

# Causal semantics for implicative verbs

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## Abstract

**Implicative verbs** (e.g., *manage*, *dare*) are characterized by a pattern of complement inferences (Karttunen, 1971). English *manage* entails its complement; the entailment reverses polarity with matrix negation, and is accompanied in both cases by a projective inference to the complement’s non-triviality (Coleman, 1975; Karttunen and Peters, 1979). I draw on data from Finnish and English to argue that the implicative inferential profile is derived from backgrounded relations of *causal necessity* and *causal sufficiency* (defined with respect to the structure of a formal causal model; Pearl 2000; Schulz 2011) which link the lexical content of an implicative verb to the realization of its complement. The proposal builds on Baglini and Francez’s (2016) causal analysis of *manage*, but significantly revises the earlier proposal to offer a treatment which accounts not only for English *manage*, but extends to the lexical semantics of the full implicative class, including ‘polarity-reversing’ verbs like *fail*, lexically-specific verbs like *dare*, and their Finnish counterparts. Unlike earlier analyses, the proposed causal semantics also provides a natural explanation of the commonalities between two-way entailing verbs like *manage* and a related class of weaker ‘one-way’ implicatives such as Finnish *jaksaa* (‘have the strength’), which entail complement truth values under only one matrix polarity, but generate strong pragmatic implicatures in the two-way implicative pattern under the non-entailing polarity.

## 1 Introduction

Across the languages in which they occur, **implicative verbs** systematically license inferences about the truth of their complements (Karttunen, 1971). As (1)-(2) show for English *manage* and Finnish *onnistua* (‘succeed’, ‘manage’), implicative complement inferences have the force of entailment, crucially reversing under matrix negation (and thus distinguishing implicative verbs from complement-presupposing factives like *know* and *regret*; Kiparsky and Kiparsky 1970).

- (1) a. Mika **managed** to solve the riddle. → *Mika solved the riddle.*  
b. Mika did not **manage** to solve the riddle. → *Mika did not solve the riddle.*
- (2) a. Eman **onnistu-i** kuitenkin pakenema-an.  
Eman succeed-PST.3SG however flee-INF.ILL  
‘Eman managed to flee.’ → *Eman fled.*
- b. Eman e-i **onnistu-nut** kuitenkaan pakenema-an.  
Eman NEG-3SG succeed-SG.PP however flee-INF.ILL  
‘Eman did not manage to flee.’ → *Eman did not flee.*

The two-way implicative entailment pattern in (1)-(2) sets up an interesting (pseudo-)logical puzzle. Taking *I* to represent an arbitrary implicative, with *x* its subject and *P* a one-place

predicate (so that  $P(x)$  represents the reconstructed implicative complement), we have the following:

$$(i) \quad I(x, P) \rightarrow P(x) \qquad (ii) \quad \neg I(x, P) \rightarrow \neg P(x)$$

Entailment (ii) is the converse of (i), inviting the conclusion that the implicative assertion  $I(x, P)$  and its complement  $P(x)$  are logically equivalent.

$$(iii) \quad I(x, P) \equiv P(x)$$

Statements (i) and (ii) evidently hold for *manage*, *dare*, and their Finnish counterparts, but (iii) does not. The analytical challenge of implicative verbs, then, is to derive (i)-(ii) while avoiding the “intuitively unacceptable conclusion” in (iii) (Karttunen; p.343): i.e., while maintaining the distinction between an implicative assertion and that of its complement.

In this paper, I propose an account on which the characteristic inferential profile of implicative verbs is derived from **causal dependence relations** embedded in their lexical semantics. In particular, I argue that implicatives background the *causal necessity* and *causal sufficiency* of a (lexically-specified) prerequisite for the realization of their complements. Simultaneously, they assert the satisfaction of this prerequisite, so that complement entailments follow as a causal consequence when presupposition and assertion are taken together. The proposal builds on Baglini and Francez’s (2016) causal analysis of *manage*, but I draw on a wider range of data from English and Finnish to argue for a significantly revised and restructured account which extends to the full implicative class (including both polarity-reversing and one-way entailing verbs). Against past analyses, which treat *manage* as paradigmatic, I analyze *manage* and its Finnish counterpart *onnistua* as special cases: as compared to more typical verbs like English *dare* and Finnish *uskaltaa* (‘dare’; 4), which offer a characterization of the prerequisite as part of their lexical contribution, *manage* and *onnistua* are semantically underspecified.

- (3) a. Ana **dared** to enter the cave. → *Ana entered the cave.*  
 b. Ana did not **dare** to enter the cave. → *Ana did not enter the cave.*
- (4) a. Juno **uskals-i**      avat-a    ove-n.  
 Juno dare-PST.3SG open-INF door-GEN/ACC  
 ‘Juno dared to open the door.’ → *Juno opened the door.*
- b. Juno e-i      **uskalta-nut** avat-a    ove-a.  
 Juno NEG-3SG dare-SG.PP open-INF door-PART.  
 ‘Juno did not dare to open the door.’ → *Juno did not open the door.*

In tying implicative inferences to formally-defined causal dependencies, this paper contributes to a rapidly growing body of work which explores the utility of **causal models** in explicating linguistic inference across the lexical and sentential levels. I formalize causal relations in terms of the *structural equation models* of Pearl (2000), which have been fruitfully employed in the semantic analysis of counterfactual conditionals (Schulz, 2011; Kaufmann, 2013; Henderson, 2014; Ciardelli et al., 2018; Santorio, 2019, among others), as well as in the lexical analysis of *causative* verbs (Nadathur and Lauer, 2020; Baglini and Bar-Asher Siegal, 2020; Bassel et al., 2020). The causal approach to *manage* and other implicatives extends the use of causal models to the lexical analysis of language that does not directly predicate causation, but instead invokes causal information in its presuppositional contribution, and, in so doing, proposes that causal structure plays a role across both at-issue and not at-issue dimensions of meaning.

## 2 The division of labour in implicative semantics

### 2.1 The ingredients of an analysis

Karttunen (1971) suggests that the undesirable equivalence between an implicative assertion and its complement is blocked by presuppositional material associated with the implicative verb. The idea is that an implicative constrains its appropriate contexts of utterance in ways which its bare (reconstructed) complement does not. As a result, the implicative assertion can be used in a strict subset of the contexts where its complement is appropriate, so that use of the implicative construction licenses inferences which do not follow from the complement alone.

Karttunen’s suggestion has been widely adopted in work on implicative *manage*, although consensus on the precise presuppositional content has proven surprisingly elusive (Coleman, 1975; Baglini and Francez, 2016). Perhaps most prominently, Karttunen and Peters (1979) argue that *manage* introduces a projective inference of effort or difficulty, so that (1a) and (1b) both convey that solving the riddle required effort on Mika’s part (see also Bhatt 1999).

- (1) a. Mika **managed** to solve the riddle.  $\rightarrow$  *Mika solved the riddle.*  
*presumes:* Solving the riddle was effortful for Mika.  
b. Mika did not **manage** to solve the riddle.  $\rightarrow$  *Mika did not solve the riddle.*  
*presumes:* Solving the riddle was effortful for Mika.

Looking beyond *manage*, ‘requirement’ inferences also seem to attach to other implicative verbs. Alongside their characteristic entailments, each of the verbs in (5) invokes some condition or factor which operates as a *prerequisite*—that is, which is needed for the realization of the complement proposition. English *dare* in (5a) indicates a need for daring (courage or boldness), as does Finnish *uskaltaa* (‘dare’; 4). *Condescend*, in (5b), suggests that attending the meeting required Mr. Sinha to suppress inherent disdain; Finnish *viitsiä* (‘bother’; 5c) indicates a need for active interest or engagement, while *malttaa* (‘have patience’; 5d) indicates a need for patience.

- (5) a.  $\gamma$ I **dared** to open an umbrella indoors.<sup>1</sup>  $\rightarrow$  *I opened the umbrella.*  
*Presumes:* Opening an umbrella indoors required daring (from me).  
b.  $\gamma$ Mr. Sinha **condescended** to meet the tainted persons.  
 $\rightarrow$  *Sinha met the tainted persons.*  
*Presumes:* Meeting the tainted persons required Sinha’s condescension.  
c. Hän **viits-i** vastat-a.  
he.NOM bother-PST.3SG answer-INF  
‘He **bothered** to answer.’  $\rightarrow$  *He answered.*  
*Presumes:* Answering required him to take an interest.  
d. Marja **maltto-i** odotta-a.  
Marja have.patience-PST.3SG wait-INF.  
‘Marja had the patience to wait.’  $\rightarrow$  *Marja waited.*  
*Presumes:* Waiting required patience from Marja.

Each of the prerequisite inferences projects through negation, supporting a preliminary presuppositional diagnosis (per the ‘family of sentences’ tests; Chierchia and McConnell-Ginet 1990).

- (6) a. I did not **dare** to open an umbrella indoors.  $\rightarrow$  *I did not open an umbrella.*  
*Presumes:* Opening an umbrella indoors requires daring.

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<sup>1</sup>Adopting a convention from L. Horn (2010), examples marked with  $\gamma$  were found on the internet. Sources are given in the appendix.



takes place when John *manages to do* something is that he does it [...]” (1971; pp.349–350), Karttunen and Peters propose that *manage* asserts only the semantic content of its reconstructed complement, but adds to this the presupposition that realizing this complement was difficult or effortful for the implicative subject.<sup>3</sup>

(7) **The direct assertion account of *manage*.** (Karttunen and Peters, 1979).

Given an agent  $x$  and a one-place predicate  $P$ ,  $x$  *managed to P*:

- i. *Asserts*:  $x$  did  $P(x)$  ( $P(x) = 1$ )
- ii. *Presupposes*:  $P(x)$  was effortful for  $x$

We have seen that (7)ii projects through matrix negation. Additional support for Proposal 7 comes from (8):

(8) I just discovered that Solomon **managed** to build the temple.

- a. *Entails*: I just discovered that Solomon built the temple.
- b. *Does not license*: I just discovered that building the temple was effortful for Solomon.
- c. *Licenses*: Building the temple was effortful for Solomon.

The embedding verb in (8), *discover*, belongs to Karttunen’s (1973) class of presupposition ‘holes’. It is therefore expected to embed any entailments of its complement clause, but to project complement presuppositions without modification. This is precisely what we see in (8) for the proposed implications of *manage*. In using (8), a speaker naturally conveys that the building of the temple is a new discovery, thus embedding (7)i under *discover*. The speaker is further committed to the truth of the unembedded presupposition (8c), but not to (8b).

Despite the success of these predictions, and despite Karttunen and Peters’s apparent initial success in capturing both the projective effort inference (Fact A, broadly construed) and the two-way pattern of complement entailment associated with *manage* (Fact C), there are some important reasons to question whether Proposal 7 reflects the correct division of implicative semantic labour. I discuss these reasons below, to motivate turning to the alternative approach of Baglini and Francez (2016).

First, as noted in Section 2.1, it is not clear that the effortfulness of the implicative complement captures the full range of projective content associated with *manage* claims. Givón (1973) suggests, for instance, that *manage* presupposes that its subject actively and intentionally tried to bring about the complement; a weaker form of this inference isolates intentionality. Both inferences seem to be licensed by (9), and both project through matrix negation:

- (9) a. Solomon **managed** to build the temple.
  - i. *Licenses*: Solomon tried to build the temple.
  - ii. *Licenses*: Solomon intended to build the temple.
- b. Solomon did not **manage** to build the temple.
  - i. *Licenses*: Solomon tried to build the temple.
  - ii. *Licenses*: Solomon intended to build the temple.

