

Necessity, sufficiency, and actuality: Causal dependence in implicative inferences*

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1 Introduction: actuality inferences

Three constructions license ‘actuality’ inferences:

(I) **implicative verbs** (Karttunen, 1971)

- implicative verbs **entail** the realization of their complements.

(1) Solomon **managed** to build a temple. \vdash *Solomon built a temple.*

(II) **enough** and **too** constructions (Karttunen, 1971; Meier, 2003; Hacquard, 2005)

- E&T constructions **implicate** the realization of their complements

(2) Juno **was fast enough** to win the race. \leadsto *Juno won the race.*

(III) **ability modals** and **be able** (Bhatt, 1999)

- past-tense *be able* **implicates** the realization of its complement

(3) (Yesterday,) Marja **was able** to swim across Lake Harriet.
 \leadsto *Marja swam across Lake Harriet.*

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These constructions are linked by the special case of *actuality entailments*:

- in aspect-marking languages like French (Greek, Hindi, etc), something surprising happens in the perfective aspect¹
 - perfectly-marked ability modals **entail** (rather than just implicating) their complements (Bhatt, 1999)

(4) *Marja a pu traverser le lac à la nage, #mais elle ne l’a pas traversé.*
 ‘Marja can-PFV swim across the lake, #but she didn’t cross it.’
 - the same thing happens with perfectly-marked E&T constructions (the expected implicature becomes an entailment; Hacquard, 2005)

(5) *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.’
- the convergence in complement entailment leads Bhatt (1999) and Hacquard (2005) to treat actuality entailments as true implicative entailments:
 - on their view, shared entailment patterns reflect underlying semantic similarity
 - **proposal:** E&T constructions (Hacquard) and ability modals (Bhatt) have the same complement-entailing lexical semantics as implicatives

Problem: if all three constructions (I)-(III) share the same semantics, why do the inference patterns only match under perfective marking?

- E&T constructions (6) and ability modals (7) only produce actuality entailments in the perfective, not under imperfective marking (or in English)

(6) *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.’

(7) *Marja pouvait traverser le lac à la nage, mais elle ne l’a jamais traversé.*
 ‘Marja can-IMPF swim across the lake, but she never crossed it.’
- implicative entailments, on the other hand, are not affected by aspectual marking

(8) *Juno a réussi à gagner la course, #mais elle n’a pas gagné.*
 ‘Juno manage-PFV to win the race, #but she did not win.’

(9) *Juno réussissait à gagner la course, #mais elle n’a jamais gagné.*
 ‘Juno manage-IMPF to win the race, #but she never won.’

¹The perfective, represented here by the French *passé composé*, typically indicates episodic or bounded eventualities, while the imperfective (French *imparfait*) can be used to make generalizations or describe ongoing situations.

	PFV	IMPF	Engl.
implicatives	\vdash	\vdash	\vdash
E&T	\vdash	\rightsquigarrow	\rightsquigarrow
ability modals	\vdash	\rightsquigarrow	\rightsquigarrow

Table 1: Actuality inference patterns by aspect

Today: an account of ‘defeasible implicativity’ in E&T constructions

1. The lexical semantics of implicative verbs:
 - causal dependencies and prerequisites for complement entailment
2. The semantic components of E&T constructions:
 - adjectival degree comparatives with a modal component
 - necessity, but not (always) sufficiency
3. Actuality inferences in E&T constructions:
 - updated E&T semantics
 - actuality entailments are a special case: adjective type and aspect
 - further predictions, loose ends
4. Recap and consequences

2 A causal semantics for implicative verbs

Goal: rather than treating implicative entailments as a ‘black box,’ we want to see how they are derived in the semantics of implicative verbs

Karttunen (1971) characterizes implicatives by their complement entailment pattern; crucially, the polarity of the entailment reverses with negation in the matrix clause.²

- (10) a. Solomon managed to build a temple. \vdash *Solomon built a temple.*
 b. Solomon did not manage to build a temple. \vdash *Solomon did not build a temple.*

²Implicatives are therefore distinct from **factive** predicates like *regret*, which presuppose (rather than entail) their complements. The distinction shows up in the projective behavior of the complement in each case: negating a factive has no effect on the truth value inferred for the factive complement.

