Where Force Matters: Embedding Epistemic Modals (and Attitudes)

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This talk features the Slovenian verb *dopuščati* (‘let’, ‘to allow for the possibility that’), analysed as an existential doxastic attitude verb.

(1)  
\[\text{Dopuščam (možnost), da sem se zmotila.}\]  
\[\text{I allow possibility that aux refl made.a.mistake}\]  
\[\text{‘I allow for the possibility that I made a mistake.’}\]  

b.  
\[\text{Othello dopušča, da Desdemona ljubi Cassija.}\]  
\[\text{Othello allows that Desdemona loves Cassio}\]  
\[\text{‘Othello allows for the possibility that Desdemona loves Cassio.’}\]  

c.  
\[\text{(seveda dopuščam da obstajajo določene izjeme. ampak jih of.course I.allow that exist certain exceptions but them še nisem srečala) yet not aux come.across}\]  
\[\text{‘(of course I allow for the possibility that there are certain exceptions. but I haven’t yet come across them)’ (web)}\]

There has been much recent interest in the analysis and distribution of embedded epistemic modals, especially in the types of examples akin to (2).

(2)  
Suppose you wake up late one morning (so it’s already bright outside) and you’re too lazy to open your eyes.

a.  
\[\text{Mislim, da utegne biti sončno.}\]  
\[\text{I.think that might be sunny}\]  
\[\text{‘I think it might be sunny.’}\]  

b.  
\[\text{Mislim, da mora biti sončno.}\]  
\[\text{I.think that must be sunny}\]  
\[\text{‘I think it must be sunny.’}\]

Under *dopuščati*, however, an embedded universal epistemics is odd, as in (3b). My goal is to explain why (3b) is odd.

(3)  
\[\text{Dopuščam, da utegne biti sončno.}\]  
\[\text{I allow that might be sunny}\]  
\[\text{‘I allow for the possibility that it might be sunny.’}\]  

b.  
\[\text{#Dopuščam, da mora biti sončno.}\]  
\[\text{I allow that must be sunny}\]  
\[\text{‘I allow for the possibility that it must be sunny.’}\]

I reanalyse doxastic attitudes and epistemic modals and propose that (3b) is odd because the embedded modal makes it contextually equivalent to (2b).
1. Dopuščati: Existential Belief

Dopuščati seems to be cross-linguistically uncommon. (The only other verb that I’m aware of is the Russian cognate dopuskat’.)

Intuitively, it expresses that the attitude holder is leaving something open. Unsurprisingly then, the following conjunction is not contradictory:

\[(4) \quad \text{a. Dopuščam, da dežuje, in dopuščam, da ne dežuje.} \]
\[\text{I allow that it rains and I allow that not rains.} \]

‘I allow for the possibility that it’s raining and I allow for the possibility that it’s not raining.’

The intuition that the attitude holder is leaving something open arises through an implicature, since dopuščati can be reinforced into belief:

\[(5) \quad \text{In a debate with Flat-Earthers, a scientist is asked:} \]
\[\quad \text{Ali dopuščate, da je Zemlja okrogla?} \quad \text{Q: you allow that the Earth is round} \]
\[\quad \text{‘Do you allow for the possibility that the Earth is round?’} \]
\[\quad \text{The scientist replies:} \]
\[\quad \text{Seveda dopuščam, da je – trdno verjamem, da je!} \quad \text{cf. some…in fact...} \]
\[\quad \text{of course I allow that is firmly I believe that is} \]
\[\quad \text{‘Of course I allow for the possibility that it is – I firmly believe that it is!’} \]

Dopuščati is arguably not a knowledge verb (e.g. a know counterpart), since there is no such thing as false knowledge.

\[(6) \quad \text{Dežuje, ampak Janez ne dopušča, da dežuje.} \]
\[\text{rains but John not allows that rains} \]
\[\text{‘It’s raining but John doesn’t allow for the possibility that it’s raining.’} \]

2. Embedding Epistemic Modals

In (2)–(3) the attitude holder considers his own available evidence. In such anchored cases, a universal epistemic is odd under an existential doxastic:

\[D \diamond p \quad B \boxdot p \quad B \Box p \quad \# D \Box p \]

The oddness seems to be about the wide-scope universal meaning in the complement of dopuščati, rather than the force of the modal item per se.
(7) Context: as in (2).