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<sup>3</sup>In Karttunen and Peters (1979), the effort inference is described as conventional implicature rather than presupposition; however, since one of the goals of that paper is to unify projective phenomena, the change in label is perhaps not that significant. I do not provide a detailed adjudication between the two classifications here, but take the view that the projective content of implicatives seems to align less closely with current theories of conventional implicature (e.g. Potts, 2005) than with the admittedly heterogeneous behavior of presuppositions (see Tonhauser et al., 2013).

Coleman (1975) further complicates the picture by observing that *manage* can be felicitous in contexts which support neither effort nor intention on the part of the subject:

- (10) a. Harry **managed** to insult Ursula without even trying.  
 b. Harry’s dog **managed** to wake him up every time he fell asleep on the couch.  
 c. My neighbors **managed** to schedule their one wild party of the year on the night before my exam.

(10a) explicitly denies that Harry attempted to insult Ursula—and, accordingly, suggests that doing so was not effortful. (10b) is acceptable whether or not the dog intends to wake Harry, and (10c) certainly does not require that the neighbors meant to cause problems for the speaker, nor that it took any particular effort from them to do so.

To explain these data, Coleman suggests that the “vanishing” effort and intention inferences are in each case supplanted by a weaker presupposition—namely, that realizing the complement was *a priori* unlikely. Her idea is that the presuppositional contribution of *manage* varies systematically between the three options in (11): intention, effort/difficulty, and unlikeliness.

- (11) Solomon **managed** to build the temple.  
 a. Solomon intended to build the temple.  
 b. Building the temple required effort for Solomon.  
 c. It was unlikely that Solomon would build the temple.

On Coleman’s view, variation is governed by a strength-based ordering of (11a)-(11c), with intention as the strongest possible presupposition, followed by effort, and only then by unlikeliness. In any given context, the strongest tenable presupposition is expected to hold, subsuming the weaker ones (Fillmore, 1975; Dalrymple et al., 1998). Thus, if intention is ruled out, as in (10a), we might instead expect a presupposition of effort.<sup>4</sup> If effort also fails, then the context must support unlikeliness. In other words, Coleman predicts *manage* to be infelicitous if—and only if—unlikeliness (the weakest presupposition) fails.

Baglini and Francez (2016) show that Coleman’s hierarchy does not provide a satisfactory general account of the malleable not-at-issue contribution of *manage*. It is crucial for Coleman that the validity of a stronger presupposition necessitates the validity of the weaker ones. Against this requirement, Baglini and Francez draw on naturally-occurring data to show that *manage* remains felicitous in contexts that support one of the intention, effort or unlikeliness inferences, to the exclusion of the others.<sup>5</sup> (12a)-(12c) illustrate the same point as Baglini and Francez’s examples: each example precludes one or more of the proposed presuppositions, while leaving the others intact. Crucially, it is possible for *manage* to be felicitous in contexts where the unlikeliness presupposition fails.

- (12) a.  $\gamma$ Without intending to, Ms. Streisand actually managed to synthesize the problem of diversity mania.  $\not\rightarrow$  intention,  $\not\rightarrow$  difficulty,  $\sim\rightarrow$  unlikeliness

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<sup>4</sup>Coleman (1975) focuses on *manage*, but argues that implicatives like *happen* and polarity-reversing *fail* (see Section 5.4) also invoke strength-ordered presuppositional content; she suggests that ranked presuppositions (along with complement entailment) are thus an implicative class feature.

<sup>5</sup>Examples (1a)-(1b) are from Baglini and Francez (2016): (1a) explicitly denies difficulty, but nevertheless presumes effort, and (1b) denies unlikeliness, but supports both effort and intention.

- (1) a. Clad in civilian clothes and having passports, they easily **managed** to get back over the Volga.  
 b. Now it’s becoming obvious that Fork will **manage** to kill someone important.

- b.  $\gamma$ By 1998, four years after a federal ban on assault weapons took effect, gun manufacturers had easily managed to bypass the laws by making small alterations to their weapons.

$\leadsto$  *intention*,  $\not\leadsto$  *difficulty*, ?  $\leadsto$  *unlikeliness*

- c.  $\gamma$ The social democrats (Socialdemokratiet) managed to strengthen their position as Denmark’s strongest political force as expected during local elections.

$\leadsto$  *intention*, ?  $\leadsto$  *difficulty*,  $\not\leadsto$  *unlikeliness*

Thus, while it seems clear that *manage* places (not at-issue) constraints on its utterance context (as per Karttunen 1971), it is evidently difficult to offer a precise characterization. One explanation, anticipated in Section 2.1, suggests itself immediately: it might simply be the case that the inferences so far proposed have been overly specific. If this explanation is correct, then the way forward involves adopting a more general view of *manage*’s presupposition—in other words, establishing a presupposition which distills presumptions of intention, difficulty/effort, unlikeliness, etc., down to some common semantic core. This is the approach adopted by Baglini and Francez (2016), discussed below. Such a presupposition would, ideally, capture the impression that realizing the implicative complement is in some way nontrivial (see also Bhatt 1999), but remain general enough to capture inferences of intention, effort/difficulty, or unlikeliness as reflexes of the specific contexts in which they arise.

Setting aside the puzzle of malleable presuppositions, a perhaps more fundamental problem for Proposal 7 remains. This has to do with the structure of asserted content. According to Karttunen and Peters, *manage* itself contributes nothing to the at-issue dimension, instead piggybacking on the asserted content of its complement proposition. While this evidently predicts the desired two-way pattern of complement entailment, it cannot explain the behaviour of *manage* claims under specific types of adverbial modification.

Temporal and locative modifiers attached to the main implicative claim are ‘inherited’ by the complement (Karttunen, 1971).

- (13) a. Yesterday, Mika **managed** to solve the riddle.  $\rightarrow$  *Yesterday, Mika solved the riddle.*  
 b. At the door, Juri finally **managed** to apologize.  
 $\rightarrow$  *At the door, Juri finally apologized.*

The entailments in (13) are consistent with the direct assertion account, insofar as any at-issue modification of the *manage* claim should apply directly to its at-issue content (i.e., the complement proposition).

The pattern fails, however, when we attempt to modify *manage* is modified by a *because*-adverbial. A modified claim like (14a) does not license an inference to its similarly-modified complement. In fact, the modifying *because*-clause receives an altogether different (default) interpretation if it is applied to the *manage*-complement, as in (14b).

- (14) a. Juno **managed** to open the door because it was unlocked.  
 b. Juno opened the door because it was unlocked.

The *because*-clause in (14a) is naturally interpreted as explanatory, indicating how or why Juno was able to open the door (in other words, providing information about how a potential obstacle was circumvented). In (14b), however, the same clause supplies information about Juno’s motivation—suggesting, for instance, that her actions were guided by idle curiosity. These two interpretations are largely complementary: the explanatory reading is at best marginal for (14b), and the motivational reading is ruled out for (14a).

This is unexpected if *manage* and its complement make identical at-issue contributions, as the implicative and complement claims should then behave the same way under all processes

that modify asserted content. The simplest explanation for the contrast in (14) is that the direct assertion account is incorrect: i.e., that either the implicative or its complement asserts something that the other does not.

### 2.3 An alternative approach

Baglini and Francez (2016) aim to address the problems with the direct assertion account by proposing a division of *manage*'s semantic labour that differs from that of Karttunen and Peters. Baglini and Francez draw on the *because*-clause contrast in (14) as evidence of a non-trivial difference between the at-issue content of a *manage* claim and that of its complement proposition, arguing that the truth of the implicative complement is entailed but crucially not asserted by *manage*. In particular, they suggest that the entailment is derived as a consequence of *manage*'s assertion, taken together with presuppositionally-imposed constraints on the utterance context.

Simultaneously, and as suggested above, Baglini and Francez argue that the apparent malleability of *manage*'s presuppositions can be explained if the basic presuppositional contribution is relatively abstract in nature. Examples like (10)-(12) show that *manage*'s projective content varies on the basis of contextual cues, further suggesting that the 'abstract' presupposition should be formulated in a manner which lends itself to contextual enrichment.

The central insight of Baglini and Francez's proposal, given in (15), is that the relationship between an implicative assertion and the realization of its complement is one of **causal dependence**. Treating complement entailments as a causally-derived consequence of the main assertion allows us to differentiate *manage*'s at-issue content from that of its complement, while maintaining a straightforward explanation of the characteristic entailment pattern. On this approach, since *manage* backgrounds only the existence of the relevant causal dependency, but specifies no further details, the utterance context can easily supply different ways of fleshing out the basic relationship, resulting in the malleability observed by Coleman (1975).

(15) **The catalyst account of *manage*.** (Baglini and Francez, 2016)

Given an agent  $x$  and a one-place predicate  $P$ ,  $x$  *managed to*  $A$ :

- i. *Presupposes*: The familiarity (salience and truth) of a **catalyst**, or *causally necessary but causally insufficient situation*, for the truth of  $P(x)$
- ii. *Asserts*: The catalyst **actually caused**  $P(x)$

Proposal (15) readily evokes the 'obstacle' generalization from Section 2.1. *Prima facie*, the necessary but insufficient *catalyst* in (15)i seems to correspond to the notion of a prerequisite for the *manage*-complement. Moreover, insofar as only its causal relationships—but crucially not its content—are specified, a catalyst seems to capture the idea that *manage* is underspecified as compared to other implicatives. Extrapolating from this, lexically-specific implicatives like *dare* or Finnish *viitsia* ('bother'; 5c, 6c) might impose certain constraints on the make-up of a backgrounded catalyst, where the nature of *manage*'s catalyst is subject only to contextual enrichment.

Of course, the real weight of Proposal (15) rests in the precise formulation of the three causal dependence relations: *causal necessity*, *causal sufficiency*, and *actual cause*. To see whether the above intuitions are borne out, and determine whether or not Proposal (15) derives Facts A-C, we will need to set out formal definitions for these relations. Following Baglini and Francez, I use Schulz's (2011) **causal dynamics** framework, introduced below, as a basis for the relevant definitions.

### 3 Modeling causal dependencies

This section introduces the notion of a **causal model**. My aim in so doing is to demonstrate that relations which can be articulated over the structure of a causal model play an explanatory role in semantic inference. The choice in particular of Schulz’s (2011) dynamics framework, which belongs to the school of **structural equation modeling** (SEM) developed by Pearl (2000), is motivated by a desire for mutual intelligibility with a growing body of work (including Baglini and Francez 2016) employing causal models as a tool for semantic analysis. As far as I am aware, nothing in the following discussion hinges fundamentally on the use of SEM, and the types of models built within this framework are certainly not the only ones which support an approach on which linguistic causation subsumes multiple distinct causal dependency relations.<sup>6</sup> In the interests of focusing on the main investigation, however, I leave the exploration and comparative evaluation of modeling alternatives as a topic for future research (see, e.g., Wolff and Song 2003; Sloman et al. 2009; Livengood and Rose 2016 for relevant experimental work).

#### 3.1 Preliminary remarks

The use of causal models is motivated in part by a need to distinguish between causal relations of necessity and sufficiency and their alethic or metaphysical counterparts (Nadathur and Lauer, 2020). Causal necessity and sufficiency describe relationships that hold when consideration is restricted to particular courses of events—intuitively, those which are ‘normal’ or ‘stereotypical’, insofar as they proceed according to a set of expectations based on (established) facts about the world, and generalized knowledge of the typical consequences of these facts. Reasoning about causal expectations relies on three things: a starting context (or set of facts about the world), a set of (relevant) causal laws, and a mechanism for using the latter to derive the causal consequences of the former.

A (structural equation) causal model provides these elements. Its basic components are a set of propositional variables (representing facts and/or events indexed to worlds and times), and a set of causal arrows, so that the model is a network of one-way links between variables, in which an arrow indicates that the value of its origin point exerts a causal influence on the value of its destination. I take the relation of *causal relevance*, as represented by such arrows, to be atomic.

