Causation and the logic of ability

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COCOA Workshop, Paris/CNRS

June 28, 2022

Two ways of being able?

Past tense claims of ability are ambiguous between (pure) abilitative and actualized interpretations:

(1) Marja **was able** to swim across Lake Nokomis.

a. **Ability reading:**
Marja had the ability to swim across Lake Nokomis

(over some past time, e.g.:
In her twenties, Marja was able . . .)

b. **Actualized reading:**
Marja swam across Lake Nokomis.

(at a specific time, e.g.:
This morning, Marja was able . . .)

Thalberg (1972, p.121):
"'was able' sometimes means 'had the ability', and sometimes means 'did'."

Two ways of being able?

The alternation extends to **abilitative uses of the possibility modal**, and is disambiguated by overt grammatical aspect:

(2) Hindi **saknaa** ('can') (Bhatt 1999)

a. **Ability reading**, imperfective marking:

Yusuf havaii-jahaaz uɽaa **sak-taa** thaa, lekin us-ne
Yusuf air-ship fly can-IMPF.M PST, but 3SG-ERG
havaii-jahaaz kabhii nahĩĩ uɽaa-yii.
air-ship sometime NEG fly-PFV.F

'Yusuf could fly planes, but he never flew a plane.'

b. **Actuality reading**, perfective marking:

Yusuf havaii-jahaaz uɽaa **sak-aa**, #lekin us-ne
Yusuf air-ship fly can-PFV.M, #but 3SG-ERG
havaii-jahaaz nahĩĩ uɽaa-yii.
air-ship NEG fly-PFV.F

'Yusuf could fly the plane, #but he didn't fly the plane.'

Two ways of being able?

(3) French **pouvoir** ('can') (Hacquard 2006)

a. **Ability reading**, imperfective marking:
Marja **pouvait** traverser le lac à la nage, mais elle ne l'a pas traversé.
'Marja could-IMPF swim across the lake, but she did not cross it.'

b. **Actuality reading**, perfective marking:
Marja **a pu** traverser le lac à la nage, #mais elle ne l'a pas traversé.
'Marja could-PFV swim across the lake, #but she did not cross it.'

Actuality entailments (Bhatt 1999):
Perfectively-marked ability modals **entail the realization** of their prejacents

The puzzle of ability and actuality

Actuality entailments are mysterious from a compositional standpoint:

- ability modals are (typically) treated as circumstantial possibilities

$$x \text{ can}_{\text{ability}}\ P := \Diamond_{\text{circ}} P(x)$$

(4) Marja can/is able to swim across Lake Nokomis.
∼ In at least one of the worlds which preserve the circumstances of the lake, Marja's strength, mental discipline, muscle memory, etc, she swims across Lake Nokomis.

- entailments don't arise with all modal flavours:

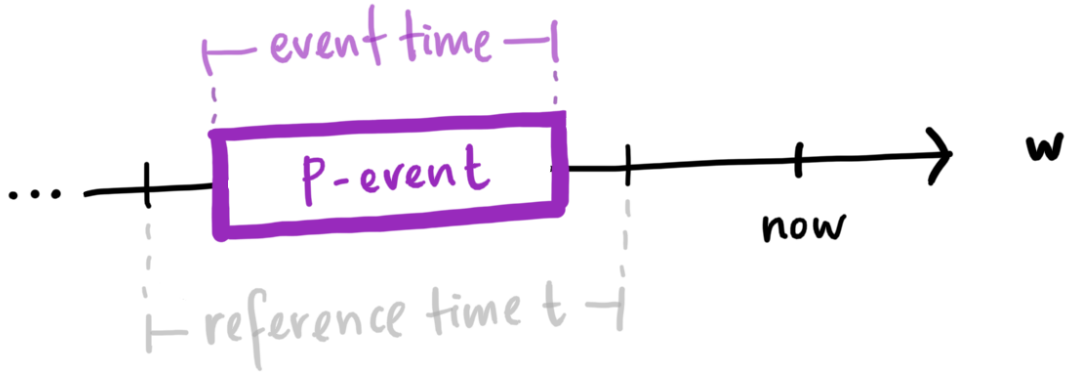
(5) Epistemic **pouvoir:**
Jean **a** *(bien)* **pu** *partir, mais il est aussi possible qu'il soit resté.*
'Jean might-PFV (well) have left, but it is also possible that he stayed.'