\#Dopuščam, da ne more deževati.

I.allow that not can rain

'I allow for the possibility that it can't be raining.'

It is more difficult to find examples of \( \neg \Box \) with an epistemic interpretation (and morati is a PPI). Here is an example with 'be necessary':

(8) Context: discussion on a forum about the borderline personality disorder (BPD). The speaker has just stated that certain feelings (e.g. isolation) were in large part responsible for him developing BPD. Dopuščam možnost, da ni mogoče, da sem prinesel "tako" I.allow possibility that is not necessary that aux brought such hude poškodbe in bil zato lahek plen MOMa, a vendar bad injuries and been therefore easy prey BPD but nevertheless nameravam še posvetiti kopanju v to smr. I.intend still dedicate digging in this direction 'I allow for the possibility that it is not necessarily the case that having such bad wounds made me easy prey to BPD, but I intend to investigate this further.' (web)

Plausibly, then, the pattern is in fact:

\[
\begin{array}{c}
B \Box \psi \\
B \neg \Box \psi \\
\hline
D \Box \psi \\
D \neg \Box \psi \\
\hline
#D \Box \phi \\
#D \neg \Box \psi
\end{array}
\]

I will focus on the positive cases, but let's keep in mind that we want to preserve duality \( \Diamond p = \neg \Box \neg p \) between existential and universal epistemics.

This is a common desideratum in any case.

Two Brief Notes on \( D \Diamond p \)

- speakers describe the embedded modal in \( D \Diamond p \) sometimes as 'redundant' and sometimes as 'adding tentativeness'
- \( D \Diamond p \) is intuitively felt to be weaker than \( B \Diamond p \)

(9) Context: Othello is asked whether he thinks that Desdemona is cheating on him. He replies:

a. Dopuščam, da me (mogoče) vara.
   I.allow that me (maybe) cheats.on
   'I allow for the possibility that she is (perhaps) cheating on me.'

b. Mislim, da me mogoče vara.
   I.think that me maybe cheats.on
   'I think she might be cheating on me.'
Negated attitudes pose a challenge of their own by adding another oddness into the mix.

(10) Context: You, me, and John see Bob go home from work early. We sit down on some couches in front of Bob’s office. John has his back turned to Bob’s door. He puts on some headphones and starts cheating on the latest homework. After a while, Bob, who has a secret entry to his office, which he used to come back, creeps out of his office and comes up behind John’s back. John, still immersed in cheating, does not notice this. I nudge you and whisper, with both of us staring at Bob:

a. John does not think that Bob might be behind his back.  \(\neg D\Box p\)

b. John does not think that Bob must be behind his back. \(?\neg D\Box p\)

c. Janez ne misli, da je Bob mogoče za njegovim hrbtnom. John not thinks that is Bob maybe behind his back. 'John does not think that Bob might be behind his back.'

d. Janez ne misli, da mora biti Bob za njegovim hrbtnom. John not thinks that must be Bob behind his back. 'John does not think that Bob must be behind his back.'

e. Janez ne dopušča, da je Bob mogoče za njegovim hrbtnom. John not allows that is Bob maybe behind his back. 'John does not allow that Bob might be behind his back.'

f. Janez ne dopušča, da mora biti Bob za njegovim hrbtnom. John not allows that must be Bob behind his back. 'John does not allow that Bob must be behind his back.'

Finally, notice also the contrast between (10b)/(10d) and (11).

(11) It’s not the case that John thinks that Bob must be behind his back.

3. Embedding Doxastic Attitudes Are Different

Embedded existential attitudes (\(\#DDp\)) differ in oddness from embedded existential modals (\(D\Box p\)).

(12) \#Dopuščam, da dopuščam, da sem se zmotila. I allow that I allow that aux refl erred

'I allow for the possibility that I allow for the possibility that I made a mistake.'

