Introduction to natural language semantics
Class 9: de re/de dicto ambiguity, modals

1 De re/de dicto ambiguities

- When quantifiers (or definite descriptions) interact with intensional operators, they give rise to so-called *de re/de dicto* ambiguities.
- Here is an example where the relevant intensional context is an attitude verb.

(1) Alice believes that some MCMP member is a robot.

- Two readings:
  - De re: There is some MCMP member that A. believes to be a robot.
  - De dicto: A. believes that there are robots among the MCMP members.
- To bring out this difference we can consider two contexts.
  - Context 1. Alice met Norbert at the café and formed the conviction that he is a robot. She does not know that Norbert is an MCMP member.
    * De re $\rightsquigarrow$ true
    * De dicto $\rightsquigarrow$ false
  - Context 2. Alice thinks that the best mathematical philosophy is done by robots, and that the MCMP couldn't be a successful institute if it didn't have robots among its members. She has no suspicions about specific people.
    * De re $\rightsquigarrow$ false
    * De dicto $\rightsquigarrow$ true
- Can our semantics deliver both readings for (1)?
- Yes, we can capture this as a special case of scope ambiguity:
  - de re: quantifier takes scope above the attitude verb;
  - de dicto: quantifier takes scope below the attitude verb.

2 Modals

- A prominent class of intentional operators in natural languages is gives by *modals*. This includes:
  - modal auxiliaries: must, should, may, can, might, would, shall, will;
  - modal main verbs: have to, ought to, need to;
  - modal adjectives: obligatory, required, allowed, necessary, possible, ...

- We will focus on *must* and *may*.
- What we will see is supposed to be a general story on the semantics of modals, but of course, each modal also has its specific features.
- This story draws directly on the semantic analysis of modalities given in modal logic (especially by Carnap, Kanger, Montague and Kripke); it was refined and turned into a general story about modals in natural language by Angelika Kratzer.

2.1 The basic idea

- Imagine that we are playing a board game. Consider:

(2) a. Alice must take a card.
    b. Alice may take a card.

- These sentences can be factually true or false, depending on the rules of the game and on the current situation.
- Intuitively we could phrase the truth-conditions as follows:
  - (2-a) true iff all legal continuations of the game are continuations where Alice takes a card;
  - (2-b) true iff some legal continuations of the game are continuations where Alice take a card.
- We can model these conditions in the framework of intensional semantics.
- Let w be the actual world, and let $\sigma(w)$ be the set of worlds which coincide with w up to now, and where the game proceeds in accordance with the rules.
  - (2-a) true at w iff $\forall v \in \sigma(w)$: Alice takes a card at v
  - (2-b) true at w iff $\exists v \in \sigma(w)$: Alice takes a card at v
- This suggest the following ideas (essentially familiar from modal logic):
  - modals are quantifiers over sets of worlds;
  - the relevant set of worlds depends on the evaluation world;
  - *must* is a universal quantifier;
  - *may* is an existential quantifier.

2.2 Implementing the basic idea

- We add new sentential operators $\Box, \Diamond$ to our type theory (if $\varphi : t$ then $\Box\varphi, \Diamond\varphi : t$).
- Assume that we also enrich the notion of models (we will revise this later).
- A model comes with a map $\sigma : W \to \wp(W)$, i.e., a function mapping each world w to a set of worlds $\sigma(w)$, intended to model the set of legal continuations of w.

- We then give the semantics of our new operators as follows:
  - $[\![\Box\varphi]\!]^{M,g,w} = 1 \iff \forall v \in \sigma(w) : [\![\varphi]\!]^{M,g,v} = 1$
  - $[\![\Diamond\varphi]\!]^{M,g,w} = 1 \iff \exists v \in \sigma(w) : [\![\varphi]\!]^{M,g,v} = 1$
- Suppose that the sentences in (2) get the following translations.[1]

(3) a. Alice must take a card. $\Box Ta$
b. Alice may take a card. $\Diamond Ta$

- Then we obtain the expected truth-conditions:
  - $[\![\Box Ta]\!]^{M,g,w} = 1 \iff \forall v \in \sigma(w) : [\![Ta]\!]^{M,g,v} = 1$
  - $[\![\Diamond Ta]\!]^{M,g,w} = 1 \iff \exists v \in \sigma(w) : [\![Ta]\!]^{M,g,v} = 1$
- This analysis makes some very nice predictions. Here are some examples:
  1. Duality. $\Box\varphi \equiv \neg\Diamond\neg\varphi$ and $\Diamond\varphi \equiv \neg\Box\neg\varphi$.