The puzzle of ability and actuality

No reason why adding the perfective should force actualization:

- *standard:* PFV contains event time in reference time (cf. Klein 1994)

$$[\![\text{PFV}]\!] := \lambda w \lambda P \lambda t . \exists e [P(e)(w) \;\&\; \tau(e) \subseteq t]$$



- we might therefore expect bounded ability, as with (6):

(6) Jean **a eu la capacité** de soulever un frigo, mais il ne l'a pas soulevé.
'Jean had-PFV the ability to lift a fridge, but he didn't lift it.'

$\rightsquigarrow$ *John no longer has the capacity.*

The puzzle of ability and actuality

Conclusion:

There's a missing ingredient, or one of our assumptions is incorrect

- ability modals are distinct from pure possibility
- the structure of ability embeds causal dependence

Roadmap

1. Two linguistic approaches to actuality entailments
2. The logic of ability
3. **Proposal:** complex causal structure for ability
4. Conclusions and open issues

Linguistic approaches to actuality entailments

Bhatt (1999): *being able* as *managing*

- *be able*, Hindi *saknaa*, French *pouvoir* aren't (possibility) modals
- instead, ABLE shares the lexical semantics of **implicative** *manage*

$$x \text{ ABLE } P \equiv x \text{ manage to } P$$

- per Karttunen (1971), *manage* always entails its complement

  (7) Marja **managed** to swim across Lake Nokomis.
  $\rightarrow$ *Marja swam across Lake Nokomis*

- complement entailment (under perfective) follows immediately

Question: what about the **pure ability** reading?

Linguistic approaches to actuality entailments

Bhatt (1999): *being able* as *managing*

- imperfective non-entailment attributed to a **covert genericity operator** introducing quantification over 'normal' worlds

$$[\![\textsc{gen}]\!] := \lambda w \lambda P . \forall w' \in \textsc{norm}(w)[P(w)]$$

(8) Olga **pouvait** soulever un frigo.
'Olga could.IMPF lift a fridge.'

$$\begin{aligned}[\![(8)]\!]^{w^*,t^*} &= [\![\textsc{pst}(\textsc{gen}(\textsc{impf}(\textsc{able}(\mathsf{O}, \text{lift-fridge}))))]\!]^{w^*,t^*} \\ &= \forall w \in \textsc{norm}(w^*) \\ &\qquad [\exists e[\tau(e) \supseteq t\{\prec_i t^*\} \\ &\qquad\quad \wedge \texttt{manage}(\texttt{lift-fridge}, \texttt{O})(e)(w)]]\end{aligned}$$

All normal worlds contain an event of Olga lifting a fridge whose duration includes the past reference time

Linguistic approaches to actuality entailments

Two problems with *being able* as *managing* (Bhatt 1999)

1. Implicitly **postulates polysemy:**

   Where possibility modals (*can*, *saknaa*, *pouvoir*) have abilitative uses, implicative ABLE must be a distinct lexical entry

2. Explaining pure (unrealized) ability via GEN **makes the wrong predictions** for imperfective implicatives:

   (9) Jean **réussisait** à parler à Marie, #mais il n'a jamais parlé à son.
   'Jean managed.IMPF to speak to Marie, #but he NEG-has never spoken to her.'

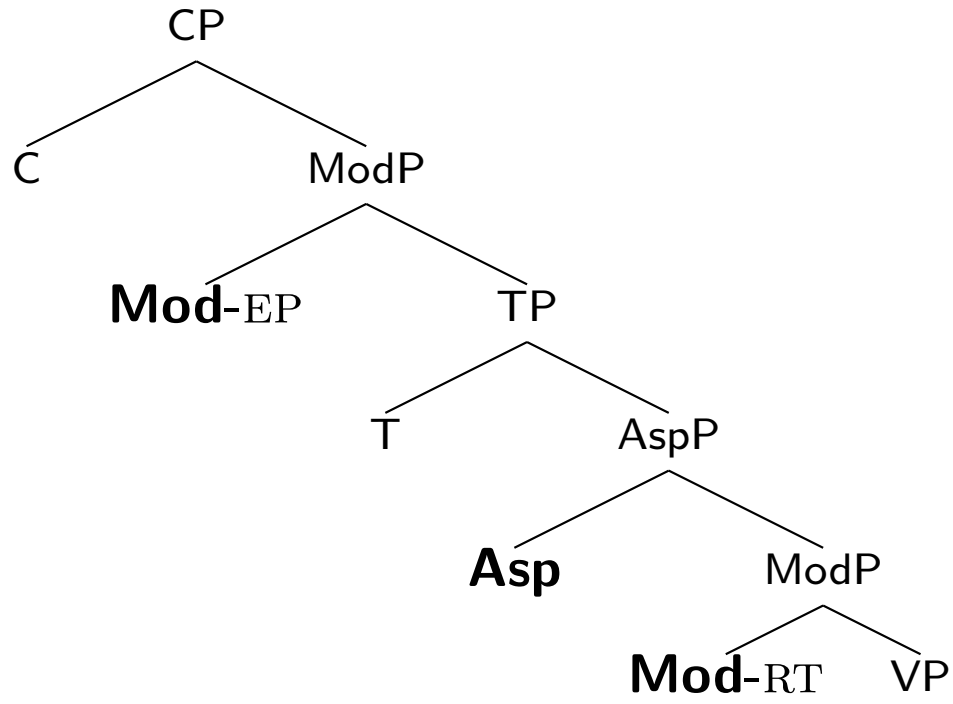
   - implicative *réussir* ('manage, succeed') entails its complement regardless of aspectual marking