The logical problem of implicatives

For an agent S and a one-place predicate A :

- $manage(S, A)$ entails $A(S)$
- $\neg manage(S, A)$ entails $\neg A(S)$
- **but:** $manage(S, A)$ and $A(S)$ are not equivalent assertions

Basic solution: implicatives are associated with presuppositional content

- $manage(S, A)$ gives rise to implications that do not follow from $A(S)$ alone
- (11) Solomon managed to build a temple.
- a. \leadsto Solomon intended to build a temple.
 - b. \leadsto It was difficult/effortful for Solomon to build a temple.
 - c. \leadsto It was unlikely that Solomon would build a temple.
- the implicative assertion is only felicitous when its presuppositions are satisfied
 - $A(S)$ is not restricted to these contexts
 - consequently, an implicative assertion will not always follow in contexts where its bare complement is assertable

Analytical task:

- (a) spell out the presuppositional content
- (b) show how this combines with asserted content to derive complement entailments (and implications like 11a-11c)

2.1 Necessary and sufficient conditions

- looking at *manage* alone, it is difficult to pin down the presuppositional content (see Coleman, 1975; Karttunen and Peters, 1979; Bhatt, 1999)
 - *intention*, *difficulty*, and *unlikelihood* all seem to be possible candidates
 - none of these inferences is universal (Coleman; Baglini and Francez, 2016)
- (12) a. γ Without intending to, Ms. Streisand actually managed to synthesize the problem of diversity mania.
 $\not\leadsto$ intention, $\not\leadsto$ difficulty, \leadsto unlikelihood
- b. γ By 1998, [...] gun manufacturers had easily managed to bypass the laws by making small alterations to their weapons.
 \leadsto intention, $\not\leadsto$ difficulty, $? \leadsto$ unlikelihood
- c. γ The Socialdemokratiet managed to strengthen their position as Denmark's strongest political force as expected during local elections.
 \leadsto intention, $? \leadsto$ difficulty, $\not\leadsto$ unlikelihood

- **however:** English and Finnish have a wide range of lexically-specific implicatives:
 - **dare** suggests that the implicative complement required daring/courage
 - (13) a. She dared to open the door. \vdash *She opened the door.*
 - b. She did not dare to open the door. \vdash *She did not open the door.*
 - Finnish **hennoa**(=*have.the.heart*) suggests that the complement required ‘heart’
 - (14) a. *Hän henno-i tappa-a kissa-n*
 he.NOM have.the.heart-PST.3SG kill-INF cat-GEN/ACC
 ‘He had the heart to kill the cat’ \vdash *He killed the cat.*
 - b. *Hän e-i henno-nut tappa-a kissa-a.*
 he.NOM NEG-3SG have.the.heart-PP.SG kill-INF cat-PART
 ‘He did not have the heart to kill the cat.’
 \vdash *He did not kill the cat.*

Karttunen’s proposal:^a

“...let us ignore the individual differences among implicative verbs and try to state more precisely in what respect they are all alike. Let v stand for any implicative verb and S for the ...infinitival complement of that verb I assume that, in the representation of the main clause, $v(S)$ constitutes the central part of the proposition ... Leaving out ... details, the semantic analysis of the whole sentence can be represented by the following schema.” (p.352)

(15) **Schema:**

- a. *presupposition*: $v(S)$ is a necessary & sufficient condition for S
- b. *proposition*: $v(S)$

^aThis proposal has largely been obscured due to the later Karttunen and Peters (1979) account on which *manage* provides no assertive content beyond that of its complement

- while underspecified, this proposal derives the desired entailments:
 - a positive implicative assertion conveys that a sufficient condition for the complement was met
 - a negative assertion conveys that a necessary condition was not met

Open question: what constitutes the “central part of the proposition,” $v(S)$?

- with verbs like *dare* and *hennoa*, $v(S)$ is the assertion that the lexically-specified prerequisite was met (Nadathur, 2016)
 - (16) a. She dared to open the door, #but she didn’t have the courage.
 - b. She didn’t dare to open the door, #but she had the courage.

- what about *manage*?
 - under (15), difficulty, unlikelihood, etc, cannot be the main presupposition
 - *manage* is semantically bleached, compared to *dare*, *hennoa*, etc
 - **proposal**: *manage* presupposes an abstract prerequisite
- we can refine this:
 - the type of necessity/sufficiency *manage* invokes is constrained
 - a context which backgrounds a legal (deontic) necessary/sufficient condition does not make *manage* felicitous:

(17) a. *Context*: being 21 is legally necessary and legally sufficient for drinking alcohol in the United States. Amira turned 21 yesterday.

b. ?Amira managed to drink alcohol.
 - instead, we infer **circumstantial** conditions: e.g., that Amira has to overcome her aversion to alcohol, or figure out where to buy it

Baglini and Francez (2016)’s insight:

the relationship between an implicative’s presupposition and its complement is about **causal dependence**

2.2 Causal dependence

Proposal (Nadathur, 2019):

