Causation, implicativity, and the logic of ability

Prerna Nadathur
The Ohio State University

New York Philosophy of Language Workshop

May 8, 2023

Causal reasoning and causal language

'Practical' causal intuitions vs. linguistic causation

- causal reasoning draws on complex networks of relationships: **causal models**
- linguistic causation: typically binary *cause-effect* relations

An alternative: causal models as discourse parameters

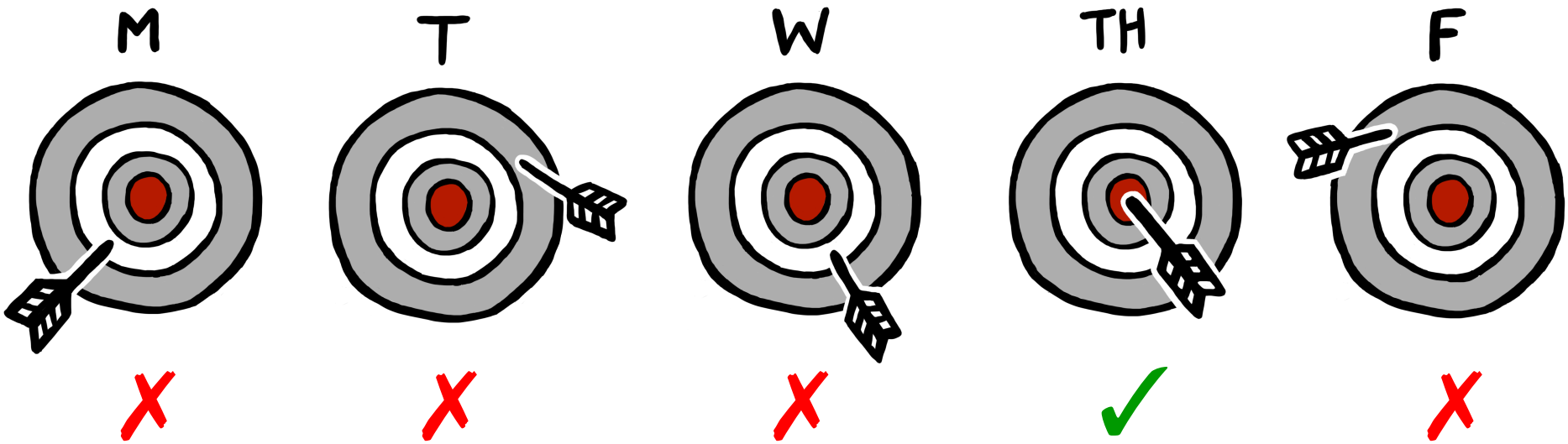
- causal language describes structures in an online language-independent representation
- discourse contributions interact (in familiar ways) with such representations
- model relationships can explicate linguistic effects

(Nadathur & Lauer 2020, Baglini & Bar-Asher Siegal 2021, a.o.)

Today: use this approach to shed light on a longstanding semantic puzzle

A longstanding puzzle: two kinds of ability?

Tara's typical college week at the dartboard:



(1) In college, Tara **was able** to hit the bullseye.

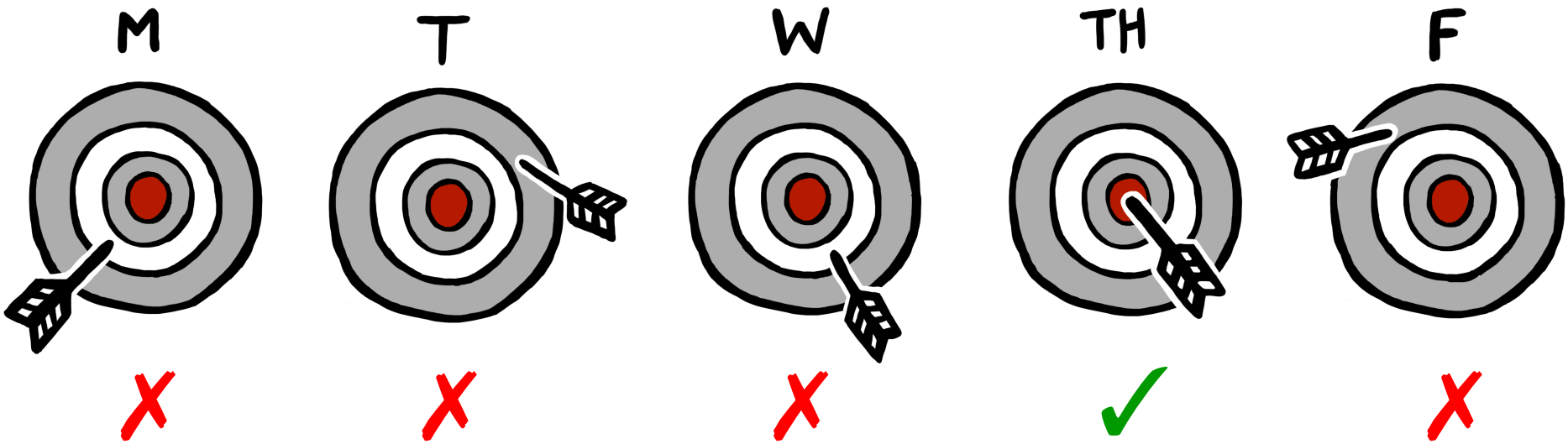
FALSE

She might do it once in a while, but she doesn't really *have this ability*

(loosely based on Thalberg 1972)

A longstanding puzzle: two kinds of ability?

Tara's last week at the dartboard:



(2) On Thursday, Tara **was able** to hit the bullseye.

TRUE

She doesn't do it regularly, but she *actually did* it on Thursday.

(loosely based on Thalberg 1972)

Actuality inferences: two kinds of ability?

Ability modals (e.g., Hindi *saknaa*) in aspect-marking languages: (Bhatt 1999)

- **imperfective** aspect has the **pure ability** reading

(3) 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-yaa.
air-ship sometime NEG fly-PFV.M
'Yusuf could fly planes, but he never flew a plane.'

- **perfective** aspect gives rise to an **actuality entailment**

(4) Yusuf havaii-jahaaz uɽaa **sak-aa**, #lekin us-ne
Yusuf air-ship fly can-PFV.M, #but 3SG-ERG
havaii-jahaaz nahĩĩ uɽaa-yaa.
air-ship NEG fly-PFV.M
'Yusuf could fly the plane, #but he didn't fly the plane.'

Actuality inference: two kinds of ability?

The same 'ambiguity' arises for abilitative uses of the possibility modal across aspect-marking languages: (Hacquard 2006)

- **French** *pouvoir* ('can'): *imparfait*/ability vs. *passé composé*/actuality

(5) Marja **pouvait** traverser le lac à la nage, mais elle ne
Marja can.PST.IMPF cross.INF the lake at the swim, but she NEG
l'a jamais traversé.
it-has never cross.PP

'Marja could-IMPF swim across the lake, but she never crossed-PFV it.'

(6) Marja **a** **pu** traverser le lac à la nage, #mais elle ne
Marja has can.PP cross.INF the lake at the swim, #but she NEG
l'a pas traversé.
it-has NEG cross.PP.

'Marja could-PFV swim across the lake, #but she did not cross it.'

(also in Greek, Russian, . . .)

The problem of actuality

1. **The problem of ability**
   'Ambiguity' is systematic across languages, ability predicates (ability modals, English *be able*, Spanish *ser capaz*, . . .)