The intuition for oddness in (12) is that speakers are taken to be authorities on their own beliefs (and it is odd for one to not be sure, as above). The crucial point is that no such inference arises with \(D\Box p\).
4. Roadmap

Idea: a sentence like (3d) ($\#D\square p$) is odd because it ends up expressing a contextually equivalent proposition to (3b) ($B\square p$), à la Magri:

\[(13)\]

\begin{enumerate}
\item $\#D\square p$
\item $D\square p$
\item $\#\neg B\square p$
\item $\#\neg D\square p$
\end{enumerate}

Likewise for (12).

\begin{enumerate}
\item $\#D\square p$
\item $D\square p$
\item $\#\neg B\square p$
\item $\#\neg D\square p$
\end{enumerate}

special intonation (wide-scope negation)

Likewise for (12).

Desiderata for contextual entailment:

\[D\diamond p \quad B\diamond p \quad \#D\square p\]

\[\#\neg D\square p\]

\[\neg D\diamond p\]

\[\neg B\diamond p\]

\[B\square p\]

Plan: Re-think the meaning of doxastic attitudes and epistemic modals to obtain these equivalences. Use Magri’s theory to derive oddness.
5. The Meaning of Epistemic Modals and Doxastic Attitudes

1. Epistemic modals are local (Mandelkern, 2018). By default (i.e. unless shifted) epistemic modals are sensitive to the information that is locally provided to them. When embedded under belief, epistemic modals quantify over the attitude holder’s belief worlds.

\[
\forall v \in B^w_J : g(i)(v) \subseteq B^w_J .
\]

Locality under belief: A way to understand this is that our individual beliefs can serve as pieces of evidence (e.g. my belief that it’s raining can be evidence for John being in the house). An epistemic modal under a belief predicate is restricted by this body of evidence (=the attitude holder’s beliefs). A way to think of proper subsets is that we can also consider completely unreliable evidence, i.e. propositions that are merely consistent with our beliefs (e.g. ‘the weather report is accurate’).

Example of a modal base function that obeys locality under belief.


2. Doxastic attitudes differ in their content

Verbs like misliti (‘think’) and dopuščati (‘allow for the possibility that’) differ in how they structure the doxastic state in terms of prominence (what they make salient/highlight).

Misliti (‘think’) makes salient the doxastic state as is, while dopuščati makes salient the (set of) witnesses to its existential statement. (In terms of event semantics, we might say that it highlights the event of allowing for a possibility.)

The term is from Roelofsen and van Gool (2010), where it’s used for Is the door open? making salient (=highlighting) the proposition that the door is open (cf. Is the door closed?). I don’t know if the two notions of highlighting are related.

3. Epistemic modals are total/complete

People don’t only rely on unreliable evidence, such as ‘the weather report is accurate’. We take our beliefs to be reliable evidence for navigating the world. This constraint embodies the idea that people are assumed to actively consider reliable evidence (the modal base function maps at least some (relevant) worlds onto a proposition that one believes, e.g. ‘my mother is always right’).

Totality under belief: A way to understand this is that our individual beliefs can serve as pieces of evidence (e.g. my belief that it’s raining can be evidence for John being in the house). An epistemic modal under a belief predicate is restricted by this body of evidence (=the attitude holder’s beliefs). A way to think of proper subsets is that we can also consider completely unreliable evidence, i.e. propositions that are merely consistent with our beliefs (e.g. ‘the weather report is accurate’).

\[
\exists v \in f(B^w_J) : B^w_J \subseteq g(i)(v)
\]

For any belief world v: the modal base from v forms a subset of the doxastic set.

There is a world v in the salient part of the belief state (given by f) such that the modal base from v is a superset of the doxastic set.
Locality + Totality:

How Totality (assuming Locality) brings about a difference between *must* and *might*:

This is why $D \square p$ becomes contextually equivalent to $B \square p$, while $D \lozenge p$ remains weaker than $B \lozenge p$. 

See Appendix for the details of interaction.
6. Oddness

(14) #Some Italians come from a warm country.