- (18) For an implicative verb I , an agent S , a one-place predicate A , and a context c , the proposition $I(S, A)$:
- Presupposes*: The existence of a predicate H such that $H(S)$ is **causally necessary** for $A(S)$ in the utterance context. $H(S) \blacktriangleleft_c A(S)$
 - Asserts*: $H(S)$
 - Presupposes*: $H(S)$ is the only unmet causally necessary condition for $A(S)$ in context (so $H(S)$ is **causally sufficient** for $A(S)$ relative to c) $H(S) \blacktriangleright_c A(S)$

- causal dependencies are defined via Schulz (2011)’s **dynamics** for causal entailment
 - a dynamics D is a representation of causal information in a discourse context
 - D encodes which propositions (actions/events) are causally linked to others
 - D encodes the nature of the dependencies
 - D can be updated, referenced, and manipulated by both at-issue and not-at-issue content

Illustration: the modified Dreyfus scenario (adapted from Baglini and Francez)

Suppose Dreyfus intends (INT) to spy for Germany:

- (a) then he will collect secrets about the French army (SEC) SEC = INT
- (b) if he has the nerve (NRV) as well as the intention to
spy, he will send out a message (MSG) to make contact MSG = INT ∧ NRV
- (c) if it so happens that a German is listening on that
frequency (LST), and the message is not intercepted
(BRK), he will establish a communications line (COM) COM = MSG ∧ LST ∧ ¬BRK
- (d) he will use this line to pass information to the Germans,
thereby spying (SPY) SPY = SEC ∧ COM

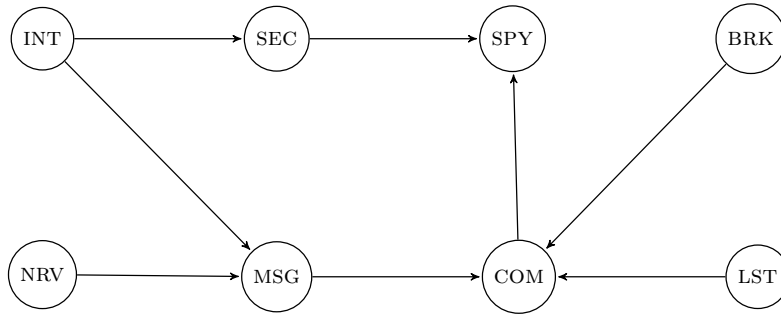


Figure 1: A dynamics for the Dreyfus example

<i>Context 1:</i> Dreyfus intends to spy, and has collected info	$INT = SEC = 1$
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- (19)
 - a. Dreyfus dared to send a message to the Germans. ✓[NRV is nec, suff]
 - b. ?/#Dreyfus dared to make contact with the Germans. ✗[BRK, LST unresolved]
 - c. ?/#Dreyfus dared to spy for the Germans. ✗[BRK, LST, COM unresolved]
- (20)
 - a. Dreyfus managed to send a message to the Germans. ✓[¬NRV = 1]
 - b. Dreyfus managed to make contact with the Germans. ✓[¬NRV = 1, MSG = 1, LST = 1, BRK = 0]
 - c. Dreyfus managed to spy for the Germans. ✓[¬NRV = 1, MSG = 1, LST = 1, BRK = 0, COM = 1]

<i>Context 2:</i> Dreyfus is very daring, but does not intend to spy.	$INT = 0, NRV = 1$
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- *dare* (19a-19c) is infelicitous; NRV is not sufficient in context
- *manage* (20a-20c) is infelicitous; given $INT = 0$, there can be no necessary/sufficient condition for MSG, COM, SPY

Takeaway:

- implicative verbs background the contextual causal necessity and causal sufficiency of some condition (or situation) for their complement
- lexically-specific verbs like *dare* tell us what this condition is
- since it's non-specific, *manage* 'bundles' causal conditions:
 - we infer difficulty, unlikelihood, etc, based on our knowledge of the dynamics
- Karttunen's $v(S)$ is the assertion that the prerequisite was satisfied
- in resolving the open condition (as at-issue content), an implicative utterance determines the complement's truth value as a consequence of presupposition and assertion
- **NB:** (18) formulates the necessity/sufficiency presupposition in two independent parts:
 - dropping one or the other predicts different inference patterns
 - there are **one-way implicatives** that only presuppose necessity:

(21) a. *Hän jakso-i noust-a.*
 he.NOM have.strength-PST.3SG rise-INF
 'He had sufficient strength to rise.' \nVdash *He rose.*

b. *Hän e-i jaksa-nut noust-a.*
 he.NOM NEG-3SG have.strength-PP.SG rise-INF
 'He did not have sufficient strength to rise.' \vdash *He did not rise.*
 - complement-taking predicates that only entail under positive matrix polarity: causatives like *make*, *force* (Lauer and Nadathur, 2019, accepted)³

Implicatives unpacked:

- (two-way) implicative entailments have **3 key components**
 - (a) existence of a necessary and sufficient condition for the complement
 - (b) the causal interpretation of necessity/sufficiency
 - (c) an assertion that resolves the truth status of the necessary/sufficient condition

construction	semantic component			inference	
	<i>mod. flavour</i>	<i>presuppose</i>	<i>assert</i>	<i>pos</i>	<i>neg</i>
implicative	causal, circumstantial	$H(S) \blacktriangleleft_c A(S)$ $H(S) \blacktriangleright_c A(S)$	$H(S)$	$\vdash A(S)$	$\vdash \neg A(S)$

Table 2: The semantic components of polarity-preserving two-way implicativity

- looking ahead, we predict that E&T constructions will be implicative (complement-entailing) just in case all three conditions are met

³Potential sufficiency-only predicates in Finnish are also causative in structure: L. Karttunen, p.c.

3 Implicativity in *enough* and *too* constructions

3.1 The semantic components of *enough* and *too* constructions

E&T constructions are analyzed as degree comparatives with a modal component (Bierwisch, 1987; Meier, 2003; von Stechow et al., 2004; Schwarzschild, 2008):

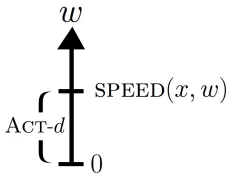
- a real degree (e.g., Juno’s speed in the actual world) is
 - attributed to the sentential subject (e.g., Juno)
 - measured with respect to a modally-determined degree (e.g., the speed needed to win a salient race)
- components of the construction:
 - (a) gradable adjective (of variable type)
 - individual-level: *tall*; stage-level: *hungry*; actionable: *fast*
 - (b) complement proposition (for degree measurement/comparison)
 - (c) a comparative (and modal) operator: *enough*, *too*

The truth conditions we want can be paraphrased as follows:

- (22) a. Juno is fast enough to win the race.
 Juno is as fast as she must be to make winning the race possible.
- b. Juno is too slow to win the race.
 Juno is slower than she can be for winning the race to be possible.

Composition (see also von Stechow et al., 2004):

- gradable adjectives relate individuals to (downward-closed) sets of degrees on a scale

$$(23) \quad \llbracket \text{fast} \rrbracket^w := \lambda d \lambda x. \text{SPEED}(x)(w) \geq d$$


where $\text{ACT-}d = \{d : \text{SPEED}(x)(w) \geq d\}$

- *enough* is an equative (*as* ADJ *as*) with a universal modal:⁴ it takes three arguments (an individual x , a predicate of individuals Q , and a gradable adjective P)

$$(24) \quad \llbracket \text{enough} \rrbracket^w := \lambda Q_{est} \lambda P_{dest} \lambda x_e$$

$$[\{d : \forall w' \in \text{ACC}(w)[Q(x)(w') \rightarrow P(d)(x)(w')]\} \subseteq \{d : P(d)(x)(w)\}]$$

- *true* if the set of degrees d s.t. x is at least d -ADJ in every $Q(x)$ -world is a subset of the set of degrees d s.t. x is at least d -ADJ in the evaluation world

⁴Its dual, *too*, is a comparative (*more* ADJ *than*) with an existential modal (von Stechow et al., 2004).

Derivation: let w^* be the world of evaluation

- (25) a. $\llbracket \text{Juno be fast enough to win the race} \rrbracket^{w^*}$
 b. $\{d : \forall w \in \text{ACC}(w^*)[\text{win}(j)(w) \rightarrow \text{SPEED}(j)(w) \geq d]\} \subseteq \{d : \text{SPEED}(j)(w^*) \geq d\}$
- the set MOD- d of degrees d s.t. Juno is at least d -fast in every world in $\text{ACC}(w^*)$ where she wins the race is a subset of the set ACT- d of degrees d s.t. Juno is at least d -fast in w^* .

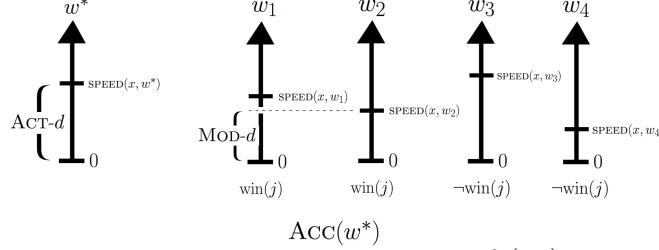


Figure 2: Representation of (25)

- equivalently: Juno's maximum degree of speed in w^* is greater than her maximum degree of speed in the slowest world where she wins the race (w_2)
- so: (25) is *true* if Juno's actual speed makes it possible for her to win (i.e., there is an accessible world where she wins with that speed or less)

This leads to a **necessity condition**:

- enough* is infelicitous if its complement is impossible
- presuppose: there is at least one world in which, e.g., Juno wins the race

$$(26) \quad \exists w' \in \text{ACC}(w) : Q(x)(w') \quad [w_1, w_2 \text{ in Figure 2}]$$

- since she has a speed in every world, it follows that the set of degrees of Juno's speed in every world where she wins is not empty ...

$$(27) \quad \text{MOD-}d = \{d : \forall w' \in \text{ACC}(w)[Q(x)(w') \rightarrow (\text{ADJ}(x)(w') \geq d)]\} \neq \emptyset$$

- ... and that there is a minimum degree d_{nec} which makes Juno's win possible:

$$(28) \quad \exists d_{\text{nec}} : \forall w' \in \text{ACC}(w)[\neg(\text{ADJ}(x)(w') \geq d_{\text{nec}}) \rightarrow \neg Q(x)(w')]$$

On these semantics:

- like implicatives, E&T constructions:
 - presuppose a **necessary condition** (28) for their complements
 - assert that this **condition was satisfied**
- unlike implicatives, E&T constructions:
 - can vary in **modal flavour** (of the predicate-complement relationship)
 - (29) Amira was old enough to drink. **deontic**
 - (30) Juno was tall enough to reach the branch. **circumstantial**
 - (2) Juno was fast enough to win the race. **circumstantial**
 - do not presuppose a **sufficiency condition**

construction	semantic component			inference	
	<i>mod. flavour</i>	<i>presuppose</i>	<i>assert</i>	<i>pos</i>	<i>neg</i>
implicative	causal, circumstantial	$H(S) \triangleleft_c A(S)$ $H(S) \triangleright_c A(S)$	$H(S)$	$\vdash A(S)$	$\vdash \neg A(S)$
be ADJ enough	deontic	$d\text{-}ADJ(S) \triangleleft A(S)$	$d\text{-}ADJ(S)$	$\nvdash A(S)$	$\nvdash \neg A(S)$
	circumstantial	$d\text{-}ADJ(S) \triangleleft A(S)$	$d\text{-}ADJ(S)$	$\nvdash A(S)$	$\vdash \neg A(S)$

Table 3: Current predictions for E&T inferences

- **deontic E&T constructions:** Table 3 predictions upheld (no entailments)

- (31) a. Amira was old enough to drink, but she was a teetotaler.
b. Amira was not old enough to drink, but she drank anyway.
- in the negative case (31b), a legally-necessary condition is not met, but the real world need not be one in which laws are obeyed

- **circumstantial E&T constructions:** predictions are not sufficiently fine-grained!

- when ADJ is a **static** property (e.g., *tall*), we only get a negative entailment, verifying the Table 3 predictions:

- (32) a. Nima was tall enough to reach the branch but he didn’t even try.
b. Nima was not tall enough to reach the branch, ?#but he reached it.

- when ADJ is **dynamic** (representing an actionable capacity; e.g., *fast*), neither positive or negative (English) E&T statements entail:

- (33) a. Juno was fast enough to win the race, but she didn’t participate.
b. Juno was not (really) fast enough to win the race, but the leader tripped on the last lap, making Juno the unexpected winner.

Two questions:

- what is the (inference-relevant) difference between static properties and actionable capacities?
- how do we get rid of the unwanted negative entailment, but *only* for actionable-capacity E&T constructions?

To figure out what’s going on here, we need to take a closer look at the facts about aspect

3.2 Adding sufficiency

Hacquard’s generalization: perfective E&T constructions **entail** their complements

- (34) a. *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.’
b. *Juno n’a été pas assez rapide pour gagner la course, #mais elle a gagné.*
‘Juno was-PFV not fast enough to win the race, #but she won.’

Contra Hacquard (2005), we **do not want to presuppose sufficiency** across the board:

(35) **Sufficiency condition** (for E&T constructions): (Hacquard, 2005)

$$\exists d_{\text{suff}} : \forall w' \in \text{ACC}(w) [(\text{ADJ}(x)(w') \geq d_{\text{suff}}) \rightarrow Q(x)(w')]$$

- setting $d_{\text{suff}} = d_{\text{nec}}$ to match the implicative presupposition, we get:

(36) **‘Implicative’ presupposition** (for E&T constructions):

$$\iota d_{\text{NS}} : \forall w' \in \text{ACC}(w) [Q(x)(w') \leftrightarrow (\text{ADJ}(x)(w') \geq d_{\text{NS}})]$$

There is a unique degree d_{NS} of ADJ such that x is d_{NS} -ADJ in a world w if and only if x realizes Q in w

The implicative-style presupposition (36) is too strong:

- for circumstantial E&T constructions with static properties, it predicts a positive entailment: this prediction is not upheld even in the perfective

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

– (this is a new qualification to Hacquard’s generalization about perfective E&T)

- we get the right result (positive and negative entailments) for perfectly-marked E&T constructions with dynamic capacities, but in an **intuitively wrong** way:

(38) *Juno a été assez rapide pour gagner la course.* \vdash Juno won the race.
‘Juno was-PFV fast enough to win the race.’

paraphrase, given (36): *Juno’s actual speed was at least as great as the speed that guarantees race-winning in all circumstantially-accessible worlds.*

– since the real world is circumstantially accessible to itself, Juno’s win is guaranteed by her speed in (38)

However ...