I will treat causal network models as contextually-governed discourse parameters, which intersect with and represent part of the world knowledge of a language user (see also Nadathur 2019; Baglini and Bar-Asher Siegal 2020). Lexically-referenced causal dependence relationships are neither themselves atomic nor reducible to purely logical terms, but instead describe particular configurations of causal relevancies (arrows): *causal necessity* and *causal sufficiency* are thus descriptors (or convenient labels) for relationships which have a recurrent role in linguistic representations; given a particular discourse context, these relations capture presumed structural relationships between salient events and objects.

#### 3.2 Dynamics for causal entailment

Schulz (2011) defines a causal **dynamics** as representation of (contextually-relevant) causal laws, together with the formal operations used to calculate causal consequences (normal causal developments) of an initial *situation*. A dynamics induces a particular notion of **causal entailment**, which I will use to define **causal necessity** and **causal sufficiency**, in a conceptual

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<sup>6</sup>This is sometimes described as a *pluralistic* view, to contrast it with approaches that associate all causal meaning with a single dependence relation (e.g., CAUSE; Dowty 1979).

parallel with the relationship between logical necessity and sufficiency and the notion of logical entailment (see also Baglini and Francez).

A dynamics encodes the causal structure of a closed system. Given a finite set  $P$  of propositional variables, we first define a language  $\mathcal{L}_P$ :

**Definition 1** (Language). *Given a set of proposition letters  $P$ , let the **language**  $\mathcal{L}_P$  be the closure of  $P$  under the the logical connectives negation  $\neg$ , conjunction  $\wedge$ , and disjunction  $\vee$ .*

**Definition 2** (Dynamics). *A **dynamics** for  $\mathcal{L}_P$  is a tuple  $\mathcal{D} = \langle B, F \rangle$  where:*

- (a)  $B \subseteq P$  is the set of background variables.
  - (b)  $F$  is a function that maps elements  $X$  of  $I = P - B$  to tuples  $\langle Z_X, f_X \rangle$ , where
    - i.  $Z_X$  is an  $n$ -tuple of elements of  $P$
    - ii.  $f_X : \{0, 1\}^n \rightarrow \{0, 1\}$  is a two-valued truth function from  $n$ -tuples on  $\{0, 1\}$  to  $\{0, 1\}$
- $F$  is rooted in  $B$ .

Background (or *exogenous*; cf. Pearl) variables are causally independent of all other variables in  $P$ . The complement set  $I$  of *inner* (or *endogenous*) variables depend on one another, as well as on the background variables. By Definition 2, inner variables in  $\mathcal{D}$  are associated with a function identifying their set of immediate causal ancestors ( $Z_X$ ), and describing the nature of their direct dependencies. The requirement that function  $F$  is *rooted* in  $B$  precludes circular chains of causation, by ensuring that a ‘backwards walk’ through the causal ancestors of any variable always ends in  $B$ .  $\mathcal{D}$  therefore comprises a *directed acyclic graph*, together with a set of (structural) equations specifying how the values of inner variables depend on the values of their immediate causal ancestors.

**Definition 3** (Rootedness). *Let  $B \subseteq P$  be a set of proposition letters, and  $F$  a function mapping elements of  $I = P - B$  to tuples  $\langle Z_X, f_X \rangle$  as above. Let  $R_F$  be the relation that holds between the letters  $X, Y$  if  $Y \in Z_X$ . Let  $R_F^T$  be the transitive closure of  $R_F$ .  $F$  is **rooted** in  $B$  if  $\langle P, R_F^T \rangle$  is a poset and  $B$  is the set of its minimal elements.*

Schulz works with the strong three-way Kleene logic (Table 1), in which propositional variables are valued from  $\{u, 0, 1\}$ . A 0 or 1 valuation is a **determination**, while a  $u$ -valued variable is **undetermined**. A  $u$ -valuation can, via causal computation, evolve into a determination, but a determination cannot be ‘undone’ in the regular course of causal reasoning. **Worlds** and **situations** can be defined in terms of complete valuations of  $P$ .

**Definition 4** (Worlds and situations). *For a language  $\mathcal{L}_P$  over  $P$ :*

- (a) A **world** for  $\mathcal{L}_P$  is any function  $w : P \rightarrow \{0, 1\}$
- (b) A **situation** for  $\mathcal{L}_P$  is any function  $w : P \rightarrow \{u, 0, 1\}$

Given a situation  $s$  for  $P$ , we would like to use the causal laws encoded by  $D$  to calculate the causal consequences of  $s$ . To do this, Schulz defines an operator  $\mathcal{T}_D$  which effectively ‘runs’ the dynamics for one step.

**Definition 5** (Causal update). *Let  $\mathcal{D}$  be a dynamics and  $s$  a situation. We define the situation  $\mathcal{T}_D(s)$  by:*

- (a) if  $X \in B$ , then  $\mathcal{T}_D(s)(X) = s(X)$

$X$	$Y$	$\neg X$	$X \vee Y$	$X \wedge Y$
0	0	1	0	0
0	1	1	1	0
0	$u$	1	$u$	0
1	0	0	1	0
1	1	0	1	1
1	$u$	0	1	$u$
$u$	0	$u$	$u$	0
$u$	1	$u$	1	$u$
$u$	$u$	$u$	$u$	$u$

Table 1: Strong Kleene logic

(b) if  $X \in I$ , with  $Z_X = \{X_1, \dots, X_n\}$ , then

- i. if  $s(X) = u$  and  $f_X(s(X_1), \dots, s(X_n))$  is defined,  
 $\mathcal{T}_{\mathcal{D}}(s)(X) = f_X(s(X_1), \dots, s(X_n))$
- ii. if  $s(X) \neq u$  or  $f_X(s(X_1), \dots, s(X_n))$  is undefined,  $\mathcal{T}_{\mathcal{D}}(s)(X) = s(X)$ .

Since  $P$  is finite, a finite number of iterations of  $\mathcal{T}_{\mathcal{D}}$  will exhaust the set of consequences of any starting situations  $s$ , producing a *fixed point* (see Schulz 2011 for a proof). This result is used to define causal entailment.

**Definition 6** (Causal entailment). *Let  $\mathcal{D}$  be a dynamics. A situation  $s$  **causally entails** a proposition  $\phi$  iff  $\phi$  is true at the least fixed point  $s^*$  of  $\mathcal{T}_{\mathcal{D}}$  relative to  $s$ :*

$$s \models_{\mathcal{D}} \phi \text{ iff } s^*(\phi) = 1$$

A situation  $s$  can be converted into a set of literals from  $\mathcal{L}_P$  such that, for any  $X \in P$ , at most one of  $X$  or  $\neg X$  is in  $s$ . Thus,  $s$  causally entails a proposition  $\phi$ —an assignment of either 0 or 1 to some variable  $Y$ —if and only if the maximal normal causal development of  $s$  determines  $Y$  in accordance with  $\phi$ .

### 3.3 Causal necessity and causal sufficiency

In identifying and defining causal dependence relations, our focus is on the different ways in which one fact or event can be causally involved in the realization of another. Moreover, causes do not act alone. Any claim that cause  $C$  brought about effect  $E$  is necessarily evaluated with respect to a given context: evaluating a causal claim requires us to assess whether or not adding the occurrence of  $C$  to the set of established facts has the right sort of consequence for the realization of  $E$ . Binary causal dependence relations are therefore defined relative to a background situation.

**Definition 7** (Facts). *Given a dynamics  $\mathcal{D}$  for  $\mathcal{L}_P$ , a **fact** is a determination for a variable  $X \in P$ ; that is, an assignment  $X = x$  where  $x \in \{0, 1\}$ . We write facts as  $\langle X, x \rangle$ .*

**Definition 8** (Augmenting a situation with a fact). *Given a situation  $s$  and a fact  $\langle X, x \rangle$ , the situation  $s[X \mapsto x]$  (re)assigns the value of  $X$  to  $x$ , but is otherwise identical to  $s$ .*

Augmenting a situation  $s$  with a fact  $\langle X, x \rangle$  overrides an existing determination for  $X$ . We will usually be concerned with cases where the *domain* of  $s$ , defined below, does not contain  $X$ .

**Definition 9** (Domain of a situation). The *domain* of a situation  $s$  is given by

$$\text{dom}(s) = \{X \in P \mid s(x) \neq u\}$$

Finally, the dynamics induces a notion of *consistency*, so that a situation is internally causally consistent if it contains no determination which breaks the causal rules with respect to the other determinations.

**Definition 10** (Causal consistency). In a dynamics  $\mathcal{D}$  over  $\mathcal{L}_P$ , a situation  $s$  is **causally consistent** if, for inner variables  $X \in P - B$  such that  $X \in \text{dom}(s)$ , we have:

$$s[X \mapsto u] \not\models_{\mathcal{D}} \begin{cases} \neg X & \text{if } s(X) = 1 \\ X & \text{if } s(X) = 0 \end{cases}$$

With this in hand, we can define binary relations of causal necessity and sufficiency. Causal sufficiency of a fact  $\langle X, x \rangle$  for another fact  $\langle Y, y \rangle$  reduces to causal entailment, once the background situation is augmented by  $\langle X, x \rangle$ . Causal necessity with respect to  $s$  captures the idea that the only causally consistent paths from  $s$  to the validation of  $\langle Y, y \rangle$  involve (first) validating  $\langle X, x \rangle$ .

**Definition 11** (Causal necessity and sufficiency of facts). Let  $\mathcal{D}$  be a dynamics for  $\mathcal{L}_P$ . Let  $s$  be a situation and let  $\langle X, x \rangle, \langle Y, y \rangle$  be facts such that  $s \not\models_{\mathcal{D}} \langle X, x \rangle, s \not\models_{\mathcal{D}} \langle Y, y \rangle$ . Then:

- (a)  $\langle X, x \rangle$  is **causally sufficient** for  $\langle Y, y \rangle$  relative to  $s$  ( $\langle X, x \rangle \triangleright_s \langle Y, y \rangle$ ) iff  $s[X \mapsto x] \models_{\mathcal{D}} \langle Y, y \rangle$
- (b)  $\langle X, x \rangle$  is **causally necessary** for  $\langle Y, y \rangle$  relative to  $s$  ( $\langle X, x \rangle \triangleleft_s \langle Y, y \rangle$ ) iff:
  - i. there is a consistent supersituation  $s'$  of  $s[X \mapsto x]$  such that  $Y \notin \text{dom}(s')$  and  $s' \models_{\mathcal{D}} \langle Y, y \rangle$
  - ii. there is no consistent supersituation  $s'$  of  $s$  such that  $Y \notin \text{dom}(s')$  and  $s' \models_{\mathcal{D}} \langle Y, y \rangle$  but  $s' \not\models_{\mathcal{D}} \langle X, x \rangle$

These definitions capture intuitive ideas about how necessity and sufficiency work. Causal sufficiency guarantees that a cause  $\langle X, x \rangle$  completes a causal pathway to the effect  $\langle Y, y \rangle$  thus guaranteeing  $\langle Y, y \rangle$  as well. Causal necessity, on the other hand, simply ‘opens up’ the possibility of  $\langle Y, y \rangle$ ; within a dynamics, a necessary cause  $\langle X, x \rangle$  makes available one or more consistent pathways to  $\langle Y, y \rangle$ . Insofar as  $\langle X, x \rangle$  does not ensure  $\langle Y, y \rangle$ , there is an evident conceptual similarity between Definition 11b and counterfactual necessity; it is worth observing, however, that a different (or absent) determination for  $X$  does not causally entail the negation of  $\langle Y, y \rangle$ .