Magri’s analysis in a nutshell:

- a covert operator \( \text{Exh} \) in the grammar that looks at the scalar alternatives (computed from Horn-scales, e.g. \{some, all\}), asserts (14) and negates the alternatives that can (semantically) consistently be negated with (14), in this case: All Italians come from a warm country
- Some but not all Italians come from a warm country is a contextual contradiction
- but implicatures are cancellable? Magri: \( \text{Exh} \) is “blind” to common knowledge (e.g. that Italians come from the same country), so as far as \( \text{Exh} \) is concerned it outputs a semantically consistent meaning. The relevance predicate \( \mathcal{R} \) makes the implicature obligatory.

**Embedded Modals**

It is common knowledge that Italians come from the same country. Similarly, there are some shared assumptions about how speakers reason with evidence and thereby with modals when they have an epistemic flavour. Taking the ingredients from the previous section, we can obtain the desired equivalences:

\[
\begin{align*}
D \diamond p & \iff B \square p \\
#D \square p & \iff -B \diamond p \\
#-D \square p & \iff -D \diamond p
\end{align*}
\]

Magri’s theory makes the following predictions under minimal relevance (\( \mathcal{R} \) contains only the prejacent of \( \text{Exh} \) and anything contextually equivalent to it).

(15) a. \( \text{Exh}_{(D \square p, B \square p)}(B \square p) = B \square p \)
    b. \( \text{Exh}_{(D \square p, B \square p)}(D \square p) = D \square p \land \neg B \square p \)
    c. \( \text{Exh}_{(B \diamond p)}(B \diamond p) = B \diamond p \)
    d. \( \text{Exh}_{(D \diamond p)}(D \diamond p) = D \diamond p \)

This means that no matter what further evidence might be relevant in a particular context, it cannot “save” \( D \square p \) as long as Locality and Totality hold (because conjoining with a contradiction still produces a contradiction).
(16) a. \( Exh (\neg Exh_{D \circ p} (D \circ p)) (\neg Exh_{D \circ p} (D \circ p)) = \neg D \circ p \)
b. \( Exh (\neg Exh_{B \circ p} (B \circ p)) (\neg Exh_{B \circ p} (B \circ p)) = \neg B \circ p \)
c. \( Exh (\neg Exh_{D \circ p, B \circ p} (D \circ p)) (\neg Exh_{D \circ p, B \circ p} (D \circ p)) = \neg D \circ p \vee B \circ p \)

(17) (11) = \( Exh (\neg Exh_{D \circ p, B \circ p} (B \circ p)) (\neg Exh_{D \circ p, B \circ p} (B \circ p)) = \neg B \circ p \)
(10d) = \( Exh_{D \circ p, B \circ p} (\neg B \circ p) = \neg B \circ p \land D \circ p \)

A Note on Embedded Attitudes
Recall (12). There are two commonly assumed principles about how people reason with belief:
- positive introspection: \( B_i p \Rightarrow B_i B_i p \)
- negative introspection: \( B_i p \Rightarrow B_i \neg B_i p \)

Assuming that these are part of the common ground, we can understand why (12) is odd. In KD45 (a common logic of belief, which contains these two introspection principles), \( D D p \) is equivalent to \( B D p \) (same agent on both). This makes \( B D p \) obligatorily relevant, which makes the enriched meaning of (12) a contextual contradiction, as shown in (18).

(18) a. \( Exh_{D D p, B D p} (D D p) = D D p \land \neg B D p \)

7. Conclusion and Outlook

I argued that reasoning with evidence involves Totality and Mandelkern’s Locality and used competition between scalar items to explain the restricted distribution of embedded epistemic expressions. A crucial component of the analysis was the idea that doxastic attitudes differ in what part of the doxastic state they make salient and how epistemic modals exploit this.

Further Work:
- fleshing out the pragmatic implementation of Locality, Totality, and salience
- varying the evidence and the sources of evidence in the examples, seeing where Locality/Totality fail
- the cross-linguistic picture of doxastic attitudes: What do neg-raising verbs (like think/believe in English) compete with and what do they make salient?