2. **The problem of modality**
   Actuality seems to erase the modality (possibility) of ability readings

3. **The problem of aspect**
   No obvious reason why temporal information or 'viewpoint' aspect should have an actualizing effect

Goal: A univocal treatment of ability attributions that derives the distribution of pure ability and actuality

Outline of the talk

1. Introduction
2. Ability and possibility
3. Chasing the actuality interpretation: implicative verbs
4. Actuality and aspect: *enough* comparatives
5. Conclusions and questions: ability revisited

Outline of the talk

1. Introduction
2. Ability and possibility
3. Chasing the actuality interpretation: implicative verbs
4. Actuality and aspect: *enough* comparatives
5. Conclusions and questions: ability revisited

The puzzle of ability and actuality

Actuality entailments are mysterious from a compositional standpoint:

- ability modals are (typically) treated as circumstantial possibilities

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

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

- **No AEs** with (e.g.) epistemic **pouvoir:** (Hacquard 2006)

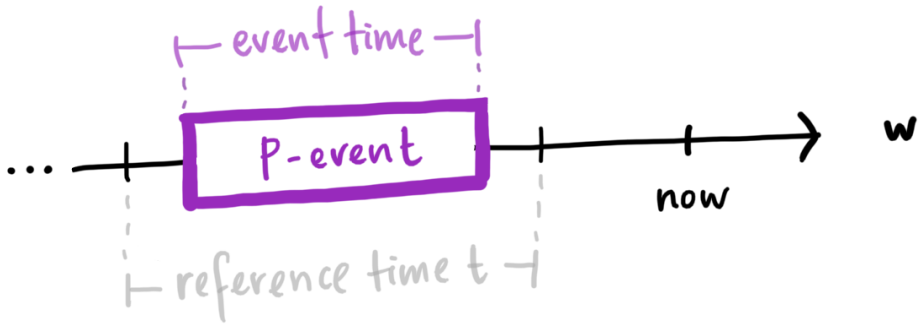
(8) Jean **a** (bien) **pu** partir, mais il est aussi possible
Jean has (well) can.PP leave.INF, but it is also possible
qu'il soit resté.
that-he be.SUBJ stay.PP.
'Jean might-PFV (well) have left, but it is also possible that he stayed.'

The puzzle of ability and actuality

No reason why adding PFV 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 expect *bounded ability*, as with (9):

(9) Jean **a** **eu** **la** **capacité** de soulever un frigo, mais il
Jean has have.PP the capacity of-the lift.INF a fridge, but he
ne l'a pas soulevé.
NEG it-has NEG lift.PP
'Jean had-PFV the ability to lift a fridge, but he didn't lift it.'

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

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**

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

(10) 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*:

(11) 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 (12) (Maier 2018)

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

(12) 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

(13) 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:**

(14) 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 requirement 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 $P(x)$

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 $P(x)$

- this structure captures a link between pure ability and possibility
- from the perspective of x, A represents a *strategy* for realizing P

Questions:

1. Are possibility modals ambiguous between $\Diamond$ and $\Diamond > \Box$ structures? (e.g., ambiguity in the golfing example)
2. What links action A to the realization of P? (What makes ability agentive?)

Possibility and ability

Different ways to formalize 'hypothetical guarantee'/$\Diamond >$ $\Box$:
(Brown 1988, Louie 2014, Mandelkern et al 2017)

- **Belnap 1991:** ability modals are (historical) possibilities embedding an agentive **stit** proposition (Belnap & Perloff 1988)

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

(15) 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** $\text{CH}(x, w, t)$: a partition of histories through $\langle w, t\rangle$ s.t. w_1, w_2 collapsed through $t' \succ_i t$ are CH-equivalent
  - x *stit* $P(x)$ at $\langle w, t\rangle$ iff $\exists t_0 \prec_i t$ with w through t_0, $\exists A \in \text{CH}(x, w, t_0)$ s.t.:
    (a) $\forall w' \in A, P(x)(w')(t) = 1$
    (b) $\exists w''$ through t_0 s.t. $P(x)(w'')(t) = 0$

Interim summary: the three problems

1. **Ability:** what do expressions of ability mean?
   - *Progress:* x can_{ab} P iff x has a strategy $A(x)$ guaranteeing $P(x)$
   - More to say about the relationship between A and P
     Preliminary claim: the link is **causal**, $A(x)$ **brings about** $P(x)$

2. **Modality:** what connects ability, actuality, and possibility?
   - We've lost sight of the actuality interpretation:

     (6) Marja **a** **pu** traverser le lac à la nage, #mais elle n'e
     Marja has can.PP cross.INF the lake at the swim, #but she NEG
     l'a pas traversé.
     it-has NEG cross.PP.
     'Marja could-PFV swim across the lake, #but she did not cross it.'

   - **The problem:** ability doesn't license $P(x) \rightarrow x$ can_{ab} P

3. **Aspect:** what role does aspect/temporal perspective play?

Outline of the talk

1. Introduction
2. Ability and possibility
3. Chasing the actuality interpretation: implicative verbs
4. Actuality and aspect: *enough* comparatives
5. Conclusions and questions: ability revisited

A starting point: implicative *manage*

Observation: **actualized ability** is closer to **managed** than to *did* (Bhatt 1999)

(4) Yusuf havaii-jahaaz uṛaa **sak-aa**.
Yusuf air-ship fly can-PFV.M
'Yusuf could fly the plane.'
≡ Yusuf **managed** to fly the plane.

Actualized ability in French (*pouvoir*) is the same: (Hacquard 2006)

(6) Marja **a pu** traverser le lac à la nage.
'Marja could-PFV swim across the lake.'
≡ Marja **managed** to swim across the lake.

A starting point: implicative *manage*

Manage shares complement entailments with **actualized ability**

Hindi:

(4) Yusuf havaii-jahaaz uṛaa **sak-aa**, #lekin us-ne havaii-jahaaz
Yusuf air-ship fly can-PFV.M, #but 3SG-ERG air-ship
nahĩĩ uṛaa-yaa.
NEG fly-PFV.M
'Yusuf could fly the plane, #but he didn't fly the plane.'

(16) Yusuf **managed** to fly the plane, #but he didn't fly the plane.

French:

(6) 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.'

(17) Marja **managed** to swim across the lake, #but she did not cross it.

A starting point: implicative *manage*

Manage and **actualized ability** share something more:

(18) a. Mika **was able** to breathe normally.
b. Mika **managed** to breathe normally.

$\rightsquigarrow$ *breathing normally was . . . unexpected? abnormal? unlikely?*

Something more **projects** through negation:

(19) a. Mika **was not able** to breathe normally.
b. Mika **did not manage** to breathe normally.

$\rightsquigarrow$ *breathing normally was . . . unexpected? abnormal? unlikely?*

Actuality as implicativity?

Bhatt's hypothesis: ABLE ≡ *manage*

- **but:** no **pure ability** reading for **manage**

  (20) In college, Tara **managed** to hit the bullseye. ∼ *did* + non-triviality

- even with aspectual modification (French *réussir*)

  (21) Marja **{réussissait / a réussi}** à traverser le lac à la nage,
  #mais elle n'a pas traversé.
  'Marja {managed-IMPF / managed-PFV} to swim across the lake,
  #but she did not cross it.'

If actuality entailments are implicative entailments:
the equivalence is analytical, not lexical (ABLE ≢ *manage*)

From implicativity to actuality: overview

New goal: a unified semantic treatment of implicative and actuality inferences

What we need to get there:

- an account of the (lexical) semantic basis of implicative inferences
- a way to take apart and identify the same components (+ sources of variability!) in the ability-aspect interaction

Key addition: a role for **causal reasoning**

- *manage*, ability make reference to the *causal background*
  (on which their complements depend)

The facts about *manage*

(A) Two-way pattern of **complement entailment:**

(22) a. Eman **managed** to solve the riddle. → *Eman solved the riddle*

b. Eman **did not manage** to solve the riddle.
→ *Eman did not solve the riddle*

(B) **Projective inference:**

(22a-b) ⇝ *Solving the riddle was (somehow) non-trivial*

(23) Eman solved the riddle. *(no inference)*

What semantic components produce this inference pattern?
(**assumption:** shared with actualized ability)

The presupposition(s) of *manage*

What **manage** projects is surprisingly **hard to pin down:**

(Coleman 1975, Karttunen & Peters 1979, Baglini & Francez 2016, a.o.)