NB: so far, we take the semantics of *manage* as a black box

Linguistic approaches to actuality entailments

Hacquard (2006): ability modals are circumstantial possibilities

- **Scope matters:**
  Actuality entailments affect **root**, but not **epistemic** modals



- **Aspect keys events to a world:**

$$[\![\text{PFV}]\!] := \lambda w \lambda P \lambda t . \exists e [e \text{ in } w \wedge \tau(e) \subseteq t \wedge P(e)]$$

Linguistic approaches to actuality entailments

Hacquard (2006): ability modals are circumstantial possibilities

(10) Olga **a pu**$_{\text{root}}$ soulever un frigo
'Olga could.PFV lift a fridge.'

$= \exists e[e \text{ in } w^* \wedge \tau(e) \subseteq t\{\prec_i t^*\}$
$\wedge \exists w \in \text{CIRC}(w^*)[\texttt{lift-fridge}(\texttt{O})(e)(w)]]$

There is a past evaluation-world eventuality which is an eventuality of Olga lifting a fridge in some circumstantially accessible world

- scope gets us the entailment, assuming event identification:

  (11) **Preservation of Event Description.** If e occurs in w, w', and e is a P-event in w, then e is a P-event in w'

- **imperfective non-entailment** attributed to GEN introduced by IMPF (cf. Bhatt)

Linguistic approaches to actuality entailments

Problems for the scope-based approach (Hacquard 2006)

1. **Event preservation** (PED) flattens possibility and necessity:

   (12) a. Jane **a pu** prendre le train pour aller à Paris.
   'Jane could-PFV take the train to go to Paris.'

   b. Jane **a dû** prendre le train pour aller à Paris.
   'Jane must-PFV take the train to go to Paris.'

   - (12)a is okay if other routes were available, (12b) is not
   - PED forces all counterparts to be train-takings, so (12)a,b should be interchangeable

2. Hacquard inherits the **problematic prediction for implicatives**
   - Asp $>$ VP, so IMPF+GEN should shift *managing* events to normal worlds, lifting complement entailment

The logic of ability

From the philosophical literature:

There is reason to suspect that **ability modals** are not circumstantial possibilities

(Thalberg 1972, Kenny 1976, Cross 1986, Brown 1988, Belnap 1991, . . .)

- ability does not validate the same modal logic relationships as circumstantial possibility

1. **Alethic modalities** (circumstantial, epistemic) **validate axiom T**

$$\textbf{T:} \quad P \rightarrow \Diamond P$$

(13) I am in San Francisco and I see a clump of dahlias growing.

circumstantial $\Diamond$: ✓Dahlias can grow in San Francisco

The logic of ability

1. **Alethic modalities validate axiom T:** $P \rightarrow \Diamond P$

Not so for ability-*can*:

(14) Tara is a beginning golfer who misses most of her shots. On this occasion, however, she strikes the ball from the tee, and it happens to go into the hole, so she makes a hole in one.

Ability-*can*: **?**Tara can make a hole in one.

Claim: it's at least difficult to decide on (14) (Maier 2018)

- the problem is **reliability**, pure chance is too weak for ability
- **but:** not a question of **repeatability**

(15) In her 20s, Marja **was able** to swim across Lake Nokomis, but she always did laps in Lake Harriet.

The logic of ability: conditionalization?