\( \iff c \top \) (general puzzle for Magri: why does non-minimal relevance not kick in?)

Why no embedded exhaust? Might relate to how one would account for the corresponding Italians case (cf. p. 5).

Maybe along the lines of Romoli (2013), where it has a scalar alternative through which it gets the neg-raised interpretation.
Appendix: A semantics for doxastic attitudes and epistemic modals

If we didn’t have to worry about Magri’s theory of oddness and we just wanted to derive the desired equivalences semantically, we could do it as follows.

A slightly richer point of evaluation:

- a world of evaluation \( w \)
- an information state \( s \) a set of worlds (YalcIN, 2007)
- a highlighted state \( s' \) a set of worlds

Formulas are evaluated with respect to triples:

\[
\begin{align*}
(19) & \quad \text{extension: } [\mathbf{T}]_{c,g}(s,s',w) \\
& \text{intension: } \lambda(s',w) [\mathbf{T}]_{c,g}(s,s',w) \quad \text{(abbreviated as: } [\mathbf{T}]_{c,g}) \\
& \text{assertion: } \lambda w. [\mathbf{T}]_{c,g}(s,s',w) \quad \text{following Lewis (1980)}
\end{align*}
\]

Semantics of doxastic attitudes:

\[
\begin{align*}
(20) & \quad [\text{mislit}]_{g}(s,s',w)(A) = 1 \iff \forall w' \in B_{x}^{w} : [p]_{g}(B_{x}^{w}, B_{x}^{w}, w') = 1 \\
& \quad [\text{dopuščati}]_{g}(s,s',w)(p)(A) = 1 \iff \exists w' \in B_{x}^{w} : [p]_{g}(B_{x}^{w}, B_{x}^{w}, w') = 1
\end{align*}
\]

Semantics of epistemic modals:

\[
\begin{align*}
(21) & \quad [\text{must}]_{g}(s,s',w) = \lambda R: \forall v \in s[R(v) \subseteq s] & \forall v \in s' [s \subseteq R(v)],[\lambda p. \forall w'' \in R(w)[p(s,s', w'')] = 1] \\
& \quad [\text{might}]_{g}(s,s',w) = \lambda R: \forall v \in s[R(v) \subseteq s] & \forall v \in s' [s \subseteq R(v)],[\lambda p. \forall w'' \in R(w)[p(s,s', w'')] = 1]
\end{align*}
\]

I will assume that the two presuppositions accommodate into the restrictor of the attitude predicate (this is relevant when the presupposition contains a variable not bound within it, but bound by the attitude’s quantification).

Reminiscent of A boy pushed his bike to school (this boy, and not some other one, owns it).

\[
\begin{align*}
(22) & \quad [\text{John thinks it must be raining}]_{g}(s,s',w) = 1 \iff \\
& \quad [\text{thinks}]_{g}(s,s',w) ([\text{it must be raining}]_{g})[\text{John}] = 1 \iff \\
& \quad \forall w' \in B_{x}^{w}[\text{it must be raining}]_{g}(B_{x}^{w}, B_{x}^{w}, w') = 1 \iff \\
& \quad [\text{must}]_{g}(B_{x}^{w}, B_{x}^{w}, w')([\text{it is raining}]_{g})[\text{John}] = 1 \iff \\
& \quad \forall w' \in B_{x}^{w}[\text{must}]_{g}(B_{x}^{w}, B_{x}^{w}, w')([\text{it is raining}]_{g})[\text{John}] = 1 \iff \\
& \quad \forall v \in s[R(v) \subseteq s] & \forall v \in s' [s \subseteq R(v)],[\lambda p. \forall w'' \in R(w')][p(B_{x}^{w}, B_{x}^{w}, w'')] = 1])((g(i))([\text{it is raining}]_{g})[\text{John}] = 1 \iff \\
& \quad \forall w' \in B_{x}^{w}(\forall v \in B_{x}^{w}[g(i)(v) \subseteq B_{x}^{w}] & \forall v \in B_{x}^{w}[B_{x}^{w} \subseteq g(i)(v)])) \rightarrow \forall w'' \in g(i)(w')*[\text{it is raining at } w'']
\end{align*}
\]
(23) \[ \vdash \langle \text{Janez dopušča, da mora, deževati} \rangle^{(s, s', w)} = 1 \iff \text{ (D□p)} \]
\begin{align*}
\forall w' & \in B_{\text{phys}}[\text{mora}]^{g, (B_{\text{phys}}[\{w\}])} (g(i))(\text{deževanje})^{(p)} = 1 \iff \\
\forall w' & \in B_{\text{phys}}[\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall v \in \{w'\} [B_{\text{phys}} \subseteq g(i)(v)] & \forall w'' \in g(i)(w') \text{[it is raining at } w''] \iff \\
\forall w' & \in B_{\text{phys}}[\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w''] \iff
\end{align*}

