Epistemic modals, deduction, and factivity

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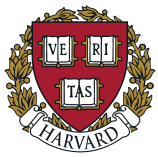


will

- English *will* has both a purely temporal interpretation and an epistemic interpretation:

(1) Anna **will** be home.

a. Anna will be home at some point in the future, e.g., at 7 pm. *FUT*✓

b. Given what I know, Anna is home right now. *EPI*✓

  - (a) is a non-modal assertion: there is no uncertainty.
  - (b) is a modal assertion: the speaker's best guess based on what she knows so far.

[Condoravdi, 2003]

cross-linguistically common

- Italian, Romanian, Dutch, Greek, German, French, Spanish ...

(2) Anna **sarà** a casa.
Anna will-be at home
'Anna will be at home.'
Italian; *FUT*✓, *EPI*✓

(3) Anna **va** fi acasă.
Anna will be home
'Anna will be home.'
Romanian; *FUT*✓, *EPI*✓

[Mihoc, 2014, Giannakidou and Mari, 2018, Ippolito and Farkas, 2018]

a specialized epistemic future form

- Romanian has a morphological form that is connected to the future BUT only has an epistemic reading:

(4) Anna **o** fi acasă.
Anna will be home
'Anna will be home.' *FUT*✗, *EPI*✓

- In this talk we will focus on this epistemic use of the future only.

[Mihoc, 2014]

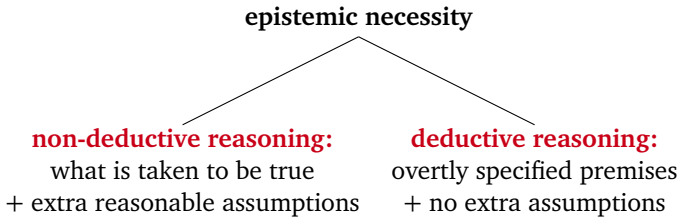
what is the epistemic future?

- Likened to an epistemic necessity modal:

(5) $[\![\text{Anna will be home now}]\!] = [\![\text{Anna must be home now}]\!]$

English: [Condoravdi, 2003]
Romanian: [Mihoc, 2014]
Greek & Italian: [Giannakidou and Mari, 2018]

epistemic necessity



[Karttunen, 1972, von Fintel and Gillies, 2010, Goodhue, 2017]

non-deductive vs. deductive

(6) Context: Anna is conscientious about saving energy. We are passing by her house, and see her lights on. I say: (non-deductive)
Anna **must** be home now.

(What is taken to be true: light on)
(Extra reasonable assumptions: If light is on, one is at home, Anna wouldn't leave the light on if she's not home)

(7) If x is divisible by 2, then x is even.
2 is divisible by 2. (deductive)
So, 2 **must** be even.

(What is taken to be true: If x is divisible by 2, then x is even, 2 is divisible by 2)
(No extra assumptions)

[Lassiter, 2016, Goodhue, 2017]

today: two puzzles

- In a DEDUCTION context, only *must* is felicitous while the epistemic future is not:

(8) If x is divisible by 2, then x is even.
2 is divisible by 2.

a. So, 2 **must** be even.

b. #So, 2 **will** be even.

c. #Deci, 2 **va** fi par.
so 2 VA be even

d. #Deci, 2 **o** fi par.
so 2 O be even

today: two puzzles

- In a FACTIVE context, again only *must* is felicitous while the epistemic future is not:

(9) a. I just found out that Anna **must** be in Honolulu now.

b. #I just found out that Anna **will** be in Honolulu now.

c. #Tocmai am aflat că Anna **va** fi în Honolulu acum.
just have.1SG found.out that Anna VA be in Honolulu now

d. #Tocmai am aflat că John **o** fi în Honolulu acum.
just have.1SG found.out that Anna O be in Honolulu now

	must	*will*-EPI/*va*-EPI / *o*
deductive context	✓	✗
embedding under factive	✓	✗

preview

MAIN QUESTION:
If ⟦epistemic future⟧ = ⟦epistemic must⟧, then why should these puzzles emerge?[1]