Observation:
Ability is stronger than pure possibility, but weaker than necessity

- **proposal:** treat ability as conditional necessity
  (P guaranteed under certain conditions)

> **The conditional analysis of ability:**
>
> x $\text{can}_{\text{ability}}$ P := x $\text{would}_{\text{circ}}$ P if x tried to P
>
> (Moore 1912, Austin 1961, Cross 1986, Thomason 2005, a.o.)

- **a problem:** psychological predispositions can block ability

(17) I am offered a bowl of red candy. I do not take one because I have a pathological aversion to the color red. (Lehrer 1968)

Ability-*can*: #I $\text{can}_{\text{ability}}$ take a piece of the candy

- the conditional holds, but **ability fails** (*trying* is out of the question)

The logic of ability

2. **Circumstantial possibility validates axiom K**:

$$\textbf{K:}\quad \Diamond(P \vee Q) \rightarrow \Diamond P \vee \Diamond Q$$

Ability-*can* **does not distribute:**

(18) We have a randomly shuffled deck of red and black cards. Karl is about to pick a card from the face-down deck.

a. ✓Karl $\text{can}_{\text{ability}}$ pick a red or a black card.

b. #Karl $\text{can}_{\text{ability}}$ pick a red card.

c. #Karl $\text{can}_{\text{ability}}$ pick a black card.

Solution: reliability req't is about available **strategy/procedure**

- Karl has an actionable, foolproof strategy for picking a card which is either red or black, but no color-specific strategy

A complex structure for ability

Claim: abilities are **hypothetical guarantees** (Mandelkern et al 2017)

$$x \text{ can}_{\text{ability}}\ P \sim x \text{ can act to } \textit{bring about } P$$

"...when I say that I can bring it about that P is true, I ...mean that there is an action open to me, the execution of which would assure that P would be true ..." (Brown 1988, p.4)

Idea: ability involves embedding necessity under possibility

- 'open' actions correspond to clusters of worlds
- ability holds where some cluster uniformly validates the prejacent

Proposal. For agent x and one-place predicate P

$$x \text{ can}_{\text{ability}}\ P$$

is true just in case there is some action A available to x such that if x does $A(x)$, then x will do $P(x)$

NB: see also Mandelkern et al's **act conditional analysis**

A complex structure for ability

Proposal. For agent x and one-place predicate P

$$x \text{ can}_{\text{ability}} P$$

is true just in case there is some action A available to x such that if x does $A(x)$, then x will do $P(x)$

Some questions:

1. What links action A to the realization of P?
   (What makes ability *agentive*?)
2. Is $\Diamond > \Box$ still too strong?
   Pure ability has a generic (non-universal) flavour (Maier 2018)
3. Are possibility modals ambiguous between $\Diamond$ and $\Diamond > \Box$ structures?

Causal dependence can help here!

A complex (causal) structure for ability

1. What links $A(x)$ and $P(x)$?
   - *x can act to bring about P*: *bringing about* is **causal**
   - $A(x)$ guarantees $P(x)$: minimally, **causal sufficiency**

     C is **causally sufficient** for E w.r.t. causal model D and situation s iff the causal consequences of $s + C$, as determined by D, include E
   - $A(x)$ should also be a difference-maker for $P(x)$ (as compared to other potential actions by x)
   - **tentative:** $A(x)$ is presupposed to be **causally necessary** for $P(x)$

     C is **causally necessary** for E w.r.t. causal model D and situation s iff all D-consistent pathways from s to E make C true

Proposal. For agent x, one-place predicate P

$$x \text{ can}_{\text{ability}} P$$

is true iff there is some *available* action A such that $A(x)$ is **causally necessary** and **causally sufficient** for $P(x)$

Motivating causal structure in ability

Bhatt's comparison of ABLE and *manage* goes beyond actualization:

(19) a. Solomon **managed** to build the temple.

b. Solomon **was able** to build the temple.

$\rightsquigarrow$ *Building the temple was non-trivial (for Solomon).*

Non-triviality is **malleable**, realized as *difficulty, unlikeliness, . . .* :

- recent accounts of *manage* explain 'vanishing' presuppositions in **causal terms** (Baglini & Francez 2016)
- Nadathur (2019):
  manage(x, P) presupposes existence of a **causally necessary** and **sufficient** action $A(x)$ for $P(x)$ (and asserts $A(x)$)
- **causal necessity** captures **non-triviality** for ABLE, *manage*:
  since $P(x)$ is *contingent* on $A(x)$, (non-realization of) $A(x)$ is a potential obstacle for $P(x)$

Motivating causal structure in ability

Causal sufficiency explains a tense asymmetry in ability ascriptions:

(20) Before he hit three bull's-eyes in a row, Brown fired 600 shots without coming close, and his subsequent tries were equally wild. (Thalberg 1972)

a. ✓Brown was able to hit the bull's-eye three times in a row.

b. ?Brown can/is able to hit the bull's-eye three times in a row.