- common proposals like *intention, difficulty, unlikeliness* aren't universal

(24) a. **Without intending to,** Ms. Streisand [. . .] **managed** to synthesize the problem [. . .]
$\not\rightsquigarrow$ intention, $\not\rightsquigarrow$ difficulty, $\rightsquigarrow$ unlikelihood

b. By 1998, [. . .] gun manufacturers had **easily managed** to bypass the laws by making small alterations [. . .]
$\rightsquigarrow$ intention, $\not\rightsquigarrow$ difficulty, ? $\rightsquigarrow$ unlikelihood

c. The Socialdemokratiet **managed** to strengthen their position as Denmark's strongest political force **as expected** [. . .]
$\rightsquigarrow$ intention, ? $\rightsquigarrow$ difficulty, $\not\rightsquigarrow$ unlikelihood

What do these inferences have in common?

Managing and *doing*

What do *intention, difficulty, unlikeliness* **inferences share?**

Reasoning about **non-triviality:**

- P is non-trivial if you can't **just** do P
- something additional (and prior) is **required** in order to do P
  (alternatively: some obstacle must be overcome *en route* to P) (Karttunen 2014)

Manage to P presupposes the existence of a **causal prerequisite** for P

Implicative presuppositions

Most implicatives characterize their prerequisites:

(25) **English dare:** *boldness, courage*

a. Ria dared to open the door. → *Ria opened the door*

b. Ria did not dare to open the door. → *Ria did not open the door*

⇝ *Opening the door required Ria to act bravely*

(26) **Finnish hennoa:** *emotional fortitude, hard-heartedness, ruthlessness*

a. Sampo henno-i tappa-a kissa-n.
Sampo have.heart-PST.3SG kill-INF cat-GEN/ACC
'Sampo had the heart to kill the cat. → *Sampo killed the cat*

b. Sampo e-i henno-nut tappa-a kissa-a.
Sampo NEG-3SG have.heart-PP.SG kill-INF cat-PART
'Sampo didn't have the heart to kill the cat.'
→ *Sampo didn't kill the cat*

⇝ *Killing the cat required Sampo to be ruthless*

The implicative semantic template

1. **Prerequisite relevance is presupposed** (projective, not at issue)

   (25) Ria { dared / did not dare } to open the door.
   $\rightsquigarrow$ *Opening the door required Ria to act bravely*

2. **Assertion resolves prerequisite status** (at issue)

   (25) a. Ria dared to open the door. $\rightarrow$ *Ria acted bravely*
   b. Ria did not dare to open the door. $\rightarrow$ *Ria did not act bravely*

3. **Complement entailments are derived as causal consequences**

   (25a) $\sim$ *Ria's bravery resulted in her opening the door* sufficiency
   (25b) $\sim$ *Ria's lack of bravery stopped her opening the door* necessity

The implications of *manage*

Manage follows the same template:

- **causal necessity** and **causal sufficiency** derive complement entailments
- underspecification of the **causal prerequisite** captures **non-triviality**

Causal background knowledge fills in details:

(27) Nur **managed** to meditate yesterday.

- *Context.* Nur is extremely busy with work lately
  $\rightsquigarrow$ *Finding/making time was required* (Finnish *joutaa*)
  (27) $\rightarrow$ Nur made the time (and consequently meditated)

- **similarly:** patience (Finnish *malttaa*), strength (*mahtua*), warmth (*tarjeta*)

Background: causal network models (Pearl 2000)

Causal information is represented using a **directed acyclic graph** D:

- **nodes** (finite set Σ): salient prop. variables (can be valued $u, 0, 1$)
- **edges:** atomic relations of **causal relevance** ($P \xrightarrow{\text{c-influences}} Q$)
- **structural equations:** specify how nodes' values are determined from their ancestors'

  Function Θ_D assigns to each $X \in \Sigma$ a pair $\langle Z_X, \theta_X \rangle$ where Z_X is the set X's immediate ancestors, $\theta_X : \{0,1\}^{|Z_X|} \rightarrow \{0,1\}$
- **causal consequences:** of a *situation* s (3-way valuation of Σ) are calculated using D and Θ_D

In lexical semantics:

Causal language refers to (predicates, presupposes) particular structural configurations (*necessity, sufficiency*) as different causal dependency types

(cf. Nadathur & Lauer 2020, Baglini & Bar-Asher Siegal 2021)

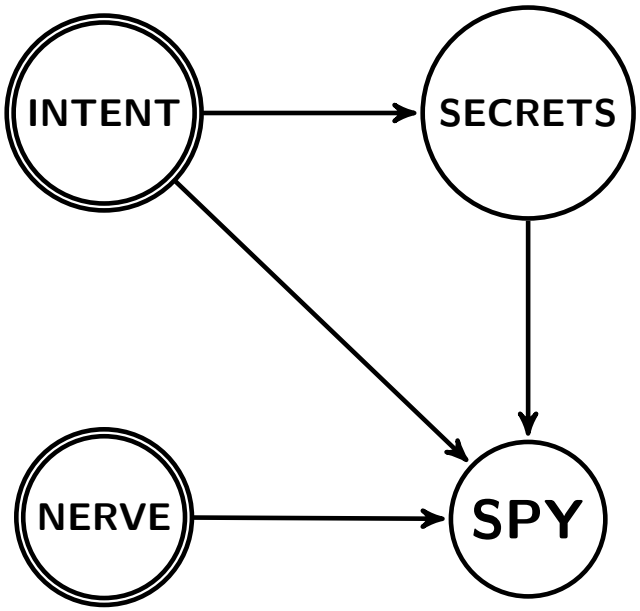
Reasoning with causal models

Background. Captain Dreyfus was wrongly accused of spying for the Germans.

Relevant causal dependencies:

1. Collecting secrets requires treasonous intent
2. Spying (sharing secrets) requires treasonous intent, secret collection, risk-taking

A causal model for the Dreyfus affair: (finite graph + structural equations)

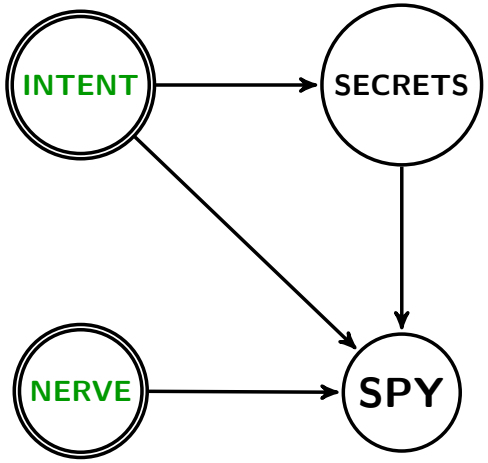


1. **SECRETS** := **INTENT**
2. **SPY** := **INTENT** $\wedge$ **SECRETS** $\wedge$ **NERVE**

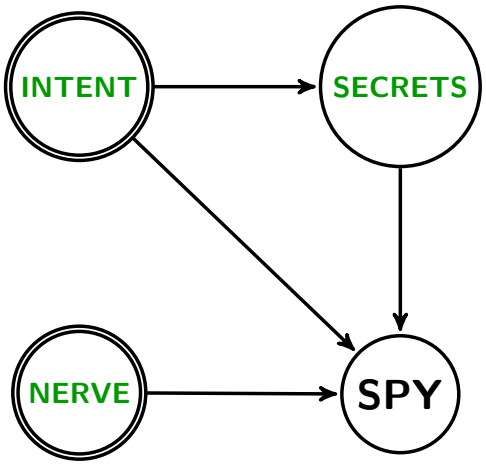
Reasoning with causal models

Use background information to reason out causal consequences:

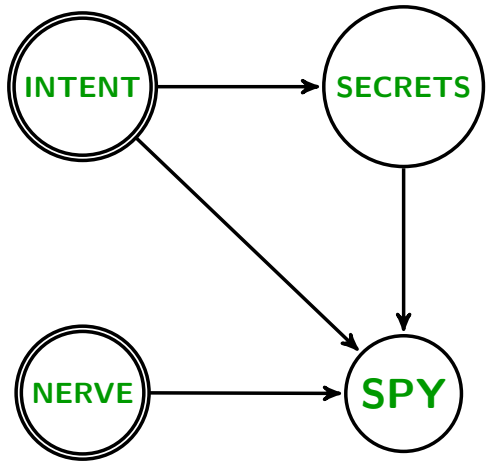
If **INTENT**, **NERVE** are **on**:



INTENT turns **SECRETS** **on**:



Which turns **SPY** **on** in turn:

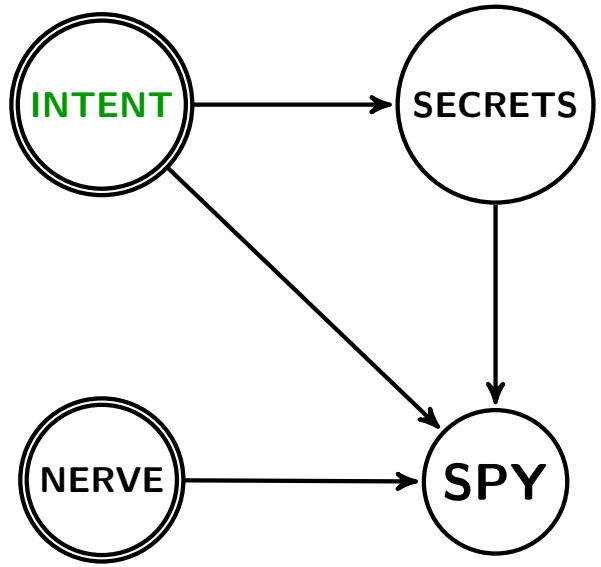


Causal dependence relations

Causal necessity, sufficiency are labels for different structural configurations:

- given a background situation s, a cause C is **causally necessary** for an effect E iff there's no (consistent) path from s to E which does not flip C

If we know that **INTENT** is **on**,
NERVE is **necessary** for **SPY**



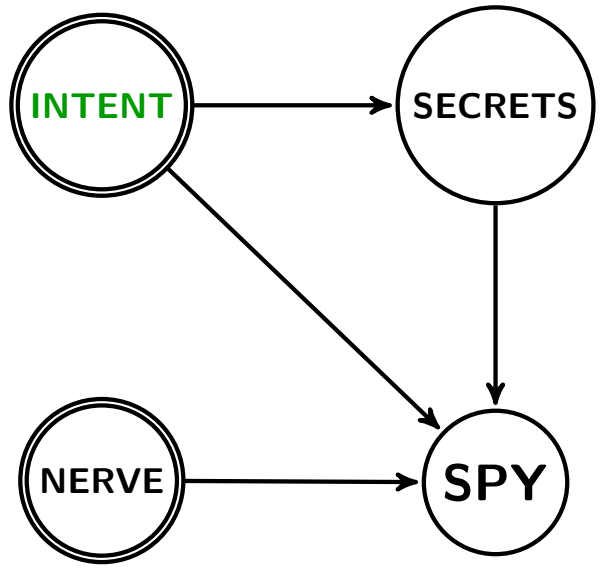
1. **SECRETS** := **INTENT**
2. **SPY** := **INTENT** $\wedge$ **SECRETS** $\wedge$ **NERVE**

Causal dependence relations

Causal necessity, sufficiency are labels for different structural configurations:

- given a background situation s, a cause C is **causally sufficient** for an effect E iff adding C to s guarantees E

If **INTENT** is **on**,
NERVE is **sufficient** for **SPY**



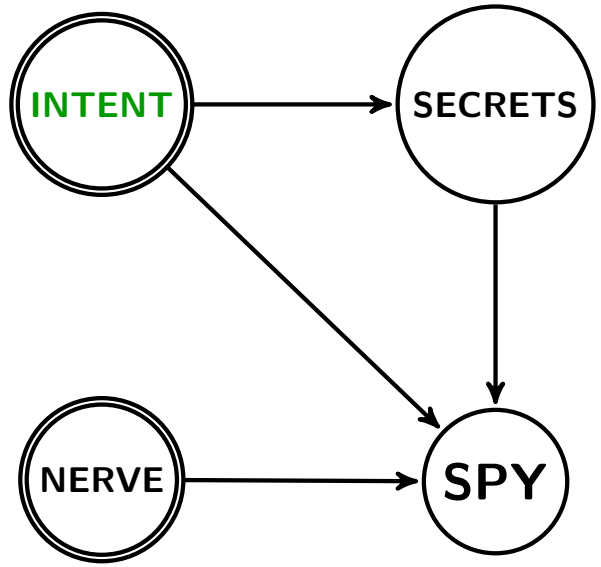
1. **SECRETS** := **INTENT**
2. **SPY** := **INTENT** $\wedge$ **SECRETS** $\wedge$ **NERVE**

Causal dependence relations

Causal necessity, sufficiency are labels for different structural configurations:

- given a background situation c, a cause C is **causally sufficient** for an effect E iff adding C to c guarantees E

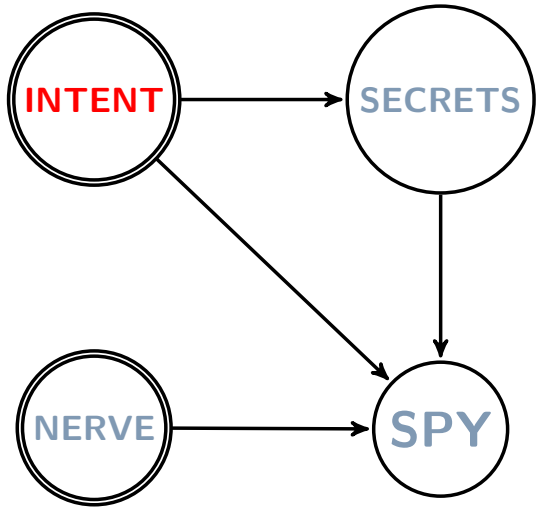
If **INTENT** is **on**,
NERVE is **sufficient** for **SPY**



This is the right kind of context for **dare**:

(28) a. Dreyfus **dared** to spy for the Germans.
b. Dreyfus did not **dare** to spy for the Germans.

Implicatives and causal dependence



In actuality, Dreyfus was loyal to France:

(28) ??Dreyfus **dared** to spy.

requires: **NERVE** is causally necessary, sufficient for **SPY**

in context: NERVE is insufficient

(29) ??Dreyfus **managed** to spy.

requires: condition/s jointly causally necessary, sufficient for **SPY**

in context: no set of sufficient conditions

Unpacking implicativity

Three key components work together to derive **implicative inferences:**

1. **presupposition:**
   the existence of an unresolved **jointly necessary & sufficient condition** (or set thereof) for the complement
2. **assertion:**
   determines the truth value of the **necessary & sufficient condition**
3. **modal flavour:**
   necessity & sufficiency are **causal**

Reminder: if actuality entailments are (analytically) implicative:

- the components emerge compositionally for **actualized ability**

$$\text{ABLE} + \text{PFV} \equiv \textbf{manage}$$

Interim summary: the three problems

1. **Ability:** what do expressions of ability mean?
   - x *can*$_{\text{ab}}$ P iff x has a strategy $A(x)$ for (causally) **bringing about** $P(x)$
2. **Modality:** what connects ability, actuality, and possibility?
   - Actualized interpretations are implicative interpretations

     (30) *x manage to P*:

     a. *presupposes:* the existence of an action $A(x)$ which is **causally necessary** and **causally sufficient** for $P(x)$

     b. *asserts:* x did A

   - Ability, actuality share causal background structure
   - *Difference:* $A(x)$ is not hypothetical in actualized readings
3. **Aspect:** what role does aspect/temporal perspective play?
   - Aspect-governed contrast: IMPF/pure ability, PFV/actuality
   - Looking 'inside' ability: complex *enough/too* constructions