     (4) a. Alice may stay.
     b. It is not the case that Alice must leave.

     (5) a. Alice must leave.
     b. It is not the case that Alice may stay.

  2. Distribution over $\wedge$.
     $\Box(\varphi \wedge \psi) \equiv \Box\varphi \wedge \Box\psi$, while $\Diamond(\varphi \wedge \psi) \not\equiv \Diamond\varphi \wedge \Diamond\psi$.

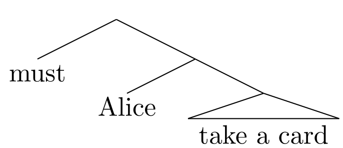
     (6) a. Alice must take a card and she must skip a round.
     b. Alice must take a card and skip a round.

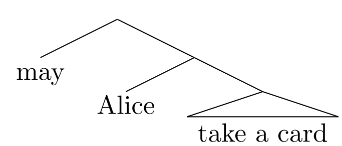
     (7) a. Alice may take a card and she may skip a round.
     b. Alice may take a card and skip a round.

  3. $\Box\varphi \wedge \Box\neg\varphi$ is contradictory; $\Diamond\varphi \wedge \Diamond\neg\varphi$ is consistent.

     (8) a. ??Alice must stay and she must leave.
     b. Alice may stay and she may leave.

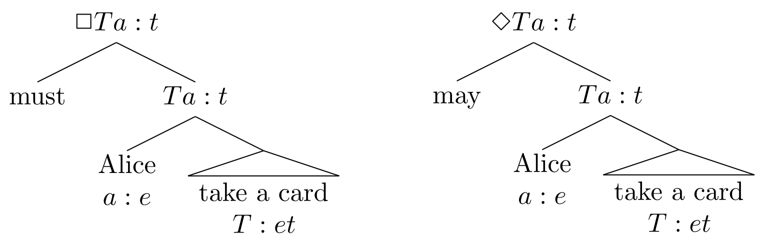
- Now let's turn to how the relevant form may be derived compositionally.
- We assume that modals are sentence level operators, that must move to adjoin an S node. So the syntactic structures of our sentences at LF are as follows:





[1] For simplicity I am treating here "take a card" as if it was an intransitive verb; in principle the presence of the indefinite "a card" gives rise to a *de re*/*de dicto* ambiguity, but we will put this aside, since for now we are only interested in the *de dicto* interpretation, which is the intended one here.

- To interpret these structures we add the following translation rule:
  - If A has daughters B, C where B is a leaf labeled by *must* and $C \rightsquigarrow \varphi : t$, then $A \rightsquigarrow \Box\varphi : t$.
  - If A has daughters B, C where B is a leaf labeled by *may* and $C \rightsquigarrow \varphi : t$, then $A \rightsquigarrow \Diamond\varphi : t$.
- Then we get the following derivations:



2.3 Accounting for modal flavours

- In the previous examples, the modals *must* and *may* were used to talk about what is required/permitted by the rules of the game.
- Of course, modals can be used to talk about what is required/permitted by other sets of rules: the official law, University regulations, rules set by the parents to their children, some shared moral code, etc.

(9) a. You may not park here.
b. You must submit your essay by the 20th of September.
c. You must be back by 10am.
d. You must not lie.

- These are known are *deontic* readings. They are about codes/sets of rules.
- But modals have other readings as well. Here are some examples.
- Teleological: modals talk about the possible means to achieve a result.