- *being d-fast* \sim having the *latent capacity* to do things at speed d
- the relationship between *being fast* and winning the race **is causal**, but only when the ‘fastness’ is **manifested in an action** (e.g., running)
- the ‘implicative’ presupposition (36) does not capture this

Making sense of these facts:

- static E&T and dynamic E&T constructions are differentiated **causally**
 - some causing action must take place in order for the complement to be realized
 - **dynamic capacities** (e.g., *be fast*) characterize the causing action: acting on the capacity brings about the E&T complement

- there is a sufficiency relationship between dynamic properties and E&T complements
 - then: agent S **instantiating** $d_{\text{nec-ADJ}}$ is *causally sufficient* for realizing $A(S)$
- (39) **Dynamic-capacity sufficiency:** $\text{INST}(\text{ADJ}(S)(d_{\text{nec}})) \blacktriangleright_c A(S)$

E&T assertions differ from implicative assertions even when ADJ is dynamic:

- implicatives assert the satisfaction of a necessary/sufficient condition
 - dynamic E&T constructions instead at-base assert only the *possibility* of satisfaction
- (40) $\text{ADJ}(S)(d_{\text{nec}})(w) \sim \Diamond[\text{INST}(\text{ADJ}(S)(d_{\text{nec}})(w))]$

construction	<i>mod. flavour</i>	semantic component		inference	
		<i>presuppose</i>	<i>assert</i>	<i>pos</i>	<i>neg</i>
implicative	causal, circ.	$H(S) \blacktriangleleft_c A(S)$ $H(S) \blacktriangleright_c A(S)$	$H(S)$	$\vdash A(S)$	$\vdash \neg A(S)$
	deontic	$d\text{-ADJ}(S) \triangleleft A(S)$	$d\text{-ADJ}(S)$	$\nVdash A(S)$	$\nVdash \neg A(S)$
be ADJ enough	circ. static	$d\text{-ADJ}(S) \triangleleft A(S)$	$d\text{-ADJ}(S)$	$\nVdash A(S)$	$\vdash \neg A(S)$
	circ. dynamic	$d\text{-ADJ}(S) \triangleleft A(S)$ $\text{INST}(d\text{-ADJ}(S)) \blacktriangleright_c A(S)$	$\Diamond[\text{INST}(d\text{-ADJ}(S))]$?	?

Table 4: Updated predictions for E&T inferences

Given the components of actionable-capacity E&T inferences, we predict actuality inferences/entailments just in case instantiation of the dynamic property is implied/entailed.

- we need the perfective aspect to do this work
- to replace the question marks in Table 4 with the right aspect-governed facts:
 - we don’t need the perfective to *introduce* a sufficiency condition, since this is built into the structure of dynamic property E&T constructions
 - instead, perfective ‘peels off’ the possibility operator by forcing instantiation

Additional points:

- there are some additional conditions governing the ‘implicative’ readings of E&T constructions
 - e.g., there is a requirement of temporal overlap in the specification of the matrix attribution and the complement clause (Marques, 2012)
- these features support the claim that dynamic capacities and E&T complements have a causal relationship rather than a purely circumstantial one
- NB: the non-causal necessity relationship in Table 4 can be equivalently framed as causal necessity between an instantiation of the dynamic capacity and the realization of the E&T complement

4 Actuality inferences in E&T constructions

Proposal: implicative semantics of *enough* constructions

Let P be a proposition of the form $P = S$ be ADJ *enough* to A , where S is an agent, ADJ a relation between individuals and sets of degrees, and A a property of individuals. Evaluated with respect to a world w and context c :

- i. P presupposes the existence of a degree d_{nec} that is necessary for $A(S)$:

$$\exists d_{\text{nec}} : \forall w' \in \text{ACC}(w) [\neg(\text{ADJ}(S)(d_{\text{nec}}(w')) \rightarrow \neg A(S)(w'))]$$