MAIN IDEAS

- maintain that there is a common core: epistemic necessity semantics [Kratzer 1977, 2012]

- DEDUCTION contexts
  - p is entailed
  - epistemic *must* tolerates an empty ordering source; compatible with entailing p
  - the epistemic future does not and thus does not entail *p*

- FACTIVE contexts
  - the factive presupposition is interpreted relative to the modal base of the epistemic modal; amounts to a requirement that the modal base should entail *p*
  - *must* can satisfy the factive presupposition
  - the epistemic future cannot satisfy the factive presupposition

[1] [Fălăuș and Laca, 2014], [Ippolito and Farkas, 2018] have questioned this claimed equivalence as well.

modal semantics

(10) Anna must be home.

- an EPISTEMIC MODAL BASE f:

(11) $f(w) = \{p : p \text{ is taken to be true at } w\}$; $\bigcap f(w) = \{w : w \text{ is in every } p \text{ in } f(w)\}$

- an ORDERING SOURCE g:

(12) $g(w) = \{p : p \text{ is a reasonable assumption at } w\}$

  - $g(w)$ imposes an ordering on $\bigcap f(w)$:

(13) $\forall w, z \in \bigcap f(w) :\ w \leq_{g(w)} z$ iff $\{p : p \in g(w) \text{ and } w \in p\} \supseteq \{p : p \in g(w) \text{ and } z \in p\}$

  - $Best$ picks out the $g(w)$-best worlds in $\bigcap f(w)$:

(14) $Best(\bigcap f(w), g(w)) = \{w \in \bigcap f(w) : \neg\exists w' \in \bigcap f(w) :\ w' \leq_{g(w)} w\}$

  - universal quantification over $Best$:

(15) $[\![\text{must}]\!]^{w,g} = \lambda f_{\langle s,\langle\langle s,t\rangle t\rangle\rangle} . \lambda g_{\langle s,\langle\langle s,t\rangle t\rangle\rangle} . \lambda p_{\langle s,t\rangle} . \forall w' \in Best(\bigcap f(w), g(w))[p(w')]$

epistemic *must* and epistemic future

- have the same truth conditions:

(16)

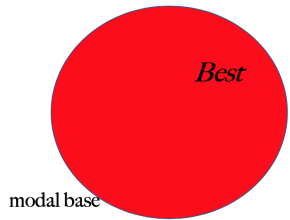
a. $[\![\text{must}]\!]^{w,g} = \lambda f\,.\,\lambda g\,.\,\lambda p\,.\,\forall w' \in Best(\bigcap f(w), g(w))[p(w')]$

b. $[\![\text{will-EPI/va-EPI/o}]\!]^{w,g} = \lambda f\,.\,\lambda g\,.\,\lambda p\,.\,\forall w' \in Best(\bigcap f(w), g(w))[p(w')]$

- given this shared semantics, why do we see different distributions in deduction and factive contexts?

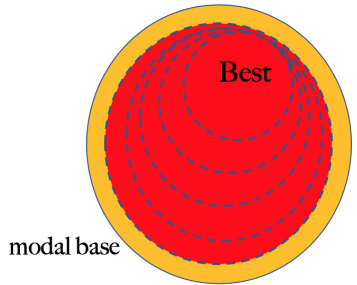
proposal: deduction

- $\mathbf{f(w)}$ = what is taken to be true = just overtly uttered premises
- $\mathbf{g(w)} = \emptyset$ (no extra assumptions)
- $Best = \bigcap f(w)$, w is necessarily in $Best$
- consequence: ***[universal modal] p* entails** p
- no uncertainty about the validity of p
- this captures the deductive use of *must*



proposal: non-deduction

- $\mathbf{f}(\mathbf{w})$ = what is taken to be true
- $\mathbf{g}(\mathbf{w})$ = extra reasonable assumptions
- $Best \subset \bigcap f(w)$, w may not be in $Best$
- consequence: ***[universal modal] p* does not entail *p***
- uncertainty about the validity of p
- this captures the non-deductive use of *must*