Outline of the talk

1. Introduction
2. Ability and possibility
3. Chasing the actuality interpretation: implicative verbs
4. Actuality and aspect: *enough* comparatives
5. Conclusions and questions: ability revisited

Enough predicates

Enough (and *too*) constructions **license inferences in the implicative pattern:**

(31) a. Juno **was fast enough** to win the race. $\rightsquigarrow$ *Juno won the race.*

b. Juno **was not fast enough** to win the race.
$\rightarrow$ *Juno did not win the race.*

(32) a. Ria **was brave enough** to open the door. $\rightsquigarrow$ *Ria opened the door*

b. Ria **was not brave enough** to open the door.
$\rightarrow$ *Ria did not open the door*

Compare **be brave enough** to **dare**

(25) a. Ria **dared** to open the door. $\rightarrow$ *Ria opened the door*

b. Ria **did not dare** to open the door. $\rightarrow$ *Ria did not open the door*

Enough and actuality

Enough actuality inferences are **aspect sensitive** (Hacquard 2005)

- **actuality entailments** with perfective:

  (33) 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 didn't win.'

- **ability/capacity** reading with imperfective

  (34) Juno **était assez rapide** pour gagner la course, mais elle n'a jamais gagné.
  'Juno was-IMPF fast enough to win the race, but she never won.

(compare with French ability modal *pouvoir* under aspectual modification)

Enough/too predicates: the basics

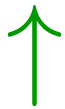
Enough constructions attribute **specific abilities:**

(35) Juno **is fast enough** to win the race.
$\sim$ *Juno can win the race, in view of her speed*

The ability attribution breaks into (variable) components:

Juno was **fast** **enough** **to win the race.**

gradable ADJ
(individual properties)



comparative operator

infinitival complement
(purpose or goal)

Paraphrase:

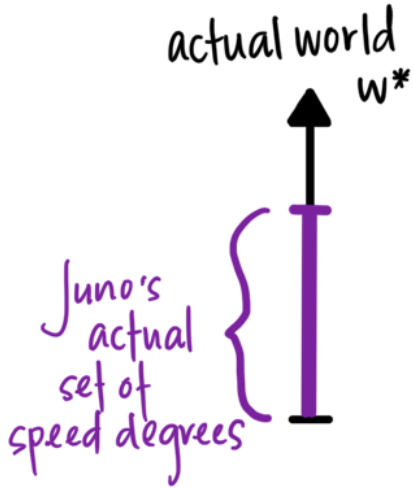
Juno's actual speed is as great as it needs to be in order for her to win the race
$\sim$ *Juno's actual speed makes it possible that she wins the race*

Composition: (modalized) degree comparison

- **matrix adjective** picks out an individual's allotment of some property (in sets of degrees)

(36) Juno is *d*-fast
$\sim$ *Juno has at least degree d of speed*

$[\![\text{fast}]\!] := \lambda w \lambda d \lambda x.\text{speed}(x)(w) \geq d$



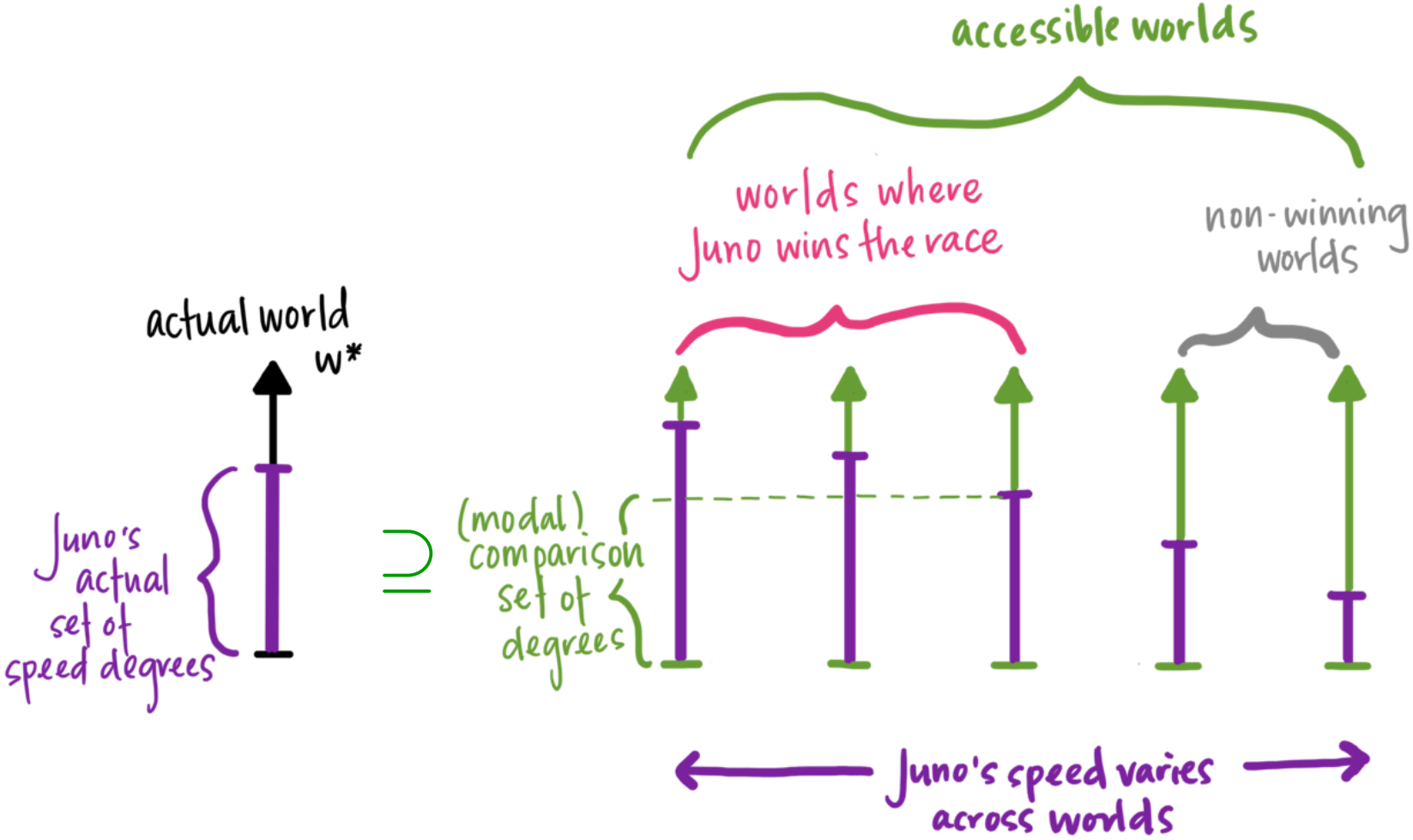
- **enough** compares an actual degree allocation to the allocation in worlds where the complement is realized (von Stechow et al 2004)

(37) Juno is ADJ enough to *P*
$\sim$ *Juno's actual* ADJ *allocation is at least as big as the smallest allocation compatible with P*

$[\![\text{enough}]\!] := \lambda w \lambda P \lambda A \lambda x.$
$\{d : A(d)(x)(w)\} \supseteq \{d : \forall w' \in \text{ACC}(w)[P(x)(w') \rightarrow A(d)(x)(w')]\}$