It is essential that Definitions 11a-b are relativized to background situations which are not themselves sufficient for either cause or effect. In the case of causal sufficiency, if we allow the causing fact to be causally entailed by the background situation, we must also allow the effect to be entailed (since adding the causing fact is sufficient for the effect). The consequence of this is that any fact in a cause-entailing background situation becomes sufficient for the effect, even if it is not a causal ancestor of the effect. Allowing only the effect to be entailed by the background situation also causes problems: in this case, any fact not entailed by the background situation becomes sufficient for the effect. In the case of causal necessity, allowing the background situation to entail either cause or effect means that the background situation itself makes available a consistent causal pathway to  $\langle Y, y \rangle$ , obviating the causal role of  $\langle X, x \rangle$ .

To capture the causal dependence of an implicative complement on a catalyst (per Baglini and Francez), we need to define relations of causal necessity and sufficiency between situations and

facts. Causal sufficiency is again a straightforward application of causal entailment, but causal necessity turns out to be more complicated, since it requires considering the consequences of revising the valuations of (causally-relevant) facts from the established context.<sup>7</sup>

**Definition 12** (Causal ancestors). *Let  $\mathcal{D}$  be a dynamics for  $\mathcal{L}_P$ . Given a variable  $X \in P - B$ , the set of **causal ancestors** of  $X$  is given by  $\text{Anc}(X) = \{Y \in P \mid R_F^T(X, Y)\}$ .*

**Definition 13** (Causal necessity and sufficiency of situations). *Let  $\mathcal{D}$  be a dynamics over  $P$ . Let  $s$  be a situation and let  $\langle X, x \rangle$  be a fact.*

(a)  $s$  is **causally sufficient** for  $\langle X, x \rangle$  ( $s \triangleright \langle X, x \rangle$ ) iff  $s \models_{\mathcal{D}} \langle X, x \rangle$ .

(b)  $s$  is **causally necessary** for  $\langle X, x \rangle$  ( $s \triangleleft \langle X, x \rangle$ ) iff, for any situation  $s'$  with:

- i.  $\text{dom}(s) \cap \text{Anc}(X) \subseteq \text{dom}(s') \cap \text{Anc}(X)$  and
- ii.  $\exists Y \in \text{dom}(s) \cap \text{Anc}(X)$  with  $s(Y) \neq s'(Y)$  and
- iii.  $s'(X) \neq x$

we have  $s' \not\models_{\mathcal{D}} \langle X, x \rangle$ .

One further definition is required in order to evaluate the catalyst proposal for *manage*: the notion of *actual cause*. The following is adapted from Baglini and Francez (2016, p.554).<sup>8</sup>

**Definition 14** (Actual cause). *Given a dynamics  $\mathcal{D}$ , a world  $w$ , and a variable  $X \in P - B$ , a situation  $s$  **actually causes** fact  $\langle X, x \rangle$  iff  $s(X) = u$ ,  $w(X) = x$ , and  $w$  is consistent with  $s^*$  (the least fixed point of  $\mathcal{T}_{\mathcal{D}}$  on  $s$ ).*

With Definitions 13-14 in hand, we can now evaluate Proposal (15).

## 4 *Manage* and other implicatives

### 4.1 A closer look at the catalyst proposal

Baglini and Francez's (2016) proposal is restated below:

(15) **The catalyst account of *manage*.**

Given an agent  $x$  and a one-place predicate  $P$ ,  $x$  *managed to*  $P$ :

- i. *Presupposes*: The familiarity (salience and truth) of a **catalyst**, or *causally necessary but causally insufficient situation*, for the truth of  $P(x)$
- ii. *Asserts*: The catalyst **actually caused**  $P(x)$

According to (15)i, assertions or denials of *manage*( $x, P$ ) are only felicitous in contexts which establish the truth of a causally necessary but insufficient situation  $c$ , for  $P(x)$ . As anticipated by Karttunen (1971), the presuppositional content of *manage* will block an entailment from  $P(x)$  to the implicative claim.

The at-issue question for *manage*( $x, P$ ) is whether the relationship of *actual cause* holds between  $c$  and  $P(x)$ . Asserting *manage*( $x, P$ ) is an affirmative answer. Thus, since the catalyst

<sup>7</sup>Definition 13b differs slightly from Baglini and Francez's original definition of causal necessity; the update is due to Nadathur (2019) (see Chapter 3 for discussion and motivation).

<sup>8</sup>The causal modeling literature offers a variety of definitions for an *actual cause* relation, some of which more closely resemble Definitions 11b and 13b for causal necessity than Definition 14. See, in particular, Pearl (2000), Halpern and Pearl (2005), Halpern (2015), and references therein.

$c$  holds in any context where *manage* is felicitous, actual causation ensures that  $P(x)$  is true in the evaluation world. This gives us the entailment from *manage* to its complement. Conversely,  $\neg\text{manage}(x, P)$  denies that  $c$  actually caused  $P(x)$ . Again, since  $c$  is presupposed to hold, we conclude that  $P(x)$  is false, giving us the entailment from  $\neg\text{manage}(x, P)$  to  $\neg P(x)$ .

Recall the central facts about implicatives:

- (A)  $I(x, P)$  conditions  $P(x)$  on  $x$  overcoming a potential obstacle for  $P(x)$
- (B) Given both  $I(x, P) \rightarrow P(x)$  and  $\neg I(x, P) \rightarrow \neg P(x)$ , overcoming the obstacle is sufficient and necessary for  $P(x)$  in context
- (C) Asserting  $I(x, P)$  non-defeasibly conveys  $P(x)$ ;  $\neg I(x, P)$  conveys  $\neg P(x)$

The catalyst presupposition appears to capture Facts A and B. Since  $c$  is causally insufficient for  $P(x)$ , the problem of achieving sufficiency in context can be construed as a potential obstacle for  $P(x)$  (cf. Karttunen 2014). Moreover, since  $c$  is causally necessary for  $P(x)$ , the conditioning relationship involves necessity as well as sufficiency. Baglini and Francez argue that formulating the not at-issue contribution of *manage* in terms of causal dependencies accounts for the context-sensitivity noted by Coleman, while preserving Karttunen’s (1971) intuitions about the relationship between *managing* and *doing*. Since a dynamics is maintained as a contextual parameter, a “familiar” catalyst can resolve to highlight the role of effort, intention, and/or unlikelihood, based on the context of an implicative utterance. (16) illustrates:

- (16) Maya **managed** to sit through an opera.

Suppose that Maya dislikes opera (DLO), but her best friend, who enjoys it, has bought them both tickets. Maya never says no to this friend, so she’ll go if she is asked (equation 17a). In this scenario, the ticket purchase (TKT) and the request (ASK) represent a catalyst:  $c = \{\langle \text{TKT}, 1 \rangle, \langle \text{ASK}, 1 \rangle\}$  is causally necessary but insufficient for Maya to sit through the opera ( $\langle \text{STO}, 1 \rangle$ ). STO (equation 17b) depends not only on whether or not Maya makes the attempt (by attending the opera; ATT), but also on whether the opera takes more than two hours (HRS), and whether Maya has a drink beforehand (ALC). A graphical model for (16) is given in Figure 1. Background variables are distinguished by double enclosing circles.

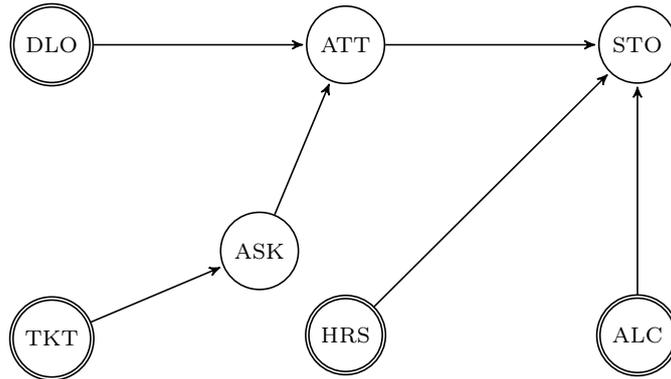


Figure 1: Dynamics for the opera example

- (17) Selected structural equations for the opera example:
  - a.  $\text{ATT} := \text{ASK} \vee \neg \text{DLO}$
  - b.  $\text{STO} := \text{ATT} \wedge \neg \text{HRS} \wedge \text{ALC}$

From the truth of  $c$  ( $c(\text{TKT}) = c(\text{ASK}) = 1$ ), it follows that Maya attends the opera ( $\langle \text{ATT}, 1 \rangle$ ). Independently of the truth or falsity of (16), this context supports the inference that sitting through the opera is difficult for Maya, given what we know about her background preferences ( $\langle \text{DLO}, 1 \rangle$ ). Her aversion simultaneously supports the inference that sitting through an opera is an unlikely thing for Maya to do.

Changing the context changes the background inferences. Suppose that Maya knows nothing about opera, so that DLO is undetermined ( $u$ -valued), with the potential to evolve in either direction. In this case, given the invitation, we infer that Maya intends (and tries) to sit through the opera ( $\langle \text{ATT}, 1 \rangle$ ), but there is no reason to presume any special difficulty. If she happens to enjoy it, (18) is felicitous.

(18) Maya easily **managed** to sit through an opera.

The malleability of *manage*'s presuppositions thus follows naturally from the way in which a contextually-developed dynamics sets values for background variables and sorts the causal ancestors of the implicative complement into catalyst and non-catalyst variables.

Taken together with (15)i, the *actual cause* assertion in (15)ii captures the Fact C entailments. According to Baglini and Francez, distinguishing the at-issue contribution of *manage*( $x, P$ ) from that of the proposition  $P(x)$  readily explains the facts about *because*-clause modification in (14). On Proposal (15), the *because*-clause in (14a) modifies the claim of actual cause, thus addressing the how and why of a causal chain for  $P(x)$ . In (14b), by contrast, the *because*-clause targets the how or why of  $P(x)$  directly.

- (14) a. Juno **managed** to open the door because it was unlocked.  
 b. Juno opened the door because it was unlocked.

If this explanation is correct, (14a) indicates both that a discourse-familiar catalyst actually caused Juno to open the door, and that the relation of actual cause holds as a consequence of the door being unlocked. Assuming (for concreteness) a causally necessary catalyst  $c$  comprising an attempt to open the door (i.e., by turning the knob and pushing),  $c$  could be insufficient for several different reasons—the door might be heavy, wedged shut from the other side, or simply locked. Without *because*-modification, (14a) asserts the in-context efficacy of  $c$ , licensing the conclusion that some potential obstacle was circumvented. By modifying *actual cause* in this context, the *because*-clause necessarily adds the information that  $c$ 's efficacy followed from the door being unlocked (thereby identifying the lock as a potential obstacle). The state of the lock was thus decisive for the actual causal relationship between  $c$  and Juno's success.

Consequently, (14a) indicates that the state of the lock represents the only (contextually) unresolved causal factor for opening the door. Given (15)i—specifically, the presupposition that the catalyst is true as well as salient—it seems that the door being unlocked (when things might have been otherwise) is *contextually sufficient* for  $P(x)$  (as per Definition 11a); it is thus this causal factor, and not the catalyst itself, which represents the proximate cause of  $P(x)$ . In other words, the truth of  $P(x)$  appear to hinge not on  $c$ , but instead on a causal ancestor of  $P(x)$  which is undetermined in  $c$ . Given the insufficiency of  $c$  for  $P(x)$ , coupled with the potential for  $c$  and  $P(x)$  to occur together, it must also be the case that the truth of this undetermined causal ancestor is neither entailed nor precluded by the truth of  $c$ .