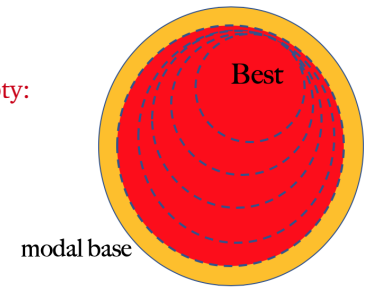


proposal: epistemic future

- **f(w)** = what is taken to be true
- **g(w)** = extra reasonable assumptions
  - crucially, like in the non-deduction case, $g(w)$ not empty:

(17) $[\![\text{will-EPI/va-EPI/o}]\!]^{f,g}$ is defined iff $g(w) \neq \emptyset$

- $Best \subset \bigcap f(w)$, w may not be in $Best$
- uncertainty about the validity of p
- captures why the epistemic future is never deductive



capturing the deduction puzzle

	must	*will*-EPI/*va*-EPI / *o*
deductive context	✓ $g(w) = \emptyset$	✗ $g(w) \neq \emptyset$
embedding under factive	✓	✗

prediction about plain assertions

- On our analysis of the deductive use of *must*, *must p* entails *p*.
- Just like a plain assertion!
- Therefore, we predict they can be used interchangeably in such contexts.

(18) If x is divisible by 2, then x is even.
2 is divisible by 2.

a. 2 **must be** even.
b. 2 **is** even.

factive contexts

(19) a. I just found out that Anna **must** be in Honolulu now.

b. #I just found out that Anna **will** be in Honolulu now.

c. #Tocmai am aflat că Anna **va** fi în Honolulu acum.
just have.1SG found.out that Anna VA be in Honolulu now

d. #Tocmai am aflat că John **o** fi în Honolulu acum.
just have.1SG found.out that Anna O be in Honolulu now

- **How is an epistemic modal interpreted under a factive predicate?**
- **How is the epistemic future interpreted under a factive predicate?**

factive attitude predicate semantics

- Attitude predicate:

(20) $[\![\text{believe p}]\!]^w = \lambda x\,.\,\forall w' \in Acc_{Dox,x}[p(w')]$

- *Factive* attitude predicate:

(21) $[\![\text{know p}]\!]^w = \lambda x : p(w) = 1.\,[\![\text{believe}]\!]\,(p)(x)(w) = 1$

[Hintikka, 1962, Anand and Hacquard, 2013, Spector and Egré, 2015]

proposal: factive with modal complement

(22) $[\![\text{know that } \Box \text{ p}]\!]^w = \lambda x : [\![\Box \text{ p}]\!](w) = 1.\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$

- Unpacking the presupposition, we get:

(23) $\forall w' \in Best(\bigcap f(w), g(w))[p(w')] = 1$

- **Hypothesis:** The factive requires $g(w) = \emptyset$.
- The presupposition becomes:

(24) $\forall w' \in \bigcap f(w)[p(w')] = 1$

- Putting it all together:

(25) $[\![\text{know that } \Box \text{ p}]\!]^w$
$= \lambda x : \forall w' \in \bigcap f(w)[p(w')].\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$

proposal: necessity under factives

(26) $[\![\text{know that must p}]\!]^w$ $g(w) = \emptyset$ ✓
$= \lambda x : [\![\text{must}]\!](p)(w).\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$
$= \lambda x : \forall w' \in \bigcap f(w)[p(w')].\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$

- prediction: it should **able to embed under a factive** only with a **deductive** meaning