Composition

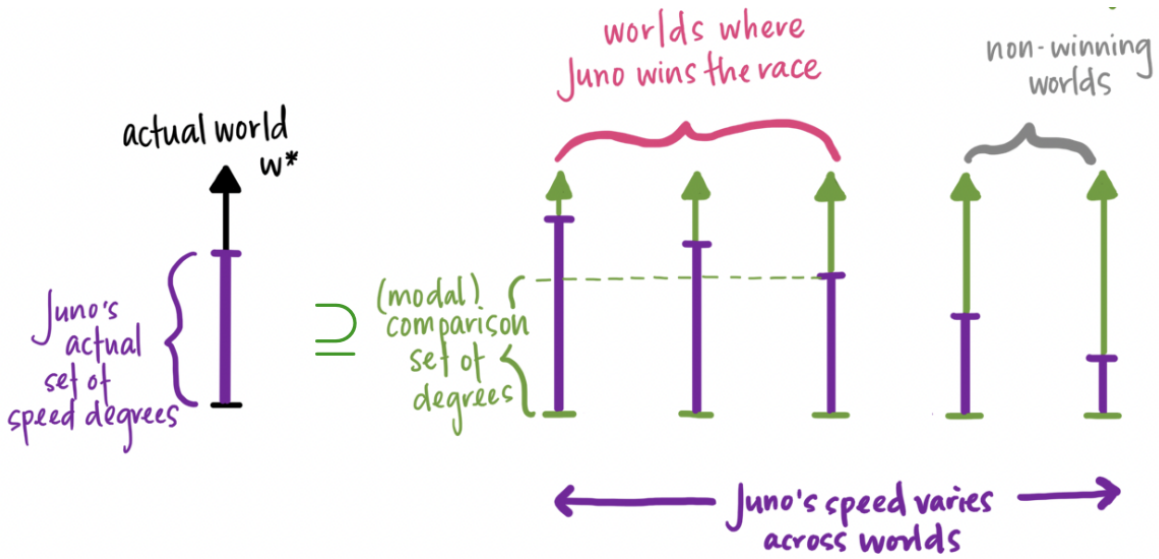
$[\![\text{Juno is fast enough to win the race}]\!]^{w^*} =$



$$\{d : \text{speed}(J)(w^*) \geq d\} \quad \supseteq \quad \{d : \forall w \in \text{ACC}(w^*)\,[\text{win}(J)(w) \rightarrow \text{speed}(J)(w) \geq d]\}$$

Enough and necessity

(35) Juno is fast enough to win the race.



- **result:** Juno's actual (max) speed $\geq$ Juno's max speed in slowest win world

Main takeaway: *enough* builds in a **necessity condition**

(35) $\equiv$ Juno's actual speed $\geq d_n$

where d_n is the **minimum speed required for Juno to win the race**

$$\iota d_n : \forall w \in \text{ACC}(w^*)[\text{speed}(J)(w) < d_n \rightarrow \neg\text{win}(J)(w)]$$

Enough predicates in the implicative perspective

Like lexical implicatives (e.g., *dare*):

1. (a) *Enough* predicates **presuppose necessity**

   a minimum degree d_n of ADJ is required to realize the complement

   $$\iota d_n : \forall w \in \text{ACC}(w^*)[\text{ADJ}(x)(w) < d_n \rightarrow \neg P(x)(w)]$$

2. *Enough* predicates **assert satisfaction of the prerequisite**

   the sentence subject actually has at least degree d_n of ADJ

   $$\text{ADJ}(x)(w^*) \geq d_n$$

Table: Components of implicativity

	presupposition	*assertion*	*modal flavour*
dare	bravery nec & suff	✓bravery	causal

Enough predicates in the implicative perspective

Unlike lexical implicatives:

1. (b) *Enough* predicates **don't presuppose sufficiency**

   missing: having degree d_n of ADJ guarantees the complement

   $$\forall w \in \text{ACC}(w^*)[\text{ADJ}(x)(w) \geq d_n \rightarrow P(x)(w)]$$

2. *Enough* constructions **vary the modal flavour** of necessity

   (31a) Juno was fast enough to win the race **circumstantial** necessity

   Calculate d_n using worlds where most circumstances are the same and Juno wins the race

   (38) Amira was old enough to drink alcohol. **deontic** necessity

   Calculate d_n using worlds where Amira drinks legally

Correct prediction: no implicative inferences in cases like (38)

Circumstantial *enough* and actuality inferences

Actuality inferences arise with circumstantial *enough*:

(31) a. Juno **was fast enough** to win the race. $\rightsquigarrow$ *Juno won the race.*

b. Juno **was not fast enough** to win the race. $\rightarrow$ *Juno did not win the race.*

- we predict the **necessity-based inference** in (31b) ✓
- **absent sufficiency,** no **actuality entailment** for (22a)
  ✓ for English, under imperfective in French
- **but:** perfective *enough* has an **actuality entailment** ✗

(33) 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 didn't win.'

⚠ **Implicative approach:** we need **perfective** to **introduce sufficiency**

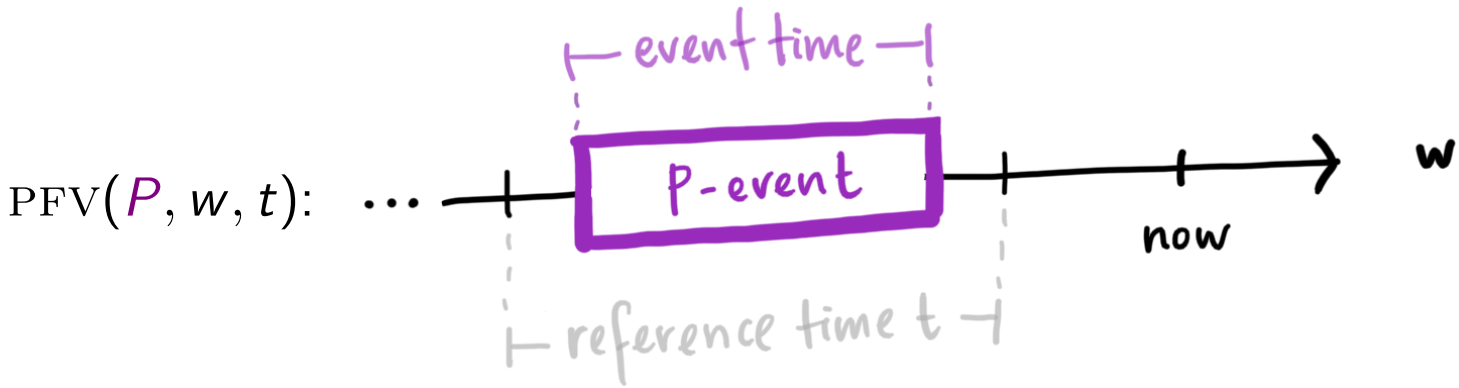
Sufficiency and perfective aspect?

⚠ **Implicative approach:** we need **perfective** to **introduce sufficiency**

This isn't *a priori* plausible:

- **'Viewpoint' aspect:** PFV yields complete events by containing runtime

$$[\![\text{PFV}]\!] = \lambda w \lambda t \lambda P_{\epsilon}.\exists e[\tau(e) \subseteq t \wedge P(e)(w)] \qquad \text{(Kratzer 1998, a.o.)}$$



- **expect:** Juno was-PFV fast enough to win the race

  $\rightsquigarrow$ *bounds time at which Juno had (at least) the necessary speed* d_n

Two kinds of circumstantial *enough*

Actuality entailments are also sensitive to the **matrix adjective:**

- circumstantial *enough* with **static adjectives** **lack actuality inferences**

  (39) Nima **was tall enough** to touch the branch, but he didn't even reach for it.

- so far as **be tall** + PFV is acceptable, **aspect makes no difference**

  (40) ??Nima **a été assez grand** pour toucher la branche, mais il ne l'a pas touché.
  'Nima was-PFV tall enough to touch the branch, but he did not touch it.'

Generalization: *enough* **actuality entailments** also require **dynamic adjectives** (e.g., *fast*)

(33) 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 didn't win.'

