prejacent since seeing the piano would not add the prejacent *that Maria plays the piano* to *Dir*. More likely this would be direct evidence for the proposition *that Maria has a piano*. Therefore (7a) is correctly predicted to be felicitous. Furthermore, I believe that no other examples in G&M 2016 are such that the indirectness account does not make the correct predictions, so as it stands there seems to be no evidence that clearly distinguishes between G&M's position and the indirectness account.[8]

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8 G&M do provide some Greek and Italian data that is incompatible with the strength component of vF&G's account (e.g. (i)), and this data is confirmed by Lassiter (2016) using English corpus data (e.g. (ii)).

Even though G&M's examples are not conclusive, I believe that there are examples that are problematic for vF&G's indirectness account just as there were examples that challenged Kratzer's proposal. These examples have a particular profile that is dependent on the structure of vF&G's account. *Dir* contains three kinds of propositions: those corresponding to direct perceptions, those derived from trustworthy reports, and those representing general reasoning conditionals. To test the indirectness account, I propose to find pairs of contexts with the following features: (i) speakers uttering *must* ϕ, who (ii) have identical direct perceptions to one another, and (iii) neither their trustworthy reports nor their general reasoning conditionals directly settle ϕ. Given the indirectness presupposition (5a) and the possible contents of *Dir*, the indirectness account predicts the *must* ϕ utterances in such context pairs to both be felicitous or both be infelicitous. The following pair is a counterexample (adapted from Kratzer 2011).

(8)   In her backyard, Bonnie and her friend see a bird 30 feet away. Bonnie is a bird expert. She has seen hundreds of cardinals. They are bright red, with a red crest sticking off their heads, and with a black mask and throat. There are other birds that have some of those features, but none that have all of them. She knows that it is a cardinal. Bonnie says to her friend:

  a. # It must be a cardinal.

(9)   In her backyard, Amelia and her friend see a bright red bird 30 feet away. Amelia isn't a bird expert, but her father is. He has frequently pointed bright red birds out to her in this backyard and told her they are cardinals. This bird resembles the birds her father has pointed out, as far as she can remember. Amelia says to her friend:

  a. It must be a cardinal.

(i) I Ariadne tha ine arosti, ala dhen ime ke endelos sigouri
  the Ariadne FUT is sick, but not be.1sg and absolutely sure
  'Ariadne must be sick, but I am not entirely sure.'   Greek

(ii) Must be an old DTS diesel setup but I'm not certain.

While such examples are clearly problematic for vF&G's claim that *must* ϕ entails that ϕ is known for sure, the strength component and the indirectness presupposition of vF&G's account are logically independent as I already noted. Therefore, the indirectness presupposition could be combined with a Kratzerian weak truth conditions for *must* ϕ, which would predict (i) and (ii) to be felicitous. In other words, these examples do not demonstrate that the indirectness presupposition makes incorrect predictions. Nor do they demonstrate that *must* ϕ **requires** ϕ not to be known (G&M's position), just that it is **compatible** with ϕ not being known (Kratzer's/Lassiter's position).

Bonnie and Amelia share exactly the same perceptions, therefore it cannot be the case that Bonnie's *Dir* contains a proposition derived from her direct perceptions that Amelia's *Dir* does not also contain. Furthermore, neither of them know a trustworthy report or general reasoning conditional that directly settles by itself the prejacent *that it is a cardinal*. Therefore, Bonnie's *Dir* and Amelia's *Dir* cannot differ in a way that is relevant to the indirectness presupposition in (5a), and the indirectness account predicts that we should have identical felicity judgments for (8a) and (9a), contrary to fact.

If one were concerned that (8) and (9) depended on something specific about naming or identification, the following examples prove the same point using different details.

(10)   Phil is cooking chicken and peas for his family. The timer goes off, he temps the chicken and discovers it is done. He tastes the peas and they are also ready. He set the table earlier. Before he can let everyone know that dinner is ready, his daughter comes in and says, "Is dinner ready?" Phil says:

   a.   # Dinner must be ready.

(11)   Phil is cooking dinner for his family and his friend Meryl. He had to step out in a hurry and shouted as he left, "Meryl, turn the peas off when they are done, and take the chicken out of the oven when the temperature is right!" When the peas are done, Meryl turns the burner off, and when the chicken is done, she removes it from the oven. She has also seen that the table is set. She wonders whether Phil was planning to make anything else, for example a salad, but Phil didn't mention anything. Phil's daughter comes in and says, "Is dinner ready?" Meryl says:

   a.   Dinner must be ready.

Neither Phil nor Meryl have any trustworthy reports nor conditionals that entail or contradict the prejacent *that dinner is ready*. This means that in order for the indirectness account to predict the asymmetry, Phil's *Dir* would need to contain a proposition derived from direct perception that Meryl's *Dir* does not. But this is clearly impossible given that they have the exact same direct perceptions. Therefore, the indirectness account incorrectly predicts that our intuitions about the felicity of (10a) and (11a) should be identical.

The preceding two pairs of examples pose the same problem for the indirectness account in roughly the same way. Here is another pair of examples that pose the problem in a slightly different way:

(12)   Billy is in her office and sees falling rain out the window.

    a.   # It must be raining.