This discussion highlights an important consequence of Baglini and Francez's proposal: the presupposition in (15)a indirectly mandates the existence of a catalyst-independent causal ancestor (or set thereof) for  $P(x)$  which is both unresolved (undetermined) and causally decisive for  $P(x)$  in context.<sup>9</sup> Given the causal insufficiency of the catalyst for  $P(x)$ , *actual causation*

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<sup>9</sup> *Causal independence* is not formally defined in Section 3, but is fairly intuitive: given a dynamics  $D$  for set

requires all catalyst-external ancestors of  $P(x)$  to be valued in a way that makes  $P(x)$  true; the failure of actual cause requires determinations for catalyst-external ancestors which collectively falsify  $P(x)$ . These catalyst-external causal ancestors, in other words, are determinative for  $P(x)$  in the context of a felicitous use of *manage*: they are collectively causally necessary and causally sufficient for the truth of  $P(x)$ .

As anticipated in Section 2.3, the catalyst account does indeed invoke the notion of a potential obstacle for *manage*'s complement. It is, however, the catalyst's causal insufficiency which represents the obstacle, and not the catalyst itself. More precisely, the obstacle is constituted by the unresolved status of causally-determinative catalyst-independent ancestors of  $P(x)$ . Overcoming the obstacle means resolving these ancestors in a way that is causally conducive to the truth of  $P(x)$ , while a negative resolution precludes the implicative complement, indicating that the obstacle in this case prevailed.

## 4.2 Lexically-specific implicatives and catalyst-external causes

As suggested in Section 2.1, *manage* represents a special, semantically-bleached case among the implicative verb class. It is worth considering, therefore, whether Proposal (15) can also account for the inference patterns of more typical, lexically-specific implicatives, such as *dare* and Finnish *hennoa* ('have the heart'; 20).

- (19) a. He **dared** to kill the cat. → *He killed the cat.*  
 b. He didn't **dare** to kill the cat. → *He didn't kill the cat.*
- (20) a. Hän **henno-i** tappa-a kissa-n.  
 he.NOM have.heart-PST.3SG kill-INF cat-GEN/ACC  
 'He had the heart to kill the cat.' → *He killed the cat.*
- b. Hän e-i **henno-nut** tappa-a kissa-a.  
 he.NOM NEG-3SG have.heart-SG.PP kill-INF cat-PART  
 'He didn't have the heart to kill the cat.' → *He didn't kill the cat.*

The prerequisites invoked by (19) and (20) (courage and 'heart' or sympathy, respectively) are understood to be determinative for complement realization in the utterance context. From the (a) cases we conclude that the prerequisite obtained and, consequently, that the cat was killed; in the (b) examples, by contrast, failure of the prerequisite blocks complement realization.

The relevance of a named prerequisite must be contextually supported or accommodated for the examples in (19)-(20) to be felicitous: this is what we expect if the prerequisite belongs to an implicative's not at-issue contribution. If the catalyst proposal applies to lexically-specific implicatives, then, its presupposition should incorporate the named prerequisite, so that courage and 'heart' are part of a "familiar" catalyst for *dare* and *hennoa*, respectively.

It turns out that a catalyst is not compatible with the role played by lexically-specific implicative prerequisites. As formulated in Proposal (15), a catalyst is presupposed to obtain regardless of implicative polarity. By contrast, (19) and (20) show that negation affects the status of a prerequisite. Courage and 'heart' are understood to be present in (19a) and (20a), but absent under matrix negation in (19b) and (20b), and it is moreover this difference which drives the complement entailment pattern. The same relationship between matrix polarity, prerequisite status, and complement realization obtains for *bother* and *malttaa* ('have the patience'): positive matrix polarity in (21a) and (22a) indicates that prerequisite satisfaction (i.e., engagement

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$P$ , and two variables  $X, Y \in P$  ( $X \neq Y$ ),  $X$  is *causally independent* of  $Y$  if  $Y \notin \text{Anc}(X)$ . Extrapolating from this, a variable  $X$  is causally independent of a situation  $s$  iff, for all  $Y \in \text{dom}(s)$ ,  $X$  is causally independent of  $Y$ .

and patience, respectively) led to complement realization, while matrix negation in (21b) and (22b) conveys that the prerequisite failed, resulting in complement failure.

- (21) a. Juri **bothered** to respond to my email. → *Juri responded to my email.*  
 b. Juri didn't **bother** to respond to my email. → *Juri didn't respond to my email.*
- (22) a. Marja **maltto-i** odotta-a  
 Marja have.patience-PST.3SG wait-INF  
 'Marja had the patience to wait.' → *Marja waited.*  
 b. Marja e-i **maltta-nut** odotta-a  
 Marja NEG-3SG have.patience-SG.PP wait-INF  
 'Marja did not have the patience to wait.' → *Marja didn't wait.*

Extrapolating from (19)-(22), lexically-specific implicative verbs presuppose the (causal) relevance of their prerequisites for complement realization; felicitous use requires contextual support (or accommodation) for the existence of an unresolved condition, whose resolution settles the status of the complement. At the end of Section 4.1, we saw that just such a condition is mandated by the familiarity of a catalyst; the preceding discussion shows that lexically-specific implicatives, at least, focus attention directly on the causally-determinative condition, rather than on a causally insufficient catalyst.

The presuppositions of lexically-specific implicatives therefore cannot be identified with a catalyst *à la* Proposal (15). It is, however, straightforward to reconcile the catalyst view of *manage* with the 'prerequisite' perspective. Where specific implicatives lexicalize a particular condition  $A(x)$  (the realization of some property or condition  $A$  by  $x$ ) as causally determinative for complement  $P(x)$ , *manage* (likewise, Finnish *onnistua*) simply leaves the nature of  $A$  underspecified, and thus subject to contextual enrichment. This view in effect 'inverts' the catalyst presupposition, so that the not-at-issue contribution of *manage* introduces an unresolved, causally-determinative condition for the implicative complement. Just as the existence of such a condition is a logical consequence of the familiarity of a catalyst, the in-context satisfaction of a set of collectively necessary but insufficient conditions for  $P(x)$  (i.e., a catalyst) follows from a prerequisite presupposition.<sup>10</sup>

<sup>10</sup>There are, in addition, contexts (due to S. Peters, p.c.) where assertion or denial of  $manage(x, P)$  is felicitous even though it is impossible to specify a causally necessary but insufficient catalyst for  $P(x)$ . Broadly speaking, these are cases where  $P(x)$  depend on a disjunction of other variables. Consider the following:

- (1) Kayvan **managed** to get to school on Friday.

Suppose that Kayvan has (at most) four ways of getting to school: the public bus, biking, walking, or being driven by his mother. There was a snowstorm on Thursday night and it is very cold on Friday morning, so biking and walking are both out of the question. It is not clear, however, whether the bus will be running, or if Kayvan's mother will be able to drive, due to the dangerous conditions. In such a situation, it seems felicitous to assert (1) (or its negation) in order to communicate that one of the in-question modes of transit worked out (or that neither did). However, what could the catalyst be in such a scenario? The only plausible catalyst variable would correspond to the proposition that Kayvan tries to go to school, but it seems reasonable to assume that, in the context provided, an attempt to go to school simply constitutes embarking on one of the available modes of transportation. If we know that the bus, too, is not running, then Kayvan's asking his mother to drive him might be causally necessary (but insufficient, since she may say no). Crucially, however, (1) remains felicitous in a context where both the status of the bus and Kayvan's mother's willingness to drive remain unsettled; i.e., in a context where there is no plausible catalyst situation.

While the truth of (1) does not allow us to determine which of the available routes worked out for Kayvan, it does allow us to reason to the truth of their disjunction. Indeed, it is worth observing that, in the context provided, the disjunction of the bus and car options represents a causally necessary and causally sufficient condition for the implicative complement.

On this view, *manage* (and Finnish *onnistua*) must be generalized alternatives to lexically-specific verbs. A context licensing the use of an implicative may or may not contain information about the nature of a causal prerequisite for a particular proposition  $P(x)$ ; the choice of a particular implicative will be governed by what, if anything, is known about a causal chain for  $P(x)$ . A speaker who intends to indicate the relevance of courage for  $P(x)$ , for instance, might select *dare* (or Finnish *uskaltaa*) as the matrix verb, while *manage* (or *onnistua*) are available as alternatives if the speaker wishes to indicate the relevance of a prerequisite for  $P(x)$ , but is unable or unwilling to be specific. Inverting *manage*'s catalyst presupposition thus supports a unified approach to implicative presuppositions, while maintaining the causal background that Baglioni and Francez recruit to account for Coleman's (1975) vanishing presuppositions (as well as, ultimately, the *because*-clause contrast in 14).

### 4.3 One-way implicatives

Further complications for the catalyst proposal come from a class of **one-way implicatives**, such as Finnish *pystya* ('be able'; 23). These verbs share the overall inferential profile of *manage*, but only generate complement entailments under one matrix polarity: negating *pystya* as in (23b) entails the negated complement, but (23a) licenses only a defeasible complement implicature.

- (23) a. Maarit **pysty-i** tappelema-an.  
 Maarit able-PST.3SG fight-INF  
 'Maarit was able to fight.'  $\nrightarrow$  ( $\rightsquigarrow$ ) *Maarit fought.*
- b. Maarit e-i **pysty-nyt** tappelema-an.  
 Maarit NEG-3SG able-SG.PP fight-INF  
 'Maarit was not able to fight.'  $\rightarrow$  *Maarit did not fight.*

Since Proposal 15 derives *manage*'s two-way entailment pattern, it cannot immediately account for a one-way verb. The possibility of a unified account—on which the missing entailment in (23a) follows from trimming some simple, isolatable element from the lexical semantics of a two-way implicative—is nevertheless appealing.

At-issue content is a natural place to look for a way to weaken implicative entailments. Unfortunately, there is no obvious way to weaken the key relation of *actual cause*. Since Proposal (15) backgrounds the truth of a catalyst for complement  $P(x)$ , the truth of  $P(x)$  is the only new information introduced by asserting actual cause (revealing that the catalyst proposal is indeed closer to the direct assertion account than is obvious at first glance). Eliminating this contribution will not get us the desired outcome: if *pystya* contributes nothing new to at-issue meaning, matrix negation has nothing to target, so that we lose not only the (desired) negative entailment, but also the assertoric contrast between (23a) and (23b).

Since a catalyst is taken to be causally insufficient for the implicative complement, we can only weaken the presupposed catalyst-complement relationship by suspending causal necessity. This move not only deprives the catalyst of any meaningful causal connection to  $P(x)$ , but moreover leaves the predicted two-way entailment pattern unaffected. As long as the catalyst's truth is presupposed, actual cause ensures that  $P(x)$  is true under positive matrix polarity, and false under matrix negation. Suspending the truth of the catalyst (so that it is causally necessary and insufficient for  $P(x)$ , but unsettled in the utterance context) does not help: the positive assertion of actual cause nevertheless requires both catalyst and complement to be true.

We might get around the problem by arguing that one-way implicatives are not implicatives at all, and should thus receive an analysis distinct from that of *manage*. I find this approach to be unappealing on empirical grounds. Even if we set aside Finnish *pystya* and English *be able* (also characterized by Karttunen 1971, 2012 as a one-way implicative verb) as potential modal

(or semi-modal) verbs (see also Bhatt, 1999), there are a number of Finnish predicates which not only share the one-way entailment pattern in (23) but also invoke particular prerequisites in the manner of lexically-specific two-way implicatives.