- ii. P asserts that S is/has d_{nec} -ADJ in w :

$$\text{ADJ}(S)(d_{\text{nec}})(w)$$

- iii. In case ADJ is dynamic, P additionally presupposes the contextual causal sufficiency of an instantiation of d_{nec} -ADJ for $A(S)$:

$$\text{INST}(\text{ADJ}(S)(d_{\text{nec}}) \blacktriangleright_c A(S))$$

4.1 Aspect-governed actuality inferences

Dynamic E&T constructions align almost exactly with implicatives:

- they presuppose the existence of a necessary and sufficient condition for the realization of their complements
- necessity and sufficiency have a causal flavour
- however, they at-base assert only the possibility that this condition will be satisfied:
 - if the assertion is interpreted eventively, as an instantiation, actuality inferences are predicted
 - if the assertion is interpreted statively, as an attribution of a (latent) capacity, no actuality inferences are predicted

English E&T actuality inferences:

- English actionable-capacity attributions are **systematically ambiguous** between eventive and stative interpretations:

(41) Juno was loud.

- a. *eventive*: Juno did (something) loud/loudly.
- b. *stative*: Juno had the capacity do (something) loud/loudly.

(42) Juno was fast enough to win the race.

- a. *eventive*: Juno ran at a speed of at least d_{nec}
- b. *stative*: Juno can run at a speed of at least d_{nec}

- contexts that privilege the eventive reading (42a) activate the sufficiency condition, producing actuality inferences:

(43) I didn't know Juno was a runner, but I saw her at the 5K yesterday! She was fast enough to win! \leadsto *Juno won the race.*

- actuality inferences in English are defeasible because there is no reliable way to fix (entail) the eventive interpretation

French actuality entailments:

- in French, aspectual marking forces a choice between eventive and stative readings
- perfective aspect (in general) selects for eventive predicates (Dowty, 1986)
- perfective aspect combines with statives via **aspectual coercion** (Moens and Steedman, 1988; de Swart, 1998)

– *love*, in (44) is coerced into an **inchoative** reading, returning its onset point:

(44) *Jupiter a aimé Europa.* \rightarrow *Jupiter fell in love with Europa.*
'Jupiter loved-PFV Europa.'

- dynamic capacities lend themselves to **instantiative** coercion (cf. Homer, 2011):⁵

(45) *Juno a été rapide.* \rightarrow *Juno did something quickly.*
'Juno was-PFV fast.'

- instantiative coercion picks out predicates whose stative interpretation is inherently action-oriented or action-characterizing (also applies under progressive marking)

(46) *Nima was being funny.* \rightarrow *Nima was doing something funny*

- **as a result**, perfectly-marked dynamic E&T assertions are effectively implicative:
 - perfective marking entails that the causally-sufficient condition for the E&T complement was satisfied

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

- entails*: $\text{INST}(\text{SPEED}(j)(d_{\text{nec}}))$ sufficient for win
- interpretation*: Juno ran at a speed of at least d_{nec} (and that caused her to win the race).

- imperfective aspect, on the other hand, selects for the stative interpretation of an actionable-capacity attribution, and so we correctly predict no entailment

(47) *Juno était assez rapide pour gagner la course ...*
'Juno was-IMPF fast enough to win the race, ...'
...but she did not participate.
...but something unexpected always happened, and she never won.

⁵Homer (2011) proposes an operation of 'actualistic' coercion, which he uses to directly instantiate the complements of ability modals under perfective marking; I believe the relevant coercion operation is more constrained in output than Homer's.

Getting around necessity:

- due to the across-the-board necessity presupposition, we predict entailments in the negative direction for *all* circumstantial E&T constructions
- negated dynamic E&T constructions **do not entail** under the imperfective:

(48) *Juno n'était pas assez rapide pour gagner la course, mais elle a gagné.*
 'Juno was-IMPF not fast enough to win the race, but she won.'

- following Bhatt (1999), Hacquard (2005): the imperfective is associated with a genericity operator,⁶ which quantifies only over *normal* worlds:
- for imperfective E&T constructions:

(49) a. $\llbracket \text{GEN} \rrbracket^w := \lambda Q_{st} [\forall w' \in \text{NORM}(w) [Q(w')]]$
 b. GEN(Juno not be fast enough to win the race)
 $\forall w \in \text{NORM}(w^*) [(\exists d_{\text{nec}} : \neg(\text{SPEED}(j)(w) \geq d_{\text{nec}}) \rightarrow \neg \text{win}(j)(w))$
 $\quad [\text{SPEED}(j)(w) < d_{\text{nec}}]$
In all normal worlds where there is a necessary speed for winning the race, Juno does not have this speed.