(13)   Hillary is in her office and sees falling rain out the window. She received an e-mail that morning saying that a Hollywood movie would be filmed outside that day, and that if it didn't rain they would be making fake rain, though the filming isn't supposed to start until 5 pm. Hillary looks at the clock, which reads 4:52 pm.

    a.   It must be raining.

Neither Billy nor Hillary have any propositions corresponding to trustworthy reports or general reasoning conditionals in their *Dir* that directly settle the prejacent. Their *Dir* sets cannot differ with respect to propositions derived from direct perceptions since they have identical perceptions. Given these facts, the indirectness account again predicts that our judgments about (12a) and (13a) should be identical, contrary to fact.

In the discussion of the preceding example pairs, I have applied vF&G's indirectness account in a particular way in that I assumed that if two agents have identical direct perceptions, then they necessarily have identical propositions corresponding to those direct perceptions in *Dir*. One could imagine a different way of understanding the indirectness account in which context dependency could be used to claim that Bonnie, Phil and Billy all have the prejacent ϕ in their *Dir* sets as a result of their perceptions, even though their counterparts Amelia, Meryl and Hillary do not. In fact, vF&G claim that there is some natural context dependency affecting which propositions enter an agent's *Dir*, though they do not explain how this context dependency works. If we were to take such a context dependent approach, we would need a general principle that clearly and consistently predicts one agent to have ϕ in *Dir* while another does not despite their identical perceptions. Without such a general principle, the theory risks not making clear predictions. In defense of such an account one can simply say of context pairs like those above that context dependence enables Bonnie, Phil and Billy to have ϕ in *Dir* while their counterparts do not, without giving any explanation for this crucial claim.

Nevertheless, it is clear that a theory is required that predicts the asymmetries above. The theory will likely need to explain them as a result of the agents in each pair having different modal bases such that the contents of one agent's modal base triggers a presupposition failure while the other's does not. That the modal bases differ will be caused by the agents having different information despite their identical perceptions. We should desire a principled explanation for this last fact. While I am not aware of any theories of context

dependent direct evidence, Lewis (1996) develops a theory of context dependent knowledge which may offer a principled explanation. In section 3, I will use his work to develop a principled way of deriving the contents of epistemic modal bases from perceptions. The resulting theory predicts the asymmetries in the context pairs above. It is not a theory that claims that two agents with identical perceptions can nevertheless have different evidence, nor does it claim that the felicity conditions of epistemic *must* are about (in)directness. Instead the felicity conditions are claimed to be about what the agent knows, that is they are about the contents of the modal base $\bigcap Epi$.

3   The epistemic account, and the relationship between perceptions, evidence and the modal base

In section 1.2, I suggested that the reason for the infelicity of (3a) is that epistemic *must* has a felicity requirement that the speaker makes use of reasonable assumptions in her inference to ϕ. As Giannakidou & Mari (2016: G&M) put it, $\bigcap Epi$ necessarily contains a non-*Best* $\neg\phi$-world. In other words, the speaker needs to think there is a slight possibility that $\neg\phi$. In fact, Kratzer's (1991) analysis of *there is a slight possibility that* $\neg\phi$ includes the entailment that there is a non-*Best* $\neg\phi$-world. Since the intuition is that (3a) is infelicitous, not false, this requirement needs to be encoded as a presupposition. The presupposition in (14a) is stated parallel to von Fintel & Gillies's in (5a) for ease of comparison. When the presupposition (14a) is met, I will say that $\bigcap Epi$ is unsettled with respect to ϕ. When it is not met, I will say that $\bigcap Epi$ is settled with respect to ϕ.[9]

(14)   a. $[\![must\ \phi]\!]^{c,w}$ is defined only if $\bigcap Epi \not\subseteq \lambda w.[\![\phi]\!]^{c,w}$ and $\bigcap Epi \cap \lambda w.[\![\phi]\!]^{c,w} \neq \emptyset$

   b.   If defined, $[\![must\ \phi]\!]^{c,w} = 1 \Leftrightarrow \forall w' \in Best : [\![\phi]\!]^{w'} = 1$

Since the presupposition requires $\bigcap Epi$ to be unsettled with respect to ϕ, the truth conditions cannot be strong like vF&G's in (5b), i.e. *must* ϕ cannot be true iff $\bigcap Epi$ entails ϕ. Instead, the presupposition goes hand in hand with Kratzer's (1991) weak truth conditions, reprinted in (14b). Though stated slightly differently, the resulting denotation in (14) is essentially what Gian-

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9 Though *might* is beyond the scope of this paper, for completeness, *must*'s dual can be defined as follows:

(i)   a. $[\![might\ \phi]\!]^{c,w}$ is defined only if $\bigcap Epi \not\subseteq \lambda w.[\![\phi]\!]^{c,w}$ and $\bigcap Epi \cap \lambda w.[\![\phi]\!]^{c,w} \neq \emptyset$
   b.   If defined, $[\![might\ \phi]\!]^{c,w} = 1 \Leftrightarrow \exists w' \in Best : [\![\phi]\!]^{w'} = 1$

nakidou & Mari (2016) propose.[10] I will call this "the epistemic account". It explains the infelicity of (3a), since the prejacent is in *Epi*, and therefore $\bigcap Epi$ is settled with respect to the prejacent, causing presupposition failure. Moreover, (4a) is predicted to be felicitous and true, since *Epi* contains the proposition *that there is wet rain gear*, while the reasoning conditional *if there is wet rain gear, then it is raining* is in *Norm*. Therefore, $\bigcap Epi$ is unsettled with respect to the prejacent, while all of the *Best* worlds in (4a) are worlds in which the prejacent is true.