- (20a) is not just a **did** reading
- instead, licensed by observing Brown acting to precipitate P as part of an actual causal chain (acting otherwise would have changed things)
- it follows from past events that the causing action A was available to Brown at reference time
- (20b) is infelicitous in context: no evidence that the right causing action is available to Brown going forward

Consequence: past-tense ability claims can describe *accidental* or *unintentional* effects involving deliberate action

Genericity in ability

2. Pure ability has a generic (non-universal) flavour (Maier 2018)

(21) Gina is an excellent golfer. When she is confronted with a short putt, as she is now, she almost always sinks it.

Ability: ✓Gina can/is able to sink the short putt.

- Maier suggests capturing this via GEN:
  x *can*$_{\text{ability}}$ P just in case $P(x)$ is an *option* (practically-available action) for x under **normal circumstances**
  - actualized readings arise where GEN is suppressed "for cognitive or linguistic reasons" (p.426)
- We get reference to normality for free with a causal approach:
  - the model relating $A(x)$ and $P(x)$ in a given situation is based on generalizations over relevant evidence
  - $A(x)$ leads to $P(x)$ in **causally normal worlds** where $A(x)$ is available within reference time

Possibility and ability

3. Are possibility modals ambiguous between $\Diamond$ (pure possibility) and $\Diamond > \Box$ (abilitative) interpretations?

Step 1: Causal premise semantics

- Kaufmann (2013) outlines a process for importing the structure of a causal model into the premise semantics framework
  - background situation s translates to a realistic **modal base**
  - **causal laws** (structural equations) are converted into **ordering source** propositions
- (roughly) worlds which validate the causal consequences of s are **causally optimal** (possibilties are causally compatible with the consequences)
- in the CPS framework:
  - **causal sufficiency** of C for $E \sim \text{MUST}_{\text{caus}}[C \rightarrow E]$
  - **causal necessity** $\sim \text{MUST}_{\text{caus}}[\neg C \rightarrow \neg E]$

Possibility and ability

3. Are possibility modals ambiguous between $\Diamond$ (pure possibility) and $\Diamond > \Box$ (abilitative) interpretations?

Step 2: *stit* (seeing to it that) theories of ability

(Belnap & Perloff 1988, Belnap 1991)

(22) a. Ahab sailed in search of the white whale
$\equiv$ Ahab *stit*: Ahab sailed in search of the white whale

b. Ishmael sailed in search of the white whale
$\not\equiv$ Ishmael *stit*: Ishmael sailed in search of the white whale

- **intuition:** agentive outcomes result from agents' prior choices
  - **choice set** $\mathrm{CH}(x, w, t)$: a partition of histories through $\langle w, t\rangle$ s.t. w_1, w_2 collapsed through $t' \succ_i t$ are CH-equivalent

    (action clusters)
  - x *stit* $P(x)$ at $\langle w, t\rangle$ iff $\exists t_0 \prec_i t$ with w through $t_0, \exists A \in \mathrm{CH}(x, w, t_0)$ s.t.:
    (a) $\forall w' \in A, P(x)(w')(t) = 1$
    (b) $\exists w''$ through t_0 s.t. $P(x)(w'')(t) = 0$

Possibility and ability

3. Are possibility modals ambiguous between $\Diamond$ (pure possibility) and $\Diamond > \Box$ (abilitative) interpretations?

Step 2: ability modals are historical *stit* possibilities (Belnap 1991)

$$x\ can_{\text{ability}}\ P := \Diamond_{\text{hist}}[x\ stit\ P(x)]$$

- on the *stit* view, the truth of $x\ can_{\text{ability}}\ P$ requires some future to verify $x\ stit\ P(x)$ (x can act to ensure $P(x)$)
- can be unified with the causal approach by:
  - replacing historical with causal modality
  - tightening condition (b) of *stit* claims to causal necessity (tentative)
- introducing the *stit* form suggests a reconciliation of the $\Diamond$ and $\Diamond > \Box$ interpretations for *can*, *pouvoir*, *saknaa*, ...
- *stit* necessity describes *compulsion*, cf. Mandelkern et al (2017)

Possibility and ability

3. Are possibility modals ambiguous between $\Diamond$ (pure possibility) and $\Diamond > \Box$ (abilitative) interpretations?