Causal reasoning again

Static and **dynamic** *enough* constructions are **causally differentiated:**

- calculate necessary degree d_n by looking at worlds where Nima touches the branch, Juno wins the race, ...
- **implicitly:** circumstantial modality limits attention to worlds where complement is realized in a normal way
- **no magic:** an event P is realized in a normal world if its enabling and causing conditions are satisfied

Static *enough*: height is **not the proximate cause** of reaching the branch

(39) Nima was tall enough to touch the branch, but he **didn't even reach for it.**

- having height d_n works in tandem with a causally sufficient and necessary action, but **no inherent connection**

Causal reasoning again

Static and **dynamic** *enough* constructions are **causally differentiated:**

- calculate necessary degree d_n by looking at worlds where Nima touches the branch, Juno wins the race, . . .
- **implicitly:** circumstantial modality limits attention to worlds where complement is realized in a normal way
- **no magic:** an event P is realized in a normal world if its enabling and causing conditions are satisfied

Dynamic *enough*: speed **characterizes the proximate cause** of race-winning

(31a) Juno was fast enough to win the race

- speed only matters after other conditions are satisfied (registered, at start, . . .)
- **then:** running at speed d_n is **causally sufficient** (and necessary) for winning

Dynamic *enough* in the implicative perspective

1. (a) Dynamic, circumstantial *enough* **presuppose necessity**

   a minimum degree d_n of ADJ is required to realize the complement

   $$\iota d_n : \forall w \in \text{CIRC}(w^*)[\text{ADJ}(x)(w) < d_n \rightarrow \neg P(x)(w)]$$

   (b) and background **contingent sufficiency**

   instantiating degree d_n of ADJ is causally sufficient for complement

   $$\forall w \in \text{CIRC}(w^*)[\text{INST}(\text{ADJ}(x)(w) \geq d_n) \xrightarrow{\text{causal}} P(x)(w)]$$

2. *Enough* predicates **assert satisfaction of the (necessary) prerequisite** ⚠

   the sentence subject actually has at least degree d_n of ADJ

   $$\text{ADJ}(x)(w^*) \geq d_n$$

3. **Causal modal flavour** is embedded via 'hidden' sufficiency condition, operative with instantiation

Dynamic *enough* and actuality inferences

Dynamic circumstantial *enough* **differs minimally from implicative assertions:**

- implicatives assert that their prerequisites were satisfied

  (25a) Ria dared to open the door. → *Ria acted bravely*

- dynamic *enough* **instead establish the possibility of satisfaction**

$$\text{Juno is } d \text{ fast} \sim \textit{Juno is capable of instantiating speed } d$$

$$\text{speed}(J)(w^*) \geq d \sim \exists w \in \textsc{circ}(w^*)[\textsc{inst}(\text{speed}(J)(w^*) \geq d)]$$

Dynamic *enough* and actuality inferences

Dynamic circumstantial *enough* **differs minimally from implicative assertions:**

- Latent attribution is good enough for English (and French imperfective)

(31a) Juno is fast enough to win the race.
$\sim$ *Juno can instantiate (run at) the race-winning speed*

- **to get actuality entailments,** we need the instantiation

(33) 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 didn't win.'

Implicative approach: we need **perfective** to activate **causal sufficiency** by **forcing instantiation**

Deus ex machina: dynamic properties and aspect

In English, dynamic capacity attributions are **systematically ambiguous:**

(41) Juno **was loud.**

a. **stative:** Juno had the capacity to do loud things.

b. **eventive:** Juno did something loud(ly).

(35) Juno **was fast enough** to win the race.

a. **stative:** Juno could (had the capacity to) run at speed d_n

b. **eventive:** Juno ran at a speed of at least d_n
thereby bringing it about that she won the race

- episodic contexts privilege **eventive** and thus **actualized** interpretation
- **actuality** is defeasible because nothing fixes the **eventive** interpretation

Dynamic properties and aspect

Overt aspect forces a choice between readings:

- PFV selects for **eventives**, can compose with **statives** via **aspectual coercion**
  (Moens & Steedman 1988, de Swart 1998)

(42) Jupiter **a aimé** Europa.
'Jupiter loved-PFV Europa.'

Interpretation: Jupiter fell in love with Europa

stative *love* + PFV $\xrightarrow{\text{coercion}}$ eventive INCHOATIVE

Instantiation is the natural reinterpretation for **dynamic capacity attributions:**

(43) Juno **a été rapide.**
'Juno was-PFV fast.'

Interpretation: Juno did something fast

stative *be fast* + PFV $\xrightarrow{\text{coercion}}$ eventive INSTANTIATIVE

- coercion operator INST provides a 'witnessing' event(ive) for the capacity

Dynamic properties and aspect

Aspect-governed actuality inferences for French dynamic *enough*:

- IMPF composes with the **stative**: ability, not actuality

  (34) Juno **était assez rapide** pour gagner la course . . .
  'Juno was-IMPF fast enough to win the race, . . .'

  ✓. . . but she did not participate.

  ✓. . . but something always went wrong.

- **instantiative coercion** with PFV makes dynamic *enough* **implicative**

  (33) Juno **a été assez rapide** pour gagner la course.
  'Juno was-PFV fast enough to win the race.'

  a. *asserts:* Juno **instantiated** speed d_n sufficiency condition

  b. *causal consequence:* Juno won the race
  (because she ran at speed d_n)

Aspect-governed implicativity

Semantic components of implicativity:

1. implicatives **presuppose** the existence of a **necessary and sufficient condition** A for their complements
2. implicatives **assert** that **condition** A **is satisfied**
3. implicatives invoke **causal reasoning** via **modal flavour** of necessity and sufficiency

Implicative entailments are derived as **causal consequences** when presupposition and assertion are taken together

Aspect-governed implicativity

Enough **predicates** have **actuality entailments only** where the **same components arise compositionally:**

- baseline semantics for *enough* encode a **necessity presupposition,** but **modal flavour** varies
- we get sufficiency only with **dynamic adjectives,** which **characterize the proximate (sufficient) cause** of the *enough* complement
- with necessity and contingent **causal sufficiency**, **perfective aspect** is needed to produce an **implicative assertion**

  . . . forcing **instantiation** of the **causally sufficient condition**

  . . . and deriving **actuality entailments** as **causal consequences**

Conclusion: *enough* predicates' **actuality entailments** are **implicative**

A unified account of actuality inferences

Ability modals pattern with **dynamic adjective** *enough* **constructions:**

(5) Marja **pouvait** traverser le lac à la nage, mais elle ne l'a jamais traversé.
'Marja could-IMPF swim across the lake, but she never crossed it.'

(6) 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.'

Towards a unified implicative analysis: (Nadathur 2021, 2023)

ABLE : manage :: be brave enough : dare

- **ability as hypothetical guarantee:**
  x can_{ability} P $\sim$ x has the capacity to realize **proximate cause** of $P(x)$
- PFV activates implicative structure: ABLE is subject to **instantiative coercion**
- **key ingredient:** background **causal reasoning**

Outline of the talk

1. Introduction
2. Ability and possibility
3. Chasing the actuality interpretation: implicative verbs
4. Actuality and aspect: *enough* comparatives
5. Conclusions and questions: ability revisited

Tying things together

Ability shares **complex causal structure** with implicative *manage*:

(44) 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, assertion (at base eventive in asserting $A(x)$)
- ability claims are **at base stative** (cf. Hackl 1998, Homer 2011, 2021):
  - with IMPF: contingent possibility of $P(x)$ (in view of x's capacities)
  - with PFV: default to **instantiative** coercion

(45) Olga **a pu** soulever cette table. ('Olga could-PFV lift this table.')

a. *presumes:* $\exists A : A(\mathsf{0}) \xrightarrow[\text{c-nec}]{\text{c-suff}} \mathtt{lift}(\iota y : \mathtt{table}(y))(\mathsf{0})$

b. *assert* + PFV: $A(\mathsf{0}) = \text{INST}(A \in \text{CH}(\mathsf{0}, w, t))$

c. **conclusion:** $\mathtt{lift}(\iota y : \mathtt{table}(y))(\mathsf{0})$

The three problems

1. **Ability:** what do expressions of ability mean?
   - Abilities link a dynamic capacity to a particular goal
   - For agent x, 1-place predicate P, x $\text{can}_{\text{ability}}$ P iff $\exists A \in \text{CH}(x, w, t)$ s.t. $A(x)$ is **causally necessary, causally sufficient** for $P(x)$ (no ambiguity)