The epistemic account can explain the asymmetrical judgments in the context pairs in (8) through (13). Bonnie, Phil and Billy, the agents who could not felicitously say *must* ϕ, all have epistemic modal bases $\bigcap Epi$ that settle the prejacent ϕ, leading to presupposition failure by (14a). Amelia, Meryl and Hillary, their counterparts who could say *must* ϕ, all have modal bases that are unsettled with respect to ϕ, and therefore satisfy the presupposition (14a).

However, it is reasonable to ask *how* these three pairs of agents come to have modal bases that differ in their settledness with respect to the prejacent, given that I have claimed that they have identical perceptions and that they lack any trustworthy reports or general reasoning conditionals that *directly* settle the prejacent. Giannakidou & Mari say that a speaker like Billy cannot felicitously say "It must be raining," because she knows that it is raining, which they capture by saying that Billy's modal base $\bigcap Epi$ entails the prejacent.

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10 Specifically, G&M propose to add the following presupposition to Kratzer's truth conditions in (2): "$[\![must \ \phi]\!]^{c,\,w}$ will be defined only if the modal base is nonveridical." A modal base is defined by G&M as "nonveridical with respect to a proposition ϕ iff there is at least one world in the modal base that is a $\neg\phi$-world." This presupposition is slightly different from the one I propose in (14a) in that a modal base $\bigcap Epi$ in which every world is a $\neg\phi$-world satisfies G&M's presupposition but not (14a). This difference may be nontrivial if we consider von Fintel & Gillies's (p. 357) mastermind examples. Assuming *have to* has the same semantics as *must*:

(i)   There don't have to be two reds

Examples like (i) lead vF&G (p. 368) to revise their presupposition from requiring that the prejacent is known through indirect inference to requiring that "*neither* the prejacent *nor* its negation is known through direct evidence..." This logic applies to the epistemic account as well. A speaker upon seeing a mastermind code with no red marbles therefore has a modal base $\bigcap Epi$ in which every world is one in which there are no reds, which entails that every world in $\bigcap Epi$ is one in which the prejacent *that there are two reds* is false. Therefore, (i) is predicted to be felicitous by G&M's presupposition, and, once the negation is added, true by their denotation, even though it is intuitively infelicitous in this context. But the denotation I propose in (14) predicts such an utterance to trigger a presupposition failure since the intersection between $\bigcap Epi$ and the prejacent ϕ is empty, i.e. the modal base contradicts the prejacent.

This is a fine explanation when comparing Billy against a speaker who merely sees wet rain gear and combines that information with a general reasoning conditional in *Norm* as in (4). But we now want to understand why our felicity intuitions differ for two speakers who have identical perceptions, and to do that we need to understand why their modal bases differ in such a way as to cause presupposition failure for one *must ϕ* utterance but not another.

Moreover, as was discussed at the end of section 2, we need a general principle determining how perceptions relate to modal bases, and the manner in which this is done should make it clear that the felicity conditions of epistemic *must* are about knowledge and not directness of evidence. Therefore, certain assumptions about how perception relates to evidence and the epistemic modal base need to be made explicit.[11]

I propose to do this by exploring how propositions make their way into *Epi*. Epistemic modal bases can be derived from various sources, including reports, books, the facts of a case, and they can also be derived from groups of agents (cf. von Fintel & Gillies 2011). However, in the cases above, the modal base always seems to correspond to the speaker's information state or known facts, and what is crucial for the purpose at hand is to have some idea of how information states are built, of what counts as known facts. Luckily, Lewis's (1996) theory of context sensitive knowledge will get us most of the way there, though a bit more needs to be said. Lewis explains how agents come to know propositions based on their perceptions and their proper ignorings. I will use these concepts to determine which propositions enter *Epi* based on perceptual evidence. Lewis's semantics for *know* is in (15).

(15)   The speaker knows that $\phi \Leftrightarrow$ The speaker's evidence eliminates every possibility in which $\neg\phi$—except for those possibilities that we are properly ignoring.

To see how this works consider the following example.

(16)   (Adapted from von Fintel & Gillies 2010: p. 370): A professional epistemologist, while on vacation in Seattle, looks out the window at the pouring rain. She says:

    a.   It must be raining.

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11 Thank you to an anonymous *Semantics & Pragmatics* reviewer and to Kyle Rawlins (p.c.) for raising the question about what role evidence plays in *must ϕ* utterances if it is not one of (in)directness.