(27) $[\![\text{know that will p}]\!]^w$ $g(w) = \emptyset$ ✗
$= \lambda x : [\![\text{will}]\!](p)(w).\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$
$= \lambda x : \forall w' \in \bigcap f(w)[p(w')].\ [\![\text{believe that } \Box \text{ p}]\!](x)(w) = 1$

- prediction: it should be **unable to embed under a factive**

capturing the factivity puzzle

	must	*will*-EPI/*va*-EPI / *o*
deductive	✓ $g(w) = \emptyset$	✗ $g(w) \neq \emptyset$
embedding under factive[†]	✓ $g(w) = \emptyset$	✗ $g(w) \neq \emptyset$

[†] $\forall w' \in \bigcap f(w)[p(w')] = 1$

prediction I: possibility under factives

(28) I just found out that Anna **might** be in Honolulu.

- Our hypothesis about the shape of the factive presupposition gives us possibility for free:

(29) $[\![\text{know that } \Diamond \text{ p}]\!]^w = \lambda x : \exists w' \in \bigcap f(w)[p(w')] = 1. [\![\text{believe that } \Diamond \text{ p}]\!](x)(w) = 1$

- This presupposition merely requires the modal base to be compatible with p.
- This condition is very easy to meet.
- Captures is why, cross-linguistically, possibility is much easier to embed.[2]

[2] [Rett, 2012] for English, [Anand and Hacquard, 2014] for Romance.

prediction II: necessity under non-factive epistemic attitudes

- When the factive presupposition is missing, we do not run into the above problems.
- A variety of non-factive epistemic attitudes can embed these modals.

(30) a. John thinks/believes/suspects Anna **might** be home.

b. John thinks/believes/suspects Anna **must** be home.

c. John crede/crede/bănuieşte că Anna **o** fi acasă
John thinks/believes/suspects that Anna O be home

- Need for more work to identify cross-linguistic patterns of embedding epistemic modals/epistemic future.

an alternative proposal

- Our solution to the factive puzzle crucially relied on the assumption that the modal in the factive presupposition had to be interpreted only relative to the modal base.
- An alternative would be to say that *know [modal] p* presupposes simply *p*.
- This would give us the *know must p* case:
  - *must p* allows a use where it entails p, and therefore satisfies the presupposition.
- This would give us the *know will p* case:
  - *will p* cannot entail *p*, it is unembeddable under a factive.
- But this gives us the wrong result for epistemic possibility:
  - *might p* does not entail *p*, but is very embeddable under factives.

conclusion

- OVERALL: A comparative analysis of **epistemic future** and **epistemic modality**.
  - revealed crucial differences in deductive and factive contexts, using **Romanian *o*** as a control
  - maintained a unified core modal semantics
  - derived the differences from restrictions on domains of quantification
- New insights about epistemic *must* along the way.
  - captured both the non-deductive and deductive uses of epistemic *must*
- A compositional account of how an epistemic modal/future interacts with the **factive presupposition**.
  - captured a distributional fact about embedding *must* vs. *might*

conclusion

- A new **underspecification** account of *must*.[3]
- A unified approach to **deduction and factivity**.
- A **refined** view of the interaction between epistemics and attitudes.

[3] Ruling out an undesirable lexical ambiguity account.

outlook

- Why is the future involved in epistemic/temporal ambiguity in language after language?
  - the often non-settled nature of the future makes it a natural choice for uncertainty
  - past morphology often coincides with DIRECT evidentiality cross-linguistically

outlook

- So far we have looked at contexts where the epistemic future is infelicitous while *must* is not.
- There are cases where the opposite is true! [Fălăuș and Laca, 2014, Ippolito and Farkas, 2018]

(31) a. I don't have the slightest idea, he **#must** be home. (Moore's paradox?)

b. Habar n-am, **o** fi acasă.
I have no idea, O be home

- The epistemic future is compatible with an assertion of full ignorance, while *must* is not.
- Why?

Thank you!

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