- (24) a. Sampo **jakso-i** noust-a.  
 Sampo have.strength-PST.3SG rise-INF  
 ‘Sampo had strength to rise.’  $\rightsquigarrow$  *Sampo rose.*
- b. Sampo e-i **jaksa-nut** noust-a.  
 Sampo NEG-3SG have.strength-PP.SG rise-INF  
 ‘Sampo did not have strength to rise.’  $\rightarrow$  *Sampo did not rise.*
- (25) a. Freija **mahtu-i** kulke-ma-an ove-sta.  
 Freija fit-PST.3SG go-INF-ILL door-ELA  
 ‘Freija fit through the door.’  $\rightsquigarrow$  *Freija went through the door.*
- b. Freija e-i **mahtu-nut** kulke-ma-an ove-sta.  
 Freija NEG-3SG fit-PP.SG go-INF-ILL door-ELA  
 ‘Freija did not fit through the door.’  $\rightarrow$  *Freija did not go through the door.*

In Section 4.2, I observed that the polarity of a two-way lexically-specific implicative claim affects what is conveyed about the status of a lexicalized prerequisite. The same is true for one-way verbs like *jaksoa* (‘have strength’) and *mahtua* (‘fit’, ‘be small enough’), so that—apart from their respective prerequisite specifications—the only difference between (19)-(22), on the one hand, and (24)-(25), on the other, is in the consequences of prerequisite satisfaction for complement realization.

The data thus suggest a basic semantic unity between one- and two-way implicative verbs. While Baglini and Francez’s catalyst proposal improves on the direct assertion treatment of *manage*, we have now seen that it cannot as formulated in (15) account for a class of implicative verbs which includes both the lexically-specific two-way verbs discussed in Section 4.2 and the one-way implicatives introduced here.

## 5 Causal necessity and sufficiency in implicative verbs

What we are now after is a semantic account of implicativity that preserves the causal component introduced by Baglini and Francez (2016), but which invokes an in-question, contextually-determinative prerequisite instead of a catalyst. This account should derive Facts A-C (see Section 2.1), with the caveat that one-way implicatives do not exhibit the positive  $I(x, P) \rightarrow P(x)$  entailment. We saw in Section 4.3 that one-way implicatives parallel two-way implicatives in conveying that complement realization hinges on the (in-context) resolution of a particular prerequisite. This suggests that what is at issue remains consistent across the one- and two-way subclasses. Consequently, the one- and two-way entailment contrast should follow from a (minimal) difference in not at-issue content.

Karttunen (1971) anticipates the basic structure of a satisfactory account, in a passage whose significance has perhaps been obscured by the subsequent direct assertion proposal (Karttunen and Peters, 1979).

“[. . .] let us ignore the individual differences among implicative verbs and try to state precisely in what respect they are all alike. Let  $v$  stand for any implicative verb and  $S$  for the sentence that manifests itself as the infinitival complement of that verb in the surface structure. I assume that, in the representation of the main clause,  $v(S)$

constitutes the central part of the proposition to which negation, modals, and time and locative references are attached. Leaving out these other details, the semantic analysis of the whole sentence can be represented by the following schema:”

*Presupposition:*  $v(S)$  is a necessary and sufficient condition for  $S$   
*Proposition:*  $v(S)$  (Karttunen, 1971, p.352)

To convert Karttunen’s schema into a full analysis, we first need to identify the “central part of the proposition.” Based on the discussion in Section 4, a natural candidate is the in-question, causally-determinative prerequisite whose status is resolved by a positive or negative implicative assertion.

Building on Baglini and Francez, we can add the requirement that the connection between  $v(S)$  and  $S$  (or rather, between  $I(x, P)$  and  $P(x)$ ) involves *causal* necessity and sufficiency. In addition to the evidence we have already seen, the importance of a causal component in implicativity is further emphasized by an example like (26).

- (26) *Context.* In the United States, you must be (at least) 21 years old to legally drink alcohol. Amira has been eager to try a glass of wine for a long time, but has refrained because she is too law-abiding. She turned 21 yesterday.
- a. ??Yesterday, Amira managed to drink a glass of wine.

Amira’s age is salient in this context, as a necessary and sufficient condition for her to drink wine. Crucially, the relationship is one of *deontic* (rather than causal) necessity and sufficiency. The oddness of (26a) thus demonstrates that a deontic prerequisite is not enough to license the use of implicative *manage*. Moreover, attempting to accommodate (26a) seems to invite conjecture about the relevance of non-legal conditions for Amira’s drinking: for instance, that it may have been logistically difficult for Amira to obtain wine, or perhaps that she suffered a physical reaction to the wine which made it difficult for her to finish the full glass. In other words, even though context provides a salient deontically necessary and sufficient condition for the implicative complement, the use of *manage* encourages speculation about conditions which might instead be *causally* necessary and sufficient for Amira’s wine-drinking—that is, conditions which, unlike legal regulations, concretely precipitate or preclude the complement event.

## 5.1 The proposal

Putting everything together, I propose the following precisification of Karttunen’s (1971) semantic template:

- (27) **The prerequisite account of implicatives.**  
 For a two-way implicative verb  $I$ , an agent  $x$ , a one-place predicate  $P$ , and a background situation  $c$ , the proposition  $I(x, P)$ :
- i. *Presupposes:* The existence of a predicate  $A$  such that  $A(x)$  is *causally necessary* for  $P(x)$  in the utterance context.  $A(x) \triangleleft_c P(x)$
  - ii. *Asserts:*  $A(x)$
  - iii. *Presupposes:*  $A(x)$  is the only unmet causally necessary condition for  $P(x)$  in context (so  $A(x)$  is *causally sufficient* for  $P(x)$  relative to  $c$ )  $A(x) \triangleright_c P(x)$

On the prerequisite account, the presupposed condition  $A(x)$  is crucially left unresolved in the discourse context (unlike the ‘familiar’ catalyst from Baglini and Francez 2016). As a result, implicative presuppositional content—per Proposal (27)—highlights that, given what



### 5.1.1 Illustration: the modified Dreyfus scenario

To see how Proposal (27) works, let us consider a fictionalized version of the Dreyfus scenario (adapted from Baglini and Francez 2016). Suppose the following conditions hold:

- (28) If Dreyfus intends (INT) to spy for the Germans (SPY), then:
- a. he will collect secrets about the French (SEC) SEC := INT
  - b. if he has the nerve (NRV) as well as the intent to spy, he will send a radio message to make contact with the Germans MSG := INT  $\wedge$  NRV
  - c. if it happens that a German is listening on the correct frequency (LST), and the message is not garbled (BRK), Dreyfus will establish a private communications line (COM) COM := MSG  $\wedge$  LST  $\wedge$   $\neg$ BRK
  - d. he will use the line to pass information to the Germans, thus spying for them SPY := SEC  $\wedge$  COM

Figure 2 provides the graph for the dynamics in (28). The background variables are INT (whether or not Dreyfus has the intention to spy), NRV (whether or not Dreyfus has the nerve to spy), LST (whether or not a German is listening), and BRK (whether or not the message is garbled).

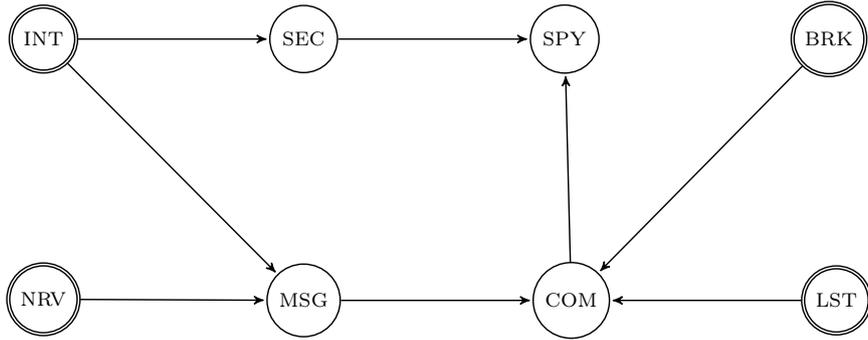


Figure 2: Graphical representation for the fictional Dreyfus scenario

Suppose that we are in a context which establishes that Dreyfus intends to spy, and has in fact already collected secrets. Then the relevant background situation  $s$  has  $s(\text{INT}) = s(\text{SEC}) = 1$ . Given  $s$ , we have the following intuitive judgements for (29a)-(29d).

- (29)
- a. Dreyfus dared to send a message to the Germans.
  - b. Dreyfus did not dare to send a message to the Germans.
  - c.  $?/\#$ Dreyfus dared to establish communication with the Germans.
  - d.  $?/\#$ Dreyfus dared to spy for the Germans.

The felicity of (29a)-(29b) is predicted by Proposal (27). In situation  $s$ , NRV is the only undetermined condition for the truth of MSG: it is thus both causally necessary and sufficient for MSG ( $\langle \text{NRV}, 1 \rangle \triangleleft_s \langle \text{MSG}, 1 \rangle, \langle \text{NRV}, 1 \rangle \triangleright_s \langle \text{MSG}, 1 \rangle$ ). The polarity of *dare* then sets the value of NRV in evaluation world  $w^*$ , allowing us to calculate  $w^*(\text{MSG})$ .

Proposal (27) also predicts the infelicity of *dare* in (29c)-(29d). For (29c), situation  $s$  leaves two relevant conditions for the implicative complement (COM) unresolved: BRK and LST. As a result, NRV is contextually necessary but not sufficient for COM ( $\langle \text{NRV}, 1 \rangle \triangleleft_s \langle \text{COM}, 1 \rangle, \langle \text{NRV}, 1 \rangle /$

$\triangleright_s \langle \text{COM}, 1 \rangle$ ), and the felicity conditions for two-way *dare* are not satisfied. In (29d), the implicative complement SPY is itself causally dependent on COM, and the same problem arises: *dare* is infelicitous because  $\langle \text{NRV}, 1 \rangle$  is causally necessary but not sufficient for  $\langle \text{SPY}, 1 \rangle$ , since BRK, LST, COM  $\in$  Anc(SPY) are all undetermined in the discourse context.

The fictitious Dreyfus dynamics will also illustrate how a non-specific implicative like *manage* works. The examples in (30) are intuitively judged to be felicitous.

- (30) a. Dreyfus managed to send a message to the Germans.  
*inferred:  $w^*(\text{NRV}) = 1$*
- b. Dreyfus did not manage to send a message to the Germans.  
*inferred:  $w^*(\text{NRV}) = 0$*
- c. Dreyfus managed to establish communication with the Germans.  
*inferred:  $w^*(\text{NRV}) = w^*(\text{MSG}) = w^*(\text{LST}) = 1, w^*(\text{BRK}) = 0$*
- d. Dreyfus managed to spy for the Germans.  
*inferred:  $w^*(\text{NRV}) = w^*(\text{MSG}) = w^*(\text{LST}) = w^*(\text{COM}) = 1, w^*(\text{BRK}) = 0$*

How is the contrast between (29c)-(29d) and (30c)-(30d) explained? On the current account, while *dare* requires that the only unresolved causal ancestor for its complement involves courageous action by Dreyfus, *manage* simply requires that the set of unresolved causal ancestors for its complement represent a causally necessary and sufficient condition. This view is supported by the fact that each statement in (30) licenses a particular set of inferences about the values of various relevant propositions in the Dreyfus situation. Crucially, for each claim in (30), the indicated set of inferred condition-value pairs represent a contextually necessary and sufficient (collective) condition for the implicative complement.<sup>12</sup>

Lastly, consider a scenario which is closer to the truth of the Dreyfus affair. Suppose Dreyfus is innocent, and has no intention to spy for the Germans; he is, however, known for showing courage in any and all situations. In this context, with a background situation  $s$  that fixes  $s(\text{INT}) = 0$  and  $s(\text{NRV}) = 1$ , each of (29a)-(29d) is infelicitous, since  $\langle \text{NRV}, 1 \rangle$  is not sufficient in context for  $\langle \text{MSG}, 1 \rangle$ ,  $\langle \text{COM}, 1 \rangle$  or  $\langle \text{SPY}, 1 \rangle$ . Notably, (30a)-(30b) also become infelicitous in the absence of Dreyfus's intent to spy, because no (set of) condition(s) can be causally sufficient for the truth of MSG, COM, or SPY relative to a background in which INT is false.