(24) \[ \vdash \langle \dagger \rangle^{(s, s', w)} = 1 \iff \text{ (D□p)} \]
\begin{align*}
\forall w' & \in B_{\text{phys}}[\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w''] \iff \\
\forall w' & \in B_{\text{phys}}[\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w''] \iff
\end{align*}

(25) \[ \vdash \langle B_j \diamond \circ \neg \phi \rangle^{(s, s', w)} = 1 \iff \text{ (D□p)} \]
\begin{align*}
\forall w' & \in B_{\text{phys}}[(\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w'']] \rightarrow \exists w'' \in g(i)(w') [p(w'') = 0] \iff
\end{align*}

(26) \[ \vdash \langle B_j \diamond \circ \neg \phi \rangle^{(s, s', w)} = 1 \iff \text{ (D□p)} \]
\begin{align*}
\exists w' & \in B_{\text{phys}}[(\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w'']] \rightarrow \exists w'' \in g(i)(w') [p(w'') = 0] \iff
\end{align*}

(27) \[ \vdash \langle \neg B_j \circ \circ \phi \rangle^{(s, s', w)} = 1 \iff \text{ (D□p)} \]
\begin{align*}
\langle \neg B_j \circ \circ \phi \rangle^{(s, s', w)} = 1 & \iff \text{ (D□p)} \]
\begin{align*}
\forall w' & \in B_{\text{phys}}[(\forall v \in B_{\text{phys}}[g(i)(v)] \subseteq B_{\text{phys}}[w'] & \forall w'' \in g(i)(w') \text{[it is raining at } w'']] \rightarrow \exists w'' \in g(i)(w') [p(w'') = 0] \iff
\end{align*}

Appendix: Magri (2009, 2011)

(31) ‘The set Alt(φ) of scalar alternatives of the prejacent LF φ consists of those LFs that can be obtained from the target LF φ by replacing one or more scalar items in φ with their Horn-mates.’ (Magri, 2011, p. 7)
where force matters: embedding epistemic modals (and attitudes)  

(32) \[
\text{Exh}_R(\varphi) = \varphi \land \bigwedge_{\psi \in R \cap \text{Excl}(\varphi)} \neg \psi
\]  

(Magri, 2011, p. 9)

(33) 'The set \text{Excl}(\varphi) of alternatives excludable w.r.t. the prejacent \varphi consists of those scalar alternatives \psi \in Alt(\varphi) such that \psi can be negated consistently with \varphi.' (Magri, 2011, p. 8)

(34) **Blindness hypothesis**: 'The computation of excludable alternatives is blind to common knowledge, in the sense that excludable alternatives are those alternatives \psi that are logically consistent with the negation of the prejacent \varphi.' (Magri, 2011, p. 10)

(35) a. 'The negation of \psi contradicts \varphi given common knowledge iff there exists no possible world compatible with common knowledge where \varphi is true and \psi false.' (Magri, 2011, p. 10)
   b. 'The negation of \psi logically contradicts \varphi iff there exists no possible world where \varphi is true and \psi false.' (Magri, 2011, p. 10)

(36) a. The prejacent of the exhaustivity operator is relevant.
   b. If two propositions are contextually equivalent, then they pattern alike w.r.t. relevance, namely they are both relevant or else both irrelevant. (Magri, 2011, p. 10)

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