- the real world need not be normal:

(50) *Juno n'était pas assez rapide pour gagner la course, ...*
 'Juno was-IMPF not fast enough to win the race, ...'
 ...but the leader tripped on the last lap, leaving Juno in first place.

construction	semantic component			inference	
	<i>mod. flavour</i>	<i>presuppose</i>	<i>assert</i>	<i>pos</i>	<i>neg</i>
implicative	causal, circ.	$H(S) \triangleleft_c A(S)$ $H(S) \triangleright_c A(S)$	$H(S)$	$\vdash A(S)$	$\vdash \neg A(S)$
be ADJ enough	deontic	$d\text{-ADJ}(S) \triangleleft A(S)$	$d\text{-ADJ}(S)$	$\nVdash A(S)$	$\nVdash \neg A(S)$
	circ. static	$d\text{-ADJ}(S) \triangleleft A(S)$	$d\text{-ADJ}(S)$	$\nVdash A(S)$	$\vdash \neg A(S)$
	circ.	$d\text{-ADJ}(S) \triangleleft A(S)$	$\Diamond[\text{INST}(d\text{-ADJ}(S))]$	Eng/IMPF $\rightsquigarrow A(S)$	Eng/IMPF $\rightsquigarrow \neg A(S)$
	dynamic	$\text{INST}(d\text{-ADJ}(S)) \triangleright_c A(S)$	$\text{INST}(d\text{-ADJ}(S))$	PFV $\vdash A(S)$	PFV $\vdash \neg A(S)$

Table 5: Semantic components of polarity-preserving two-way implicativity

⁶Alternatively, and more simply, we can appeal to an independently-motivated **habitual** coercion operator, and avoid introducing an additional layer of quantification: see Nadathur (2019). French also allows progressive readings of imperfectively-marked dynamic E&T constructions: non-entailment here becomes a case of the imperfective paradox, but the details of the causal semantics potentially obviates the need to intensionalize the progressive/imperfective aspect to deal with this, which is a nice consequence of this approach.

4.2 Differences between implicatives and E&T inferences

The original question:

Why do the inference patterns of implicatives and E&T constructions differ?

- implicative entailments are built into implicative lexical semantics
- E&T entailments arise compositionally, from a particular combination of aspect and adjective type

- in general, E&T constructions presuppose only a necessary condition for the realization of their consequent
- in the special case of actionable-capacity E&T constructions, which involve causality, necessity, and sufficiency, implicatives and E&T constructions differ in asserted content:
 - implicatives always assert that their preconditions are satisfied (eventive)
 - E&T constructions in general only assert that it is possible for their precondition to be satisfied (at base stative)

The differences emerge under imperfective aspect (and in English):

- in the imperfective, a generic interpretation of an eventive implicative assertion yields regular instances of a particular event, repeated over a period of time:

(51) *Juno réussissait à gagner la course.*

‘Juno managed-IMPF to win the race.’

Over some past period of time, Juno habitually/regularly managed to win some (salient) race.

- this requires actual events in which *managing* took place, therefore requiring actual events in which Juno won the relevant race.

(9) *Juno réussissait à gagner la course, #mais elle n’a jamais gagné.*

‘Juno managed-IMPF to win the race, #but she never won.’

- on the other hand, the generic interpretation of an actionable-capacity E&T construction is simply interpreted as the attribution of a latent capacity:

(47) *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.’

- no event of being d_{nec} -fast (at race time) is entailed; her speed might have been measured or evidenced another way

5 Summary and consequences

Recap: E&T complement inferences are sensitive to aspect; implicative entailments are not

- the lexical semantics of implicatives establishes three components for entailment:
 - (a) a presupposed necessary and sufficient condition for the complement
 - (b) causal dependence of the complement on this condition
 - (c) the assertion that the condition was met (eventive)
- across the board, E&T constructions presuppose a necessary condition for their complements
 - the asserted content and inference patterns vary according to modal flavour and adjective type
 - the representation of actionable capacities incorporates causal sufficiency
 - dynamic capacity attributions are at base stative, but can be coerced (by the perfective aspect) into eventive readings

Big picture: ability modals pattern with dynamic capacity E&T constructions

- (4) *Marja a pu traverser le lac à la nage, #mais elle ne l'a pas traversé.*
'Marja can-PFV swim across the lake, #but she didn't cross it.'
- (7) *Marja pouvait traverser le lac à la nage, mais elle ne l'a jamais traversé.*
'Marja can-IMPF swim across the lake, but she never crossed it.'
- Bhatt (1999)'s original proposal was to treat ability modals as implicatives (as *manage*)
- we have seen why the 'full' implicative route will not work
- an understanding of the components of implicative entailments helped us make sense of the E&T patterns
- **next steps:** represent abilities in the same way as actionable capacities – as potentials for a causing action with the result specified in the modal complement (or, as hypothetical guarantees)
- there are independent reasons to believe that ability modals have internal structure that pure circumstantial modals lack (Kenny, 1976, a.o.)

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