(10) Context: giving directions on the street.
a. You must turn right at the next stop.
b. You may walk for 10 minutes, or take the U-bahn for one stop.

- Epistemic: modals talk about the available information/evidence.

(11) Context: detective investigating a crime.
a. The culprit must be the butler.
b. The murder may have been committed before midnight.

- Bouletic: modals talk about the desires of an agent.

(12) a. You must stop being so rude!
b. You may keep the book—I don't need it.

- How to account for this variety of readings? Are modal ambiguous?
- Implausible, since this kind of variation is found cross-linguistically.
A unified account would be more parsimonious and more explanatory.
- Idea: in each case, the modal involves quantification over a set of worlds (dependent on the world of evaluation).
  - Deontic: set of worlds compatible with the (relevant) rules.
  - Teleological: set of worlds where you achieve your goal.
  - Epistemic: set of worlds compatible with what is known.
  - Bouletic: set of worlds compatible with speaker desires.
- *must* and *may* are still $\forall$ and $\exists$ over the relevant set.
- The flavor of the modal is determined in part by context (and in part by the specific modal used: see later).
- Context should supply the relevant *modal base*, i.e., a function $\sigma : W \to \wp(W)$.
- In fact, various modal bases might be salient in a context; they may give rise to an ambiguity, or may be relevant for the interpretation of different modals in a single sentence:

(13) Alice may pick a card. ambiguous: epistemic/deontic

(14) It may be that Alice must pick a card. epistemic > deontic

- How should this work, precisely?
- Consider the case of free pronouns, whose interpretation is an individual supplied by context.
- Context fixes the interpretation of pronouns by providing a relevant parameter g, which interprets each free variable x_i as an individual $g(x_i)$.
- One solution: postulate that the LF of modal sentences contains a free variable f of type $\langle s, st \rangle$, to be interpreted by the assignment as the relevant modal base.
- However, this requires a complicated re-structuring of our entry for the modal (you are encouraged to try to formulate this proposal).
- A simpler strategy: assume that, just like context provides a parameter g which fixes the interpretation of pronouns, it also provides a parameter σ which determines the interpretation of modals.
- We will assume that, at LF, modals, like pronouns, come with indices $i \in \mathbb{N}$.

- Our type theory will contain corresponding operators $\Box_i, \Diamond_i$, where $i \in \mathbb{N}$.
- The parameter σ will assign to each index i a modal base $\sigma_i : W \to \wp(W)$.
- A modal indexed by i is interpreted with respect to the modal base σ_i:
  - $[\![\Box_i\varphi]\!]^{M,g,\sigma,w} = 1 \iff \forall v \in \sigma_i(w) : [\![\varphi]\!]^{M,g,v} = 1$
  - $[\![\Diamond_i\varphi]\!]^{M,g,\sigma,w} = 1 \iff \exists v \in \sigma_i(w) : [\![\varphi]\!]^{M,g,v} = 1$
- As an illustration, suppose that we want to interpret the following sentence:

(15) Alice may take a card.

- Suppose that the context supplies a salient epistemic modal base σ_0 (what we know) and a salient deontic modal base σ_1 (the rules of the game).
- In order to interpret (15), we need to choose how to index the modal at LF.
- Given the salience of modal bases σ_0 and σ_1 the natural choices are 0 and 1:

(16) a. Alice may$_0$ take a card. $\Diamond_0 Ta$
b. Alice may$_1$ take a card. $\Diamond_1 Ta$

- This gives two different interpretations for (15):

(17) a. $[\![\Diamond_0 Ta]\!]^{M,\sigma,w} = 1 \iff \exists v \in \sigma_0(w) : [\![Ta]\!]^{M,\sigma,v} = 1$
it is compatible with what is known at w that Alice takes a card

b. $[\![\Diamond_1 Ta]\!]^{M,\sigma,w} = 1 \iff \exists v \in \sigma_1(w) : [\![Ta]\!]^{M,\sigma,v} = 1$
it is compatible with the rules of the game that Alice takes a card

- We predict an ambiguity for (15): on one reading, it is a claim about our information; on another, it is a claim about the rules of the game.
- So, we have a uniform treatment of *must* and *may* across different modal flavors.