Lewis claims that a skeptical epistemologist looking at rain does not know that it is raining, while a layperson, like Billy in (12), does.[12] To simplify, suppose both the epistemologist and the layperson have exactly identical perceptions of falling rain out the window. Do they have identical evidence? According to Lewis, yes. Their identical perceptions give rise to identical evidence E with identical propositional content p. Therefore, I'll stop referring to "perceptions" and "evidence" separately, and just call it "perceptual evidence". E eliminates every possibility in which the agent's evidence E does not have propositional content p. Importantly, the layperson's and the epistemologist's shared perceptual evidence does not eliminate *every* possibility in which it is not raining. For instance, there are farfetched possibilities in which the agent is suffering from a delusion or being tricked into have rain-perceptions when it is nevertheless not raining. These farfetched possibilities cannot be eliminated by E, they are still live possibilities in which the agent (or the counterpart of the agent) is having rain-perceptions despite that it is not actually raining. That is, in these farfetched possibilities, the agent has perceptual evidence E with propositional content p despite that $\neg p$ holds in each of these farfetched possibilities.

So how do the layperson and the epistemologist differ? According to Lewis, the layperson properly ignores these farfetched possibilities while the epistemologist does not. After throwing out the layperson's eliminatings and ignorings, the only live possibilities left are those in which it is raining, which means the layperson knows that it is raining. The epistemologist makes the same eliminations via the same perceptual evidence, but is left with some possibilities in which it is not raining that she cannot properly ignore. Why can't she ignore them? Her training as an epistemologist gets in the way, she is consciously aware of the farfetched possibilities, and to be aware of them is to not ignore them. So, she doesn't quite know for sure that it is raining.

I propose to apply Lewis's (1996) theory of knowledge to the phenomenon of epistemic modality by using it to explain the contents of *Epi*. This combined with the theory of epistemic *must* in (14) will explain the felicity intuitions. A layperson like Billy in (12) sees rain and the proposition *that it is raining* enters *Epi* in the way just outlined above. By the presupposition (14a), her *must* ϕ utterance (12a) is predicted to be infelicitous. The vacationing epistemologist in (16) does not have the proposition *that it is raining* in *Epi* for the reasons just given. Her *must* ϕ utterance is intuitively felicitous and true, and there is the further intuition that she seems not to know ϕ, i.e. the weakness or

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12 N.b., this claim is already incompatible with vF&G's indirectness account, which claims that a speaker who felicitously and truthfully says *must* ϕ knows ϕ. Therefore, the epistemologist in (16) knows that it is raining according to the indirectness account, but she does not know it according to Lewis.

non-confidence intuition. Why? Even though the epistemologist can't conclude *that it is raining* from her perceptions, she can conclude something weaker, *that I am having rain perceptions.* She also entertains the following reasonable assumption, *if I am having rain perceptions, then it is raining.* Most people take such assumptions for granted, and this is reflected in the proper ignoring that Lewis proposes to explain how perceptions lead to everyday knowledge. The epistemologist needs to take a slightly more circuitous route to get to ϕ however. That she doesn't take such reasoning for granted is reflected in that she doesn't quite take ϕ as known. Instead she assumes that such reasoning holds in stereotypical worlds (as she should), therefore she can be sure that the *Best* worlds are worlds in which it is raining, and so (16a) is felicitous and true.

So far so good, and we haven't needed to say more than Lewis (1996) other than connecting knowledge to *Epi* which seems reasonable enough given that *Epi* is defined as a set of propositions representing known facts or information, which is uncontroversial (cf. Kratzer 1991, von Fintel & Gillies 2010, 2011, Giannakidou & Mari 2016, Lassiter 2016). However, Lewis doesn't quite give us enough to explain the intuitions about Phil in (10). Phil has certain perceptual evidence, and as a layperson is entitled to conclude certain propositions from them: *that the chicken is done*, *that the peas are done*, and *that the table is set* are all in *Epi*. However, the combination of these propositions does not entail *that dinner is ready* since there are still live possibilities in which dinner includes another dish, say a salad. We could say that Phil properly ignores those worlds, but this would be an abuse of Lewis's proper ignoring. According to Lewis, ignoring is a weak way to know ϕ—make the ignored possibilities explicit by mentioning them, and the agent now fails to know ϕ. But this doesn't seem right for Phil at all. If Phil says "Dinner is ready," and Meryl objects, "Dinner isn't done, what about salad?", Phil could reply, "No, there is no salad. Dinner is ready." Phil clearly *eliminates* the possibilities in which there are more dishes for dinner. But he doesn't do it through his perceptual evidence, that is, he does not perceive what is for dinner. Besides the propositions that Phil knows from his perceptual evidence, he also knows a proposition representing the dinner plans. We can represent this as a conditional: *if the chicken and peas are done and the table is set, then dinner is ready.* This conditional is not a general reasoning conditional. It does not belong in the stereotypical ordering source *Norm*. Phil knows it because he himself decided what was for dinner, so it belongs in *Epi*. Therefore, when combined with his perceptual experience, every world in $\bigcap Epi$ will be a world in which dinner is ready. By the presupposition in (14a), (10a) is predicted to be infelicitous. Bonnie in (8) comes to know the prejacent *that it is a cardinal* in roughly the same way that Phil knows his

prejacent. She sees certain bird features, which leads to certain propositions entering Epi. She doesn't ignore possibilities in which birds other than cardinals have those features, she eliminates them via her expertise, which is represented as a conditional in Epi. In moving from Epi to $\bigcap Epi$, her expertise is combined with the propositions derived from her perceptual evidence, and every world in $\bigcap Epi$ is a world in which it is a cardinal, leading to presupposition failure in (8a). I am claiming, then, that in order to distinguish the modal bases of agents like Phil and Bonnie from those of Meryl and Amelia, more resources are needed than just direct perceptions, trustworthy reports and general reasoning conditionals. An agent can know propositions that do not arise from direct perceptual evidence. We can refer to these as expertise conditionals. Phil and Bonnie have expertise, and by combining it with their perceptual evidence, their $\bigcap Epi$ sets are settled with respect to ϕ.