Bonus: *stit* approach turns ability modals into a special kind of teleological modal

- the set of actualizing modalities is teleological (not all root modals; Mari 2016)
- 'standard' teleological possibilities specify sufficient causes for a particular goal
- abilities suppress description of the causing action (and further constrain the causal relationship)
- **so:** a causal theory of actuality entailments in ability cases provides relevant groundwork for a theory of actualization across the board

Explaining actuality entailments

Complex causal structure accounts for **pure ability**, but what about perfective-driven **actualization?**

- ability modals share structure with *manage* (Nadathur 2019)

(22) a. x *can*$_{\text{ability}}$ P b. x *manage to* P

Background: $\exists A : A(x) \xrightarrow{\text{c-nec}} P(x)$ & $A(x) \xrightarrow{\text{c-suff}} P(x)$

Assert: $A \in \text{CH}(x, w, t)$ *Assert:* $A(x)$

- implicative entailments are (causal) consequences of presupposition and assertion (at base eventive in asserting $A(x)$)
- ability claims are **at base stative** (cf. Hackl 1998, Homer 2011, 2021): establish possibility that x does A
- **observation:** statives undergo **coercion** to combine with PFV (Moens & Steedman 1988, de Swart 1998, Bary 2009)

(23) Jupiter a aimé Europa. **inchoative:**
'Jupiter loved-PFV Europa.' *Jupiter fell in love with Europa.*

Explaining actuality entailments

Ability is a special **dynamic stative**, attributing an actionable capacity:

(24) Juno is fast (loud, nimble, polite . . .)
Juno has available actions characterized by speed (volume, dexterity, politeness . . .)

- dynamic statives are **instantiated** (manifested) by PFV:

(25) Juno a été rapide. **instantiative:**
'Juno was-PFV fast.' *Juno did something quick(ly).*

- actuality entailments from dynamic-capacity *enough* constructions:

(26) Juno a été assez rapide pour gagner la course, #mais elle n'a pas gagné.
'Juno was-PFV fast enough to win the race, #but she did not win.' *Juno did something characterized by speed which was causally sufficient for her to win the race.*

- the actionable capacity attributed by ability is underspecified, but works the same way

Explaining actuality entailments

Upshot: marking dynamic stative (ability) with perfective coerces instantiation of the causing action $A(x)$

- once $A(x)$ is realized, ability claims are identical to implicative *manage* (cf. Bhatt 1999)

(3) b. Marja **a pu** traverser le lac à la nage, #mais elle ne l'a pas traversé.
'Marja could-PFV swim across the lake, #but she did not cross.'
Marja acted to bring about her lake-crossing . . .

- statives are compatible with IMPF, so actualization does not occur

(3) a. Marja **pouvait** traverser le lac à la nage, mais elle ne l'a pas traversé.
'Marja could-IMPF swim across the lake, but she did not cross.'

- imperfective *manage* takes a habitual interpretation: 'activation' of the cause-effect relationship is unaffected

Summary

- Abilitative possibility diverges from circumstantial possibility in its logical properties, motivating a distinct formal analysis
- Both **actualized** and **pure ability** interpretations for ability ascriptions motivate a complex structure for ability (along lines suggested in the philosophical literature)
- The issues with $\Diamond > \Box$ analyses can be mitigated by introducing **causal dependence relations** . . .
- . . . which also allows **ability** and **actuality** interpretations to be derived from a single account of ability predicates

Open questions

- The formal relationship between ability and teleological modality remains to be explored (similarly, actualization in compulsion and teleological necessity)
- Some non-agentive possibility modals have actuality entailments:

  (26) L'ascenseur **a pu**soulever 300 livres.
  'The elevator could-PFV lift 300 pounds.'
  → *The elevator lifted 300 pounds.*

- Genericity/normality effects fall out from the notion of a (type-level) causal model: what evidence licenses a model for ability?
  (crossling variation?)
- The causal approach licenses past-tense *be able* for accidental effects: can this explain out-of-control or accidental uses of ability predicates crosslinguistically? (Tagalog, Malagasy, Salish)
- What happens to ability under negation?
  What is the range of impossibility *versus* failed-attempt interpretations? Does the necessity component need to be refined?