2. **Modality:** what connects ability, actuality, and possibility?
   - Ability, actuality motivate the same causal background
   - $P(x)$ is possible in view of x's choices (causal *stit*)
   - $P(x)$ is actualized if x acts on choice/capacity

3. **Aspect:** what role does aspect/temporal perspective play?
   - for **dynamic statives:** aspect selects stative/latent-capacity or eventive/instantiated reading
   - implicative/ability contrast retained under IMPF
   - PFV forces full implicative structure for ability, *enough*

Motivating causal structure

Causal background structure captures the link between $A(x)$ and $P(x)$ in view of which the ability-target is understood as 'under the control' of x:

- Actualized ability, *manage* share **non-triviality** inferences

(18) a. Mika **was able** to breathe normally.
b. Mika **managed** to breathe normally.

$\rightsquigarrow$ *breathing normally was (in some way) non-trivial*

- **non-triviality** captured by **causal necessity**:
since $P(x)$ is *contingent* on $A(x)$, (non-realization of) $A(x)$ is a potential obstacle to $P(x)$

- $A(x)$ is a difference-maker for $P(x)$ w.r.t. reference context

Motivating causal structure

Causal background structure captures the link between $A(x)$ and $P(x)$ in view of which the ability-target is understood as 'under the control' of x:

- **Causal sufficiency** explains a tense asymmetry in ability ascriptions:

  (46) Before he hit three bull's-eyes in a row, Brown fired 600 shots without coming close, and 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.

- (46a) does not just report on the ability-target: licensed by the observation that Brown acted to precipitate P as part of an actual causal chain
- (46b) 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 of deliberate action

Motivating causal structure

Causal background structure captures the link between $A(x)$ and $P(x)$ in view of which the ability-target is understood as 'under the control' of x:

- Potential explanation for perceived genericity of ability (Maier 2018)

  (47) 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 proposes introducing GEN: x can_{ab} P just in case $P(x)$ is an *option* (practically-available action) for x under **normal circumstances**
  actualization where GEN suppressed "for cognitive or linguistic reasons" (p.426)

- Reference to normality comes for free with the causal approach:
  - the model relating $A(x)$ to $P(x)$ 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

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 previously-suggested lines)
- 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

(Some of the) open questions

- The formal relationship between ability (as causal *stit*) 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? (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?

Selected references

- Baglini & Francez 2016. The implications of managing. *JSem* 33.
- Bary 2009. Aspect in Ancient Greek. Ph. D., Radboud.
- Belnap 1991. Backwards & forwards in the modal logic of agency. *Phil. & Phenom. Research* 51.
- Belnap & Perloff 1988. Seeing to it that: a canonical form for agentives. *Theoria* 54.
- Bhatt 1999. Covert modality in non-finite contexts. Ph.D., UPenn.
- Brown 1988. On the logic of ability. *Phil. Logic* 17.
- Hacquard 2005. Aspects of too and enough constructions. *SALT* 15.
- Hacquard 2006. Aspects of modality. Ph. D., MIT.
- Homer 2011. French modals and perfective. *WCCFL* 28.
- Homer 2021. Actualistic interpretations in French. *SemPrag* 14.
- Karttunen 1971. Implicative verbs. *Language* 47.
- Kenny 1976. Human ability and dynamic modalities. In *Essays of Explanation and Understanding*.
- Maier 2018. Ability, modality, and genericity. *Phil. Stud.* 175.
- Mandelkern, Schultheis & Boylan. 2017. Agentive Modals. *Phil. Rev.* 126.
- Moens & Steedman 1988. Temporal ontology and temporal reference. *Comp. Ling.* 14.
- Nadathur 2023. *Actuality inferences*. Oxford Univ. Press.
- Nadathur & Lauer 2020. Causal necessity, sufficiency & the impl. of causative verbs. *Glossa* 5.
- Pearl 2000. *Causality.* Cambridge Univ. Press
- Schulz 2011. If you'd wiggled A, then B would've changed. *Synthese* 179.
- von Stechow, Krasikova & Penka 2004. The meaning of German *um zu*. *Modal Verbs & Modality*.
- de Swart 1998. Aspect shift and coercion. *NLLT* 16.
- Thalberg 1972. *Enigmas of Agency: Studies in the Philosophy of Human Action.* Allen Unwin.

Appendix: Instantiative coercion

Aspectual coercion theories propose **formal coercion operators:** (Bary 2009)

- **inchoative coercion:** from a stative to its initiation (transition) point, often lexically triggered

  (1) *Soudain, Anne a été triste.* → Anne *became* sad suddenly.
  'Suddenly, Anne was-PFV sad.' + INCH

- **maximal coercion:** a maximal instance of states (cessation inferences)

  (2) *Marie a été belle.* ⇝ Marie is no longer beautiful.
  '[In those days], Marie was-PFV beautiful.' + MAX

- **type mismatch** between input predicate and PFV's selectional restrictions inserts coercion (repair) operator (de Swart 1998)

$$\mathrm{PFV}(P_{\text{stative}}) \xrightarrow{\text{mismatch!}} \mathrm{PFV}(C_{\text{stative}\to\text{eventive}}(P_{\text{stative}}))$$

- the specific choice of $C_{\text{stative}\to\text{eventive}}$ depends on context, predicate properties

Appendix: Instantiative coercion

Instantiative coercion is novel: (but see Goldsmith & Woisetschlaeger 1982, de Swart)

- **here:** applies only to predicates that hold of individuals *in view of* capacity for action characterized by a particular property
- **one option:** meaning postulate relates stative, eventive denotations

(3) $[\![\text{fast}_{\text{stative}}]\!] := \lambda w \lambda e \lambda x.$
$[\Diamond \exists e'[e' \sqsubseteq e \wedge \text{fast}_{\text{eventive}}(w)(e') \wedge \text{AGENT}(e') = \text{THEME}(e) = x]]$

- INST ($C_{\text{stative}\rightarrow\text{eventive}}$) introduces a salient witness event (underspecified)

(4) $[\![\text{INST}]\!] := \lambda w \lambda R \lambda e.(\iota Q : \text{WITNESS}(Q, R))(e)(w)$
where $\text{WITNESS}(Q_{\text{eventive}}, R_{\text{stative}}) :=$
$\forall w, e[Q(e)(w) \rightarrow R(e)(w) \wedge R(e)(w) \leftrightarrow \exists w' \in \text{CR}(w)[\exists e' \sqsubseteq e[Q(e')(w)]$

- if we privilege a different coercion operator, actuality entailment goes away:

(5) *Olga* **a** *soudain* **pu** *soulever un frigo, mais elle ne l'a pas fait.*
'Olga could-PFV suddenly lift a fridge, but she did not do it.'

(5) not possible in Hindi!

Appendix: Instantiative vs. actualistic coercion

Homer (2011, 2021) suggests a (related) **actualistic** coercion operator:

(6) a. *La maison a coûté 100,000 euro.* → The house was bought.
'The house cost-PFV 100,000 euro.'

b. *La maison coûtait 100,000 euro.* ↛ The house was bought.
'The house cost-IMPF 100,000 euro.'

- ACT is less restricted than INST, no meaning postulate required
- **Homer:** ACT directly realizes ability modals' complements, by selecting a (salient) eventive which temporally overlaps the stative possibility
- **but:** this incorrectly predicts actuality entailments from perfective **static-adjective** *enough* constructions (ACT can select the *enough* complement to realize)
- INST avoids this because actuality entailments are (causal) consequences of coerced events