Meryl and Phil, and Amelia and Bonnie, have identical perceptions, therefore their Epi sets contain the same propositions derived from perceptual evidence. But unlike Phil and Bonnie, Meryl and Amelia lack expertise, so their $\bigcap Epi$ sets do not settle ϕ. Instead they rely on reasonable assumptions in the ordering source $Norm$, like *if someone gives you some instructions for making dinner before rushing off, then the instructions are complete*, and *if a bird seems to resemble other birds that you have heard called "cardinal", then it is a cardinal*. These general reasoning conditionals are fairly safe to assume, but of course they could turn out to be false. Thus Meryl and Amelia infer ϕ using facts and reasonable assumptions, and their *must* ϕ utterances are predicted to be felicitous by the epistemic presupposition in (14a). Moreover, it is clear why their *must* ϕ utterances give rise to intuitions of weakness or non-confidence: the presupposition of *must* requires them not to know ϕ, but to rely on reasonable assumptions and other knowledge to conclude ϕ. Unlike the indirectness account, under the epistemic account speakers who can felicitously say *must* ϕ and those who cannot both combine information to get to ϕ. The difference between them is not about (in)directness at all, but about whether ϕ is settled by $\bigcap Epi$, i.e. the felicity conditions are about what the agent knows.

We have already seen why Billy cannot felicitously say (12a). Hillary in (13) is roughly like the skeptical epistemologist. She can be sure that she has rain-perceptions, but even though she is a layperson, she cannot take the usual step of concluding *that it is raining* from her perceptual evidence. This is because the farfetched possibilties in which her perceptions are an illusion are unignorable due to the e-mail she has received. That is, even though a layperson with rain-perceptions would normally ignore the possibility that it was an illusion, this behavior quickly disappears in a context in which illusions are highly likely. Hillary is left to combine her rain-perceptions with other things she knows

(the time, when the fake rain is supposed to start), and to make a reasonable assumption, *that if people say they will do something at a certain time, then they don't start until that time.* This conditional is obviously not always true, e.g. the film crew could be testing their equipment out early. But stereotypically it is. Thus Hillary infers ϕ from facts and reasonable assumptions.

I have argued that the epistemic account explains the new data presented in section 2 while the indirectness account has difficulty doing so. The semantics in (14) is roughly equivalent to that proposed by Giannakidou & Mari (2016), but the explanation for the contents of *Epi* is novel as are the context pairs that establish the contrast with the indirectness account. The felicity intuitions about *must* ϕ utterances seem to track whether or not the speaker makes crucial use of reasonable assumptions in *Norm*, and not whether or not the speaker combines propositions that are directly known.

4 Implications and future work

The main claim of this paper is that the felicity conditions holding on epistemic modals is about whether the epistemic modal base $\bigcap Epi$ settles the prejacent, not whether any single member of a special directly known set of propositions *Dir* settles the prejacent. Specifically, I have claimed that epistemic modals require that $\bigcap Epi$ is unsettled with respect to the prejacent ϕ, which means that any speaker uttering *must* ϕ necessarily relies on reasonable assumptions in deciding that all of the *Best* worlds are ϕ-worlds.

In this section, I will examine more closely one advantage and one disadvantage of the epistemic account. In section 4.1, I will explore the possibility of deriving the felicity conditions I have proposed as a conversational implicature. I will argue that such a derivation is possible in principle, and that this result is a true advantage of adopting the epistemic account since it enables a more parsimonious theory of modality in general. In section 4.2, I consider the apparent fact that epistemic *must* ϕ can appear in conclusions of deductions to ϕ, which, if correct, would appear to be a counterexample to, and a disadvantage of, the epistemic account. I will argue that such examples are in fact also problematic for the indirectness account.

4.1 An implicature account is now possible

von Fintel & Gillies (2010) say that the indirectness presupposition is a placeholder for an eventual explanation of why the proposed evidential signal of epistemic modals is persistent cross-linguistically. They write (p. 367), "...

one would suspect and hope that the evidential signal can be derived as a conversational implicature that is non-detachable in Gricean terms."

(17)   [Adapted from vF&G (2010: p. 367)] A sketch of the desired implicature account:
        1. *must* is a universal quantifier over what is known.
        2. *must* competes with a stronger expression O that is only appropriate with directly known prejacents.
        3. Standard quantity implicature: choosing *must* ϕ instead of $O\phi$ implicates that ϕ is not known directly.