2.4 De re/de dicto ambiguity with modals

- Like attitude verbs, modals also interact with quantifiers and descriptions to give rise to *de re*/*de dicto* ambiguities.

(18) Alice must solve some exercise on page 10.

  - De re: there is some exercise on page 10 which Alice is required to solve;
  - De dicto: it is required that Alice solve at least one exercise on page 10.

(19) Most students must get outside funding. (von Fintel and Iatridou 2004)

- De re: most students are such that they need to acquire outside funding. Continuation: the others have been given university fellowships.
- De dicto: it needs to be the case that most students get outside funding. Continuation: in order for the faculty budget to work out.

- As in the case of attitude verbs, we can account for this ambiguity by letting the quantifier take scope above or below the modal.

2.5 Some (among many more!) open issues

2.5.1 Specialization of modals

- Not all modals can be associated with all kinds of modal bases.

(20) Alice can play the piano.

a. $\rightsquigarrow$ Alice is allowed to play the piano (deontic)
b. $\rightsquigarrow$ Alice has the ability to play the piano (ability)
c. $\not\rightsquigarrow$ it is possible that Alice will play the piano (epistemic)

(21) Alice may play the piano.

a. $\rightsquigarrow$ Alice is allowed to play the piano (deontic)
b. $\not\rightsquigarrow$ Alice has the ability to play the piano (ability)
c. $\rightsquigarrow$ it is possible that Alice will play the piano (epistemic)

- In this respect, some modals behave like personal pronouns *he/she/it*: they put constraints on the kind of object that should be assigned to them in the context.

2.5.2 Modals and scope

- We saw that quantifiers can scope above or below modals, giving rise to de re/de dicto ambiguities. But these are not always available.
- E.g., von Fintel and Iatridou (2003) claim that epistemic modals always take wide scope:

(22) Everyone might have left

a. $\rightsquigarrow \Diamond(\forall x.Lx)$
b. $\not\rightsquigarrow \forall x.\Diamond Lx$

(recent work, however, indicates that they only *tend* to take wide scope).

- Also, modal auxiliaries interact in different ways with negation.

(23) Alice must not leave.

a. $\rightsquigarrow \Box\neg La$
b. $\not\rightsquigarrow \neg\Box La$

(24) Alice may not leave.

a. $\rightsquigarrow \neg\Diamond La$ (preferred with deontic)
b. $\rightsquigarrow \Diamond\neg La$ (preferred with epistemic)

2.5.3 Weak necessity modals

- The modals *should/ought* seem intermediate in strength between *must* and *may*.

(25) a. Alice must leave.
b. Alice should leave.
c. Alice may leave.

- If *must* and *may* correspond to $\forall$ and $\exists$, what does *should* correspond to?

2.5.4 Free choice inferences

- Intuitively, (26-a) implies both (26-b) and (26-c), and in fact it seems equivalent to their conjunction.

(26) a. Alice may go to London or to Paris.
b. Alice may go to London.
c. Alice may go to Paris.

- The entailment $\Diamond(\varphi \vee \psi) \models \Diamond\varphi$ is not predicted by the standard semantics: the fact that some world in $\sigma(w)$ makes $\varphi \vee \psi$ true does not imply that some world in $\sigma(w)$ makes ψ true.

2.5.5 *In situ de re* readings

- Consider the following sentence:

(27) Everyone inside could have been outside.

- By letting the quantifier take scope above and below the modal we get the following readings:
  - De re: $\forall x(Ix \rightarrow \Diamond Ox)$
    Roughly: for every person x inside, "x is outside" could have been true.
  - De dicto: $\Diamond(\forall x(Ix \rightarrow Ox))$
    Roughly: "everyone inside is outside" could have been true.
- But there is a reading of (27) which is neither of the above. This can be put as:

(28) We could have been in a world v such that everyone who is inside in the actual world is outside in v.

- How to model this kind of reading in modal logic? How to get it compositionally?