Chapter 3

Causal dependence in implicative inferences

In his original description of the actuality inference phenomenon, Bhatt (1999) contrasts the 'had the ability' reading of generic *was able* claims like (3.1a) with what he calls the 'managed to' reading that follows naturally in episodic contexts like (3.1b).

(3.1) a. *Generic, no actuality implication, generically interpreted subject:*
In those days, a fireman was able to eat five apples in an hour.

b. *Episodic, actuality implication, existentially interpreted subject:*
Yesterday, at the apple eating contest, a fireman was able to eat five apples.

(Bhatt, 1999, p.2)

This stands in opposition to Thalberg's (1972) informal description of actualized interpretations as simply meaning 'did'. In drawing a parallel with *manage*, Bhatt is making the claim that actualized interpretations of ability ascriptions do not just contribute the 'did' of complement realization, but also carry any additional inferential material associated with the interpretation of (past-tense) *manage*.

The immediate parallel between *managed to* and episodic ability ascriptions is, of course, in the realization of their respective complements. *Manage* belongs to a class of **implicative**

verbs, which are characterized by a pattern of complement entailment (Karttunen, 1971). (3.2) illustrates this behaviour.

(3.2) Juno managed to open the door, #but she didn't open it.

As Bhatt points out, *managed to* and actualized ability have more than complement inferences in common. He observes that, like *manage*, ability modals "do not just mean that an event related to the embedded predicate took place", but add to this the impression or presumption of effort. This presumption can be identified in the contrast between Bhatt's examples (3.3a) and (3.3b). (3.3a) is marked, but the perceived infelicity disappears with the addition of context that supplies evidence of "some kind of sustained (non-minimal) effort" (1999, p.5).

(3.3) a. #/?A woman in Watertown **was able** to win 3 million dollars in the lottery yesterday.

b. After buying lottery tickets regularly for several years, a woman in Watertown **was** finally **able** to win 3 million dollars in the lottery yesterday.

We find precisely the same contrast if we replace *was able* with *managed*:

(3.4) a. #/?A woman in Watertown **managed** to win 3 million dollars in the lottery yesterday.[1]

b. After buying lottery tickets regularly for several years, a woman in Watertown finally **managed** to win 3 million dollars in the lottery yesterday.

[1]Bhatt marks this example as ruled out semantically; along with (3.3a), it seems to me to be highly marked, but not entirely unacceptable. To foreshadow the discussion in Section 3.2, general unlikelihood (in this case, the unlikelihood of winning a lottery) seem to be a potential licensing condition for *manage*. The reason for lingering oddness, despite the unlikeliness of winning a lottery, is, I suspect, due to the indefinite nature of the subject in these examples: in the case of any specific individual, winning a lottery is unlikely, but in the big picture, some person is likely to win. In support of this explanation, we can compare (3.3a) and (3.4a) with (ia) and (ib):

(i) a. I was able to win 3 million dollars in the lottery yesterday.
b. I managed to win 3 million dollars in the lottery yesterday.

By replacing the indefinite subject with the first person pronoun, we make the unlikeliness of a specific individual's lottery win salient, eliminating the infelicity perceived in the original examples.

Thus, in addition to actuality inferences, episodic ability ascriptions and *manage* appear to share a specific precondition of use: that realizing the embedded proposition required effort from the sentential subject.

We can add this precondition to our understanding of actualized ability claims. Although the examples in (3.3) involve English *be able*, and not an ability modal, comparing *pouvoir* and the French implicative *réussir* ('manage,' 'succeed') suggests that Bhatt's inferential parallels hold in the cross-linguistic context.[2]

(3.5) *Juno* ***a pu*** *ouvrir la porte.*
'Juno could-PFV open the door.'
a. *Entails:* Juno opened the door.
b. *Presumes:* Opening the door required effort (for Juno).

(3.6) *Juno* ***a réussi*** *à ouvrir la porte.*
'Juno managed-PFV to open the door.'
a. *Entails:* Juno opened the door.
b. *Presumes:* Opening the door required effort (for Juno).