The problem with (17) from vF&G's perspective is that there is no stronger competitor $O\phi$. They point out in particular that an utterance of the bare prejacent cannot be $O\phi$ since it does not indicate direct evidence, but is instead compatible with only having indirect evidence. Therefore, it is hard to see how (17) could be developed into a complete account.

However, given the epistemic account I have defended above, 1. in (17) cannot be right. *must* ϕ has to be weaker. Moreover, the goal of an implicature account is no longer to explain an evidential signal of indirectness. The goal now is to explain an inference about the epistemic modal base, that ϕ is not entailed by $\bigcap Epi$. In light of these changes, we can imagine a stronger alternative $O\phi$ that makes an implicature account possible, at least in principle.

(18)   A sketch of an implicature account:
        1. *must* is a universal quantifier over *Best*.
        2. *must* competes with a stronger expression O that quantifies universally over $\bigcap Epi$.
        3. Standard quantity implicature: choosing *must* ϕ instead of $O\phi$ implicates that ϕ does not hold throughout $\bigcap Epi$.

If we can find a suitable operator O, then the sketch in (18) should work just fine. It is not my intention to defend the existence of $O\phi$ at length here, but I suggest that an assertion of the bare prejacent ϕ is a possible candidate. Katzir (2007) argues that alternatives to ψ can be found by simply removing elements of ψ. Therefore, ϕ is a valid alternative to *must* ϕ. Moreover, it has been argued that the norms of assertion are such that one can only assert what one knows (see Williamson (1996) for a defense, and Weiner (2007) for an overview). In fact, Giannakidou & Mari (2016) argue that an assertion of ϕ indicates that $\bigcap Epi \subseteq \phi$. While this is an active area of research, if the knowledge account of bare ϕ assertions is correct, then assertions of ϕ would suffice in the role of $O\phi$ in (18). Of course, ϕ is not by itself stronger than *must* ϕ. But in the presence

of a knowledge requirement on assertions of ϕ, when a speaker utters ϕ, they know ϕ, i.e. $\bigcap Epi \subseteq \phi$. Since $Best \subseteq \bigcap Epi$, $Best \subseteq \phi$, therefore $must\ \phi$ is entailed for that speaker. Therefore, the listener can reason that if the speaker chose to say the weaker $must\ \phi$, it is because $\bigcap Epi \nsubseteq \phi$ (Grice 1989).

More work is needed to fully defend the above implicature sketch, but at the very least, the epistemic account argued for here puts an implicature account of the inference associated with $must\ \phi$ back on the table. As vF&G have argued, one reason to welcome this is that the weakness or non-confidence signal conveyed by epistemic modals appears to be stable crosslinguistically, so we should want to derive the signal rather than hardwire it into the lexical entry. There is another reason to welcome the possibility of an implicature account, which is that part of the appeal of Kratzer's (1991) account of modality is that $must$ always has the same denotation regardless of whether it is epistemic, deontic, etc. The different flavors are not due to a lexical ambiguity between different $must$s, but a contextual parameter, namely the nature of the modal base and ordering source. Hardwiring a presupposition into epistemic modals forces us to accept lexical ambiguity since other kinds of modals do not share their felicity conditions. But if we can derive the signal that we are trying to account for as a conversational implicature, then we can return to the more parsimonious explanation for different modal flavors proposed by Kratzer. The epistemic signal is triggered only as a result of quantifying over an epistemic modal base, which causes the $must\ \phi$ utterance to compete with the assertion of a bare prejacent.

4.2 An unresolved puzzle for both the epistemic account and the indirectness account

The fact that $must\ \phi$ can appear in the conclusions of deductions of ϕ, discussed in von Fintel & Gillies (2010) and Lassiter (2016), is a challenge for the epistemic account if such cases are taken to be examples of epistemic $must$. The reason is that if the premises are taken to be propositions in Epi and the premises entail ϕ, then $\bigcap Epi$ entails ϕ, which means that the presupposition in (14a) predicts the $must\ \phi$ utterance to be infelicitous, contrary to fact. However I will demonstrate that such deduction contexts are a challenge for the indirectness account as well. First, consider a typical example of $must\ \phi$ in a deduction in (19):

(19)   [Adapted from Lassiter (2016):] A teacher is explaining to a student that there is only one number that is both prime and even:

> a. If x is prime and even, then x is 2.
> x is prime ... x is even ...
> So, x must be 2.

The *must ϕ* statement in (19a) appears to be felicitous, yet the speaker's $\bigcap Epi$ entails ϕ. This runs counter to the predictions of the epistemic account.

In fact, one could take any of the examples from section 2 in which the speaker could not felicitously say *must ϕ*, embed the *must ϕ* statement into an overt deduction context like that in (19a), and by doing so, the judgments switch from infelicitous to felicitous.

(20) Bonnie, the bird expert from example (8), cannot felicitously say to her friend, "It must be a cardinal." But suppose she is explaining to her friend how it is that she knows for sure that it is a cardinal. Bonnie says:

>   a. If a bright red bird has a red crest with a black mask and throat, then it is a cardinal.
>   This bright red bird has a red crest with a black mask and throat.
>   Therefore, it must be a cardinal.