## 5.2 More evidence for the prerequisite account

Proposal (27) already has an analytical advantage over both the direct assertion and catalyst accounts, in that it not only derives Facts A-C, but also captures the differences between one- and two-way implicatives without assigning them divergent at-issue contributions. This section provides some additional empirical evidence which supports the prerequisite account over Baglini and Francez's catalyst proposal.

Proposal (27) makes two claims for a one-way implicative  $I$ . First,  $I(x, P)$  asserts  $A(x)$ . Secondly,  $A(x)$  is not enough to derive  $P(x)$ . This is illustrated by the felicity of (31), where a positive assertion of one-way *jaksaa* ('have the strength'; 24) is followed by the negation of its complement. Despite the absence of an inference from  $I(x, P)$  to  $P(x)$ , (31) conveys that the requisite strength was available.<sup>13</sup>

<sup>12</sup>Causal necessity and sufficiency of a collection of facts for  $P(x)$  are evaluated in parallel to causal necessity and sufficiency of facts (Definition 11). Instead of augmenting the background context  $c$  with a single variable-value pair, we add the relevant set  $s$  of facts (i.e., a situation) to the determinations in  $c$ . If this update moves  $P(x)$  from impossible (in  $c$ ) to possible (in  $c + s$ ), or from not guaranteed (in  $c$ ) to guaranteed (in  $c + s$ ), causal necessity and causal sufficiency hold (respectively) between  $s$  and  $P(x)$  relative to  $c$ .

<sup>13</sup>There is, however, an important difference between a positive assertion of a one-way verb like *jaksaa* ('have



(34) *Context.* A hunter in the forest had lost count of the number of times he had fired his gun and was not sure if he had used all the bullets or not. He decided to check after eating something, and put the gun down to get some food from his bag. While he had both hands in the bag, he spotted a bear coming towards him.

- a. #Hän **eht-i** ampu-a karhu-n.  
 he.NOM have.time-PST.3SG shoot-INF bear-GEN/ACC  
 ‘He had enough time to shoot the bear.’ → *He shot the bear.*

(34) explicitly suspends a necessary and time-independent condition for shooting the bear—namely, whether or not the hunter had any bullets remaining. This makes (34a) infelicitous: one informant explained that she could not use *eh*t*iä* here because “if [the hunter] didn’t have any bullets, he could not have shot the bear.” She identified the same problem for negated *eh*t*iä* in the same context, even if the speaker’s intention was to convey that the bear was not shot.

My informants also found *keh*d*ata* (‘be unembarrassed’, ‘act without shame’) to be infelicitous in (35a). Again, the context establishes an unresolved condition which might prevent complement actualization, and which is causally independent of shame: here, it is possible that the consultant simply had the inoffensive version of the survey.

(35) *Context.* Two versions of a survey were prepared for a policy consultant to take door to door. One version had unusually detailed questions about sexual preferences which were not included on the other. The policy consultant was only given one version, but we are not sure which one. We are wondering whether he asked the personal questions.

- a. #Hän **kehtas-i** kysy-ä niin henkilökohtais-i-a asio-i-ta.  
 he.NOM unashamed-PST.3SG ask-INF such personal-PL-PART thing-PL-PART  
 ‘He acted without shame in asking something so personal.’  
 → *He asked the personal questions.*

Examples (32)-(35) support the prerequisite account over the catalyst proposal. In each case, two-way verbs are judged infelicitous when a causally necessary condition independent of the specified prerequisite is explicitly left unresolved in the discourse context. This is good evidence for the claim that implicative prerequisites are backgrounded as causally sufficient in addition to being causally necessary for complement realization.

There is, in addition, a predictable contrast between contexts like (32)-(35) and contexts where causally relevant and potentially unresolved conditions are left unmentioned. In such a context—for instance, if the background for (34a) establishes only that the hunter was reaching for food when he spotted the bear, and the issue of bullets is not made salient—the use of *eh*t*iä* is not only felicitous, but moreover licenses the inference that time was the only potential obstacle for shooting the bear. Positive resolution of the time condition—as asserted by (34a)—allows us to infer that the hunter shot the bear. Taken together with the evidence from (32)-(35), this suggests that an account of implicatives which includes a(n accomodatable) precondition of causal sufficiency is on the right track.

### 5.3 Circumscription, presupposition, and implicature

In Proposal (27), the difference between one- and two-way predicates is captured by the difference between a single presupposition of causal necessity and a dual presupposition, which adds causal sufficiency to causal necessity. The condition  $A(x)$  invoked by a one-way verb is only taken to be necessary for the realization of the implicative complement, whereas the condition invoked by a two-way implicative is taken to be sufficient as well.



Nadathur and Lauer explain this phenomenon as one of **causal perfection**, an inference about the structure of a causal dynamics. Causal perfection proceeds from the stated availability of a single (sufficient) causal pathway for the realization of a particular effect, to the conclusion that no other causal pathway to this effect are consistently realizable in context. This makes the *make-cause* (climate change, in example 37) a necessary as well as sufficient condition. The analogy with conditional perfection is immediate.

Implicative antiperfection inferences also involves reasoning about the structure of a causal dynamics. **Causal antiperfection** might also be expected to arise in the interpretation of necessity causatives.<sup>14</sup> It remains to be seen whether the fourth permutation—*conditional antiperfection*—arises as a natural-language inference pattern.

The WYSIATI reasoning involved in (anti)perfection is also known as (*predicate*) *circumscription* (McCarthy, 1980, p.27, emphasis in original):

“Circumscription is a rule of conjecture that can be used by a person or program for ‘jumping to certain conclusions’. Namely, *the objects that can be shown to have a certain property P by reasoning from certain facts A are all the objects that satisfy P.*”

In the semantics/pragmatics literature, McCarthy’s circumscription has been formalized as the (pragmatic) operation of *exhaustive interpretation*, first introduced by Groenendijk and Stokhof (1984), and further developed by van Rooij and Schulz (2004); Schulz and van Rooij (2006). The idea here is that one-way implicative implicatures—instances of causal antiperfection—arise through circumscription/exhaustive interpretation, as long as the utterance context does not preclude the results of the operation.<sup>15</sup>

We have seen that two-way implicatives are infelicitous when a condition independent of  $A(x)$  is explicitly left unresolved. Moreover, they are accommodated when no other factors are mentioned. From use of a two-way implicative, listeners will infer a background in which all causal conditions for  $P(x)$  other than  $A(x)$  are met. This inference is distinguished from antiperfection implicatures, by not being at issue (and thus not defeasible) in the discourse context. Formulating the causal sufficiency presupposition of Proposal (27) as one of circumscription thus establishes a natural continuity between one- and two-way predicates.

On this view, two-way implicatives have lexicalized their antiperfection, resulting in two-way entailments. One-way implicatives leave antiperfection to the pragmatic dimension, where it arises easily in contexts where no alternative causal conditions for the implicative complement are salient. The lexicalization hypothesis remains speculative, but may find some support in Flint’s (1980) taxonomy of Finnish verbs of possibility and sufficiency. Flint ranks implicatives with similar lexical content by the strength with which they invite the conclusion that their complements hold. On this view, the distinction between presupposed and implicated causal sufficiency is gradient rather than sharp (see also White, 2019). The degree of fluidity involved, which verbs are subject to it, and the potential relevance of any frequency or usage effects are left as matters for future investigation.<sup>16</sup>

<sup>14</sup>Assuming, of course, that pure necessity causatives exist. Certain treatments of English *cause* suggest that it minimally indicates (causal) necessity, but the broad consensus goes against a view on which this is all that *cause* predicates.

<sup>15</sup>Franke (2009) and Nadathur (2013) offer accounts of conditional perfection in terms of pragmatic exhaustive interpretation. These accounts are to be distinguished from *exhaustification* accounts of conditional perfection, which rely on a proposed grammatical operator *exh* (Fox, 2007; Chierchia et al., 2012). Herburger (2015) offers an analysis of conditional perfection in the latter style.

<sup>16</sup>This hypothesis has a non-trivial interaction with the type of condition (namely, actionable or inherently eventive) that is specified by an implicative verb. See footnote 13.

## 5.4 Polarity-reversing implicatives

One more group of predicates deserves attention: polarity-reversing implicatives like *fail* and Finnish *laiminlyödä* (‘neglect’; 39). As (38)-(39), show, asserting a two-way polarity-reversing implicative entails the negation of its complement; denying the implicative entails complement actualization.

- (38) a. Juri **failed** to open the door.  $\rightarrow$  *Juri did not open the door.*  
 b. Juri did not **fail** to open the door.  $\rightarrow$  *Juri opened the door.*
- (39) a. Hän **laiminlö-i** korjat-a virhee-n.  
 he.NOM neglect-PST.3SG repair-INF error-GEN/ACC  
 ‘He neglected to correct the error.’  $\rightarrow$  *He did not correct the error.*
- b. Hän e-i **laiminlyö-nyt** korjat-a virhe-ttä.  
 he.NOM NEG-3SG neglect-PP.SG repair-INF error-PART  
 ‘He did not neglect to repair the error.’  $\rightarrow$  *He corrected the error.*

There are two straightforward ways to extend Proposal (27) to polarity-reversing implicatives, both involving a minor change to presuppositional content. The first possibility is that a polarity-reversing implicative backgrounds the highlighted condition  $A(x)$  as causally necessary for  $\neg P(x)$ ; this derives the negative entailments in (38b) and (39b) immediately, and the positive entailments in (38a) and (39a) as a result of circumscribing  $A(x)$  as the only causally necessary condition in question. Alternatively, the  $\neg A(x)$  might be backgrounded as causally necessary for  $P(x)$ . If we choose the latter option, the entailments in (38a) and (39a) follow directly, and the negative entailments are derived via circumscription. Two-way polarity-reversing data do not indicate which option is preferable.

One-way polarity-reversing implicatives resolve the matter. *Hesitate* and its Finnish equivalent *epäröidä* (41) entail complement actualization under matrix negation, but, like polarity-preserving one-way implicatives, do not entail in the positive case.

- (40) a. Amira **hesitated** to drink a beer.  $\nrightarrow$  *Amira drank a beer.*  
 b. Amira did not **hesitate** to drink a beer.  $\rightarrow$  *Amira drank a beer.*
- (41) a. Juno **epärö-i** otta-a osa-a kilpailu-un  
 Juno hesitate-PST.3SG take-INF part-PART race-ILL  
 ‘Juno hesitated to take part in the race.’  $\nrightarrow$  *Juno did not take part in the race.*
- b. Juno e-i **epäröi-nyt** otta-a osa-a kilpailu-un  
 Juno NEG-3SG hesitate-PP.SG take-INF part-PART race-ILL  
 ‘Juno did not hesitate to take part in the race.’  $\rightarrow$  *Juno took part in the race.*

Since the positive entailments (from  $A(x)$  to the negation of the implicative complement) are the ones that disappear in the one-way case, it seems as if the negative entailments should be taken as more basic. In particular, this favours an analysis on which the presupposition shared by one- and two-way polarity-reversing implicatives takes a condition  $A(x)$  to be causally necessary for the failure of the implicative complement. Then, as in the polarity-preserving cases, two-way polarity-reversers can be analyzed as having lexicalized the circumscriptive reasoning that produces the inferences in (38b) and (39b), while one-way polarity-reversers have not.