This gives us a new angle of attack. If actuality inferences can, at an analytical level, be treated as instances of implicative behaviour, or **implicativity**, an investigation of *manage* is simultaneously an investigation of the meaning and implications associated with actualized ability ascriptions. At the end of Chapter 2, I suggested that, in order to understand what an actuality inference really is, we need to understand precisely how it is derived, and whether it belongs directly to asserted content or follows in a process of semantic reasoning. The analysis of *manage* is an attractive route to take in trying to answer this question. This is because, in the implicative context, the source of complement entailments must reside in lexical semantics, rather than in the details of a compositional interaction between ability and aspect to which we do not have direct access.

[2]Bhatt's cross-linguistic evidence comes from Greek and Hindi; the judgements of similarity between (3.5) and (3.6) are due to my French informants.

Crucially, implicative entailments are not sensitive to aspect. This is shown for French *réussir* in (2.44), repeated from Chapter 2. In (3.7), we see that the entailments of *manage* are likewise unaffected by the choice of a generic or an episodic context.

(2.44) a. *Jean **réussissait** à s'enfuir, #mais il ne s'est pas enfui.*
'Jean managed-IMPF to escape, #but he did not escape.'

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

(3.7) a. *Generic:*
In those days, a fireman managed to eat five apples in an hour, #but no fireman ate five apples in an hour.

b. *Episodic:*
Yesterday, at the apple eating contest, a fireman managed to eat five apples, #but he did not eat five apples.

It follows from this indifference to aspect that the semantic features responsible for complement entailments are encoded directly by *manage/réussir*, and not introduced compositionally. Thus, an account of *manage* offers a means of establishing the semantic underpinnings of actuality inferences while filtering out any complications introduced by aspect. If actuality inferences are genuine instances of 'implicativity,' then an analysis which identifies the essential lexical semantic components that derive implicative behaviour will simultaneously identify those components of meaning which must appear in the joint contribution of aspect and ability in examples like (3.1b) and (3.5). In turn, having these components in hand paves the way for a close examination of the independent contribution of both ability and aspect in the derivation of actuality inferences.

With this goal in mind, this chapter focuses on the meaning and interpretation of *manage*, and develops a novel account of the implicative verb class. On my analysis, implicative entailments (and any associated implications) are derived from relations of **causal dependence** embedded in the lexical semantic representations of implicative verbs. The introduction of a causal component is inspired by Baglini and Francez's (2016) recent treatment of

manage, but the account I develop represents a significant revision and expansion of that work. My proposals are motivated by data from Finnish as well as English, and, in addition to identifying the key components of implicativity, extend a causal account from the specific case of *manage* alone to the full range of implicative verbs.

In the course of this chapter, I introduce a formal system for representing causal relationships. Following Baglini and Francez, I adopt the **causal dynamics** framework of Schulz (2007, 2011), which in turn is based on the structural equation models of Pearl (2000). Since my focus in this chapter is on the work done by causal dependence relations in explicating the interpretation of implicative verbs, I illustrate my claims within the dynamics framework, and set aside for the moment the formal system of representation introduced in Chapter 2. Once I have established the key features of implicativity – and their causal underpinnings – I return in Chapter 4 to the standard interpretation system. Ultimately, in Chapter 5, I discuss one route towards integrating the two systems.

3.1 Managing, specifically and gener(ic)ally

The most prominent existing account of *manage* is due to Karttunen and Peters (1979). On their analysis, all that an implicative asserts is the truth of its complement. The impression of effort associated with *manage* is analyzed as a precondition of use, contributing to the not-at-issue dimension of meaning.

(3.8) **The 'direct assertion' account:** (Proposal; Karttunen and Peters, 1979).
For an agent S and a one-place predicate A, the claim that S *managed to* A:

i. *Asserts:* S did A ($A(S) = 1$)

ii. *Presupposes:* Doing A was effortful for S

A presuppositional diagnosis of the effort inference is supported by (3.9), which shows that the inference projects through negation in the matrix clause of a *manage* claim:[3]

[3]Karttunen and Peters (1979) actually propose that the not-at-issue content of implicative *manage* is an instance of *conventional implicature*. Since this material survives the 'family of sentences' tests, I am

(3.9) Juno did not **manage** to open the door.

Licenses: Opening the door was effortful for Juno.