(21) Phil, the cook from (10), cannot felicitously say, "Dinner must be ready." But suppose he is explaining to his daughter how it is that he knows for sure that dinner is ready. Phil says:

>   a. If the chicken and peas are done and the table is set, then dinner is ready.
>   The chicken and peas are done and the table is set.
>   Therefore, dinner must be ready.

I have argued that the epistemic account predicts Bonnie's and Phil's *must ϕ* utterances to be infelicitous. This result is correct for (8) and (10), but not for (20) and (21). So the evidence is divided: some of it cuts in favor of the epistemic account, and some against it.[13]

Even a speaker like Billy who directly sees rain, can felicitously say *must ϕ* in a deduction context.

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13 Note that any account of the felicity conditions of epistemic *must*—epistemic, indirect or otherwise—would have a similar problem when faced with these shifting judgments. The issue is that nothing about the modal bases has changed from (8) to (20) or (10) to (21) even though the felicity judgments have. So any account that makes the right predictions for (8) and (10) makes the wrong predictions for (20) and (21), and vice versa. Something extra needs to be said to distinguish the former contexts from the latter.

(22)   Billy from (12) cannot felicitously say upon seeing rain, "It must be raining." But suppose she is talking to her sister on the phone, and her sister has denied that it could be raining and has demanded repeatedly that Billy explain how she knows for sure that it is raining. At her wits' end, Billy says:

    a.   If light enters your eyes in such a way that it looks like rain, then it is raining.
Light is entering my eyes in such a way that it looks like rain.
Therefore, it must be raining.

Both the epistemic account *and* the indirectness account predict Billy's *must* ϕ utterance to be infelicitous, which is correct for (12), but incorrect for (22). So the fact that *must* ϕ can appear in the conclusions of deductions is a problem for both the epistemic account and the indirectness account.

There are two quick explanations of these deduction contexts that could be offered, the first more favorable to the epistemic account, the second to the indirectness account. One could claim that in the specific linguistic context of a deduction, the speaker acts as if she does not yet know ϕ, even though she may in fact already know it. This suspension of knowledge satisfies the epistemic presupposition, and allows epistemic *must* to be felicitously uttered.[14] One could also claim that in these deduction contexts, the speaker acts as if her evidence for ϕ is indirect, even though her evidence for ϕ may in fact be direct. This suspension of directness satisfies the indirectness presupposition, and allows epistemic *must* to be felicitously uttered. Looking again at the data, either explanation seems plausible, and depending on one's position, it is clear which option one should choose. However if one chooses the option that is favorable to the indirectness account, this only explains the data in this section. An explanation for the evidence and arguments against the indirectness account in sections 2 and 3 would still be needed. Since the epistemic account already explains the data in section 2, the first option seems more desirable.

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14 An anonymous *Semantics & Pragmatics* reviewer suggests that perhaps the speaker takes on the perspective of the hearer, who does not know ϕ, and from the hearer's perspective *must* ϕ is felicitous. The reviewer believes such examples are distinct from deduction contexts because the reasoning relies on some reasonable assumptions (to put it in my terms). However, as I have argued above, the inferences to ϕ in the cardinal example (8) and dinner example (10) do not rely on reasonable assumptions, but are rock-solid deductions. The deductions are no less solid in (20) and (21). Nevertheless, I think it is plausible that such examples may involve the speaker taking the hearer's perspective. Perhaps not yet seeing how the deduction works and laying it out explicitly suspends knowledge long enough to meet the epistemic presupposition.

However, there may be a reason to reject either of these explanations of deduction contexts. We have been seeking to explain the weakness or non-confidence intuition that arises from epistemic *must* utterances like (1a) since section 1. But as both von Fintel & Gillies (2010: p. 362) and Lassiter (2016: his section 4.1) say of *must* ϕ in deduction contexts, there is no good sense in which they are weak. That is, the weakness or non-confidence signal of canonical epistemic *must* ϕ utterances is missing in these deduction contexts. vF&G claim that the non-confidence signal results from indirectness, and that *must* ϕ is felicitous in deduction contexts because they are indirect inferences to ϕ. But if indirectness gives rise to non-confidence and deductions are indirect, then why don't we get a non-confidence intuition in such contexts? The answer cannot be that indirectness only gives rise to non-confidence in *some* contexts, but not in deductions because they are too sure or confident, since according to the indirectness account every use of *must* ϕ relies on directly known premises, so there is no good sense in which overt deduction contexts are more sure or confident than other uses of epistemic *must*. Likewise, I have explained the weakness/non-confidence intuition as resulting from the requirement that the speaker's modal base $\bigcap Epi$ is not settled with respect to ϕ. But if *must* ϕ is felicitous in deduction contexts because the speaker suspends her knowledge, then why don't we get a weakness intuition?