A final observation: where one-way polarity-preserving implicatives are strongly associated with antiperfection implicatures, as discussed above, the tendency towards these inferences is for some reason much weaker in the polarity-reversing case. More surprising still is the apparent potential for positive assertions of one-way polarity-reversing verbs to generate implicatures which

follow a factive pattern (that is, do not change with matrix polarity), as well as implicatures in the implicative pattern. Whether an implicative or factive-type inference is drawn (if either is) depends heavily on context.

- (42) Juri **hesitated** to ask for help.
- a. *Implicative*:  $\rightsquigarrow$  Juri didn't ask for help (because of her hesitance).
  - b. *Factive*:  $\rightsquigarrow$  Juri asked for help (after some time had passed).
- (43) Leo **ujostel-i** näyttä-ä kuva- $\{a/n\}$  minu-lle.  
 Leo shy-PST.3SG show-INF picture- $\{PART/GEN\}$  me-ILL  
 'Leo was shy to show me the picture.'<sup>17</sup>
- a. *Implicative*:  $\rightsquigarrow$  Leo did not show me the picture (due to shyness).
  - b. *Factive*:  $\rightsquigarrow$  Leo showed me the picture (with reluctance).

The availability of both types of inferences shown in (42)-(43) opens up questions about the semantic relationship between implicative and factive verbs. If one-way polarity-reversing verbs like *hesitate* can, in fact, trend towards the factive pattern, this may shed some light on results from Karttunen et al. (2014) and Tonhauser et al. (2020), which indicate a certain fluidity in the use of implicative- or factive-type inferencing for phrasal, evaluative-adjective constructions like *be lucky to*. I leave an investigation of these connections for future work.

## 6 Conclusions and outlook

Building on Baglini and Francez's (2016) novel causal account of implicative *manage*, I have proposed a general semantics for the implicative verb class which (a) derives the characteristic implicative entailment pattern first described by Karttunen (1971), (b) avoids endorsing an undesirable functional equivalence between an implicative assertion and that of its bare (reconstructed) complement, and (c) captures projective inferences about the non-triviality of complement realization (Coleman, 1975; Karttunen and Peters, 1979, among others). The account draws on Schulz's (2011) causal **dynamics** (in turn based on Pearl 2000); I proposed that implicative verbs across the one- and two-way subtypes background the existence of a causally-necessary condition for their complements (specified to a greater or lesser degree depending on both language and verb), and assert that this condition was realized in the utterance context. To capture the bidirectional entailment pattern of two-way implicatives, I further proposed that these verbs encode a second, circumscriptive presupposition, to the effect that the lexically-invoked prerequisite is the only unresolved causal condition for the implicative complement.

Unlike previous treatments of implicative semantics, which focus almost exclusively on two-way *manage*, the account offered here provides a natural link between one- and two-way implicatives via the pragmatic prevalence of circumscriptive (exhaustive) reasoning (McCarthy, 1980; Groenendijk and Stokhof, 1984; van Rooij and Schulz, 2004; Schulz and van Rooij, 2006). In addition to considering lexically-specific English implicatives like *dare*, and *condescend*, I further support the proposal with data from the rich Finnish implicative paradigm, which includes not only a counterpart to semantically-bleached *manage* (*onnistua*, 2), but also a wealth of lexically-specific one- and two-way verbs of both the polarity-preserving and polarity-reversing types.

<sup>17</sup>In Finnish, case marking within the embedded proposition seems to correlate with which implicature is preferred. In (43), partitive marking on *kuva* ('picture'), seems to privilege a factive inference, while the genitive/accusative marker privileges an implicative inference.

The success of a causal approach in capturing the class-level semantic behaviour of implicatives raises a number of questions which deserve closer scrutiny. One of these, which involves exploring potential gradience in the factive-implicative semantic boundary, is discussed in Section 5.4. Of particular interest going forward is a class of phrasal *enough* and *too* predicates, described by Karttunen as predicates which “must sometimes be understood in an implicative, sometimes in a non-implicative sense” (1971; 354).

- (44) a.  $\gamma$ [Boehner] **was smart enough** to leave once he saw the direction his party was going.  
 $\rightsquigarrow$  Boehner left [the party].
- b.  $\gamma$ When I played soccer as a chubby little ten-year-old, I **was too slow** to score any goals, so my dad (who was the coach) had me play defense.  
 $\rightsquigarrow$  I did not score any goals.
- (45) a.  $\gamma$ Best part of this or any reunion was the cast feeling bad for Sean and swearing he **was smart enough** to be a neurosurgeon.  
 $\rightsquigarrow$  [The cast believed that] Sean was a neurosurgeon.
- b.  $\gamma$ I had a friend who taught for a while who really **was too stupid** to be a teacher.  
 $\rightsquigarrow$  My friend was not a teacher.

Whether or not they invite implicative inferences, *enough/too* predicates link (some degree) of the matrix adjective to the potential for complement realization, and convey a relationship of sufficiency (*enough*) or excess (*too*) between the subject’s allotment and the degree required for complement realization.

The distribution of implicative behaviour in *enough/too* constructions is important for (at least) two reasons. First, despite the general (requirement) link between the matrix property attribution and the realization of the *enough/too* complement, there is an intuitive difference between the conditions invoked by *enough/too* predicates and those invoked by two-way implicatives like *dare* (or Finnish *uskaltaa*; 4). In particular, *enough/too* property attributions are at base uniformly stative, and give rise to implicative inferences only where they describe characteristics that have actionable potential (*be fast enough*, *be too slow*; Nadathur 2017, 2019). A comparison between examples like (44a)-(44b) and one-way implicatives like Finnish *jaksaa* (‘have strength’; 24), which often describe similarly latent (but actionable) capacities promises therefore to shed light on the nature of the lexical divide between one- and two-way semantic implicativity.

Secondly, Hacquard (2005) observes that the implicative inferences of French *enough/too* (*assez/trop*) constructions show sensitivity to grammatical aspect. Under perfective marking in (46a), *être assez rapide* (‘be fast enough’) entails the realization of its complement, while implicative behaviour remains at best defeasible in the imperfective case in (46b).

- (46) French *enough/too* inferences:
- a. *Khalil a été assez rapide pour s’enfuir, #mais il ne s’est pas enfui.*  
 ‘Khalil was-PFV fast enough to escape, #but he did not escape.’
- b. *Khalil était assez rapide pour s’enfuir, mais il ne s’est pas enfui.*  
 ‘Khalil was-IMPF fast enough to escape, but he did not escape.’

These data strengthen the link between between implicativity and the longstanding puzzle of aspect-sensitive **actuality entailments** from ability modals, first observed (for aspect-marking Greek and Hindi) by Bhatt (1999); (47) replicates the phenomenon for French abilitative *pouvoir* (‘can’).

(47) French actuality entailments:

- a. *Eman a pu soulever cette table, #mais elle ne l'a pas soulevée.*  
'Eman could-PFV lift this table, #but she did not lift it.'
- b. *Eman pouvait soulever cette table, mais elle ne l'a pas soulevée.*  
'Eman could-IMPF lift this table, but she didn't lift it.'

Actuality entailments resist explanation on accounts which aim to derive them in the composition of (circumstantial) possibility and perfective aspect (Hacquard, 2009; Mari and Martin, 2007; Piñón, 2009; Mari, 2016; Homer, 2021, among others). Bhatt's original proposal, which assigned ability predicates (ABLE, subsuming English *be able* and ability modals in Greek, Hindi, and presumably other aspect-marking languages) the two-way 'direct assertion' semantics of Karttunen and Peters's (1979) *manage*, on the other hand fails to account for the contrast between lexical implicatives, which entail their complements under imperfective as well as perfective marking (shown for French *réussir* in 48), and the aspect sensitivity of actuality entailments, shown in (47).

(48) French implicative *réussir* ('succeed', 'manage'):

- a. *Khalil a réussi à s'enfuir, #mais il ne s'est pas enfui.*  
'Khalil managed-PFV to escape, #but he did not escape.'
- b. *Khalil réussissait à s'enfuir, #mais il ne s'est pas enfui.*  
'Khalil managed-IMPF to escape, #but he did not escape.'

The causal approach to implicative semantics offers a new perspective on the data in (47), and one which has the potential to make good on the intuition that actuality entailments are instances of implicative behaviour. Where Bhatt's original proposal attempts to establish equivalence at the lexical level (between ABLE and *manage/réussir*), the causal approach—and in particular its rapprochement between one- and two-way implicative verbs—suggests that the real equivalence may instead be analytical, so that the semantic components of implicativity (causal dependence, a necessary and sufficient prerequisite, and so on), which operate as a package deal for lexical implicatives, come together only at the compositional level (see also Nadathur, 2019, 2021). A starting point for such an account would be the one-way analysis of English *be able* (and its Finnish counterpart *pystyä*; 23) anticipated by Karttunen (1971): however, a detailed investigation of the consequences of a causal analysis of ability for the standard premise semantics approach (Kratzer, 1981, 2012) and the composition of abilitative modality and grammatical aspect—and thus, ultimately the success of a causal implicative account of actualized ability—will have to be undertaken elsewhere.

## Appendix: Sources for naturally-occurring examples

Below, example numbers refer to the number under which the example occurs in the main text.

- (5a) Tempting fate, I dared to open an umbrella indoors.  
[kool1079.com/tempting-fate-i-dared-to-open-an-umbrella-indoors/](http://kool1079.com/tempting-fate-i-dared-to-open-an-umbrella-indoors/)  
*Last retrieved on:* 2019-02-05
- (5b) That is a technical explanation, and it does not throw light on precisely why Mr. Sinha condescended to meet the tainted persons in the first place.  
[www.dailypioneer.com/2014/columnists/director-in-deep-trouble.html](http://www.dailypioneer.com/2014/columnists/director-in-deep-trouble.html)  
*Last retrieved on:* 2019-03-05
- (12a) Without intending to, Ms. Streisand actually managed to synthesize the problem of diversity mania.  
[www.baltimoresun.com/news/opinion/oped/bs-ed-op-0814-goldberg-20170813-story.html](http://www.baltimoresun.com/news/opinion/oped/bs-ed-op-0814-goldberg-20170813-story.html)  
*Last retrieved on:* 2018-12-04
- (12b) By 1998, four years after a federal ban on assault weapons took effect, gun manufacturers had easily managed to bypass the law by making small alterations to their weapons.  
[www.motherjones.com/politics/2008/07/semiautomatic-people/](http://www.motherjones.com/politics/2008/07/semiautomatic-people/)  
*Last retrieved on:* 2019-01-05
- (12c) The social democrats (Socialdemokratiet) managed to strengthen their position as Denmark's strongest political force as expected during local elections.  
[www.kas.de/nordische/en/](http://www.kas.de/nordische/en/)  
*Last retrieved on:* 2018-12-04
- (37a) Climate change made me do it: activists press the 'Necessity Defense'.  
[www.forbes.com/sites/legalnewsline/2018/01/10/climate-change-made-me-do-it-activists-press-the-necessity-defense/#721ecb0553e0](http://www.forbes.com/sites/legalnewsline/2018/01/10/climate-change-made-me-do-it-activists-press-the-necessity-defense/#721ecb0553e0)  
*Last retrieved on:* 2018-01-25
- (45a) Best part of this or any reunion was the cast feeling bad for Sean and swearing he was smart enough to be a neurosurgeon.  
[www.reddit.com/r/survivor/comments/jzixz9/would\\_you\\_do\\_what\\_richard\\_did\\_to\\_win/](http://www.reddit.com/r/survivor/comments/jzixz9/would_you_do_what_richard_did_to_win/)  
*Last retrieved on:* 2022-01-09
- (45b) I had a friend who taught for a while who really was too stupid to be a teacher.  
[www.proteacher.net/discussions/showthread.php?p=3540844](http://www.proteacher.net/discussions/showthread.php?p=3540844)  
*Last retrieved on:* 2022-01-09

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