Another explanation of deduction contexts has been offered. Giannakidou & Mari (2016) have argued that the *must* in deductions is not epistemic, but is instead alethic (i.e. logical or root necessity), which quantifies over all possibilities and says that ϕ holds in all of them. Such a modal would necessarily lack the felicity requirements that I have explored in this paper and would therefore be felicitous in deduction contexts. This hypothesis may find an antecedent in the distinction between objective and subjective epistemic modality proposed by Lyons (1977). Subjective epistemic modality, which has been the main subject of this paper, is relative to an agent and based on some reasonable assumptions. Lyons (p.791) glosses subjective *must* ϕ as "I (confidently) infer that [ϕ]." As for objective epistemic modality, Lyons notes that it is more closely related to alethic modality, and says that one may be reducible to the other. He glosses objective *must* ϕ as (p.792) "In the light of what is known, it is necessarily the case that [ϕ]." Building from these insights (but not necessarily Lyons's analysis of them), subjective epistemic modality could be analyzed as I have done in (14), following Kratzer (1991) and Giannakidou & Mari (2016), as a universal quantifier over *Best*. Objective epistemic modality would be analyzed as a universal quantifier over the realistic set $\bigcap Epi$. Assuming that objective epistemic modality is reserved for deduction contexts, this would straightforwardly explain the fact that a weakness/non-

confidence intuition arises from e.g. Amelia's *must* ϕ utterance in (9), but not from Bonnie's deductive *must* ϕ in (20). An objective or alethic *must* reports that every $\neg\phi$-world is eliminated by what is known, while (subjective) epistemic *must* reports that every $\neg\phi$-world is eliminated given what is known *and* some reasonable assumptions. To further establish the existence of these two readings, Giannakidou & Mari (2016) point out that in deductive contexts, *must* typically receives phonological prominence. Compare this with the examples of epistemic *must* in sections 1 and 2, which sound strange with stress on *must*.

Under such an account of deduction contexts, what remains to be explained is why alethic or objective modality cannot be used by e.g. Bonnie in (8) considering that her $\bigcap Epi$ entails ϕ. I.e. why isn't (8a) able to be felicitously interpreted as objective or alethic modality? It may be that the availability of a bare assertion of ϕ—which, in conjunction with the knowledge norm of assertion, indicates that $\bigcap Epi \subseteq \phi$—blocks the use of alethic or objective *must* ϕ out of the blue. Such uses of *must* ϕ may be restricted to contexts in which the speaker explicitly lays out the known premises used to deduce ϕ.

More work on *must* ϕ in deduction contexts is needed. If *must* ϕ in deduction contexts is indeed a distinct flavor of modality, then such examples do not form part of the core data that a theory of epistemic modality should explain. A complete exploration of this approach awaits future research. A starting point may be to consider crosslinguistic data to see if there are lexical items that are reserved for deduction contexts that are different from the modals used in canonical cases of epistemic modality. The main point for present considerations is that deduction contexts do not provide clear evidence in favor of one account over the other since they are puzzling from the perspectives of both the epistemic account and the indirectness account.

5 Conclusion

In this paper, I have argued that the felicity conditions of epistemic modals are about whether or not the epistemic modal base $\bigcap Epi$ is settled with respect to the prejacent ϕ. If $\bigcap Epi$ entails or contradicts ϕ, then it is settled with respect to ϕ and *must* ϕ is infelicitous. If $\bigcap Epi$ neither entails nor contradicts ϕ, then *must* ϕ is felicitous. I have combined these felicity conditions with Kratzer's (1991) account of *must* ϕ to produce what I have called the epistemic account, an account that is roughly equivalent to that proposed by Giannakidou & Mari (2016). The result is that the speaker who utters *must* ϕ indicates that ϕ is true in all of the possible worlds compatible with what is known that are most optimal relative to a stereotypical ordering source, despite that ϕ does not hold in all worlds compatible with what is known. This result implements the

insight from Karttunen (1972) that *must* ϕ indicates that ϕ follows from known facts *and* reasonable assumptions. By making the reasonable assumptions a necessary component of such inferences to ϕ, the weakness or non-confidence intuition arising from utterances of epistemic *must* ϕ are straightforwardly explained. Reasonable assumptions, though reasonable, could turn out to be false, and if they do, then ϕ may not hold. So speakers who explicitly convey via their use of an epistemic modal that they rely on such reasonable assumptions send a signal that they are less than completely sure of ϕ.

On the way to drawing these conclusions, I considered context pairs designed to tease apart the epistemic account from the indirectness account proposed by von Fintel & Gillies (2010). In these context pairs, the agents have identical perceptual evidence, but nevertheless the felicity judgments about their *must* ϕ utterances differ. Rather than seeking to explain these asymmetries by claiming without further explanation that the propositions one concludes from perceptual evidence is context dependent, I used Lewis's (1996) theory of context dependent knowledge to shed light on how epistemic modal bases are constructed. The result is not just an explanation for why a skeptical epistemologist can utter *must* ϕ while a layperson cannot, but also an explanation of how perception relates to evidence which in turn relates to knowledge and the epistemic modal base. In particular, I argued that two agents with identical perceptions derive identical propositions representing their perceptual evidence. The difference between them is caused by whether they possess other expertise that, when combined with their perceptual evidence, enables them to conclude ϕ.

One implication of this work is that, though von Fintel & Gillies (2010) argue that there is a connection between epistemic modality and indirect evidentiality, the arguments presented here seem to suggest otherwise. However a serious exploration of whether there is in fact no connection between them would require systematically comparing the behavior of epistemic modals and indirect evidentials in the kinds of contexts discussed above, which I have not done. Whether and how epistemic modality relates to evidentiality is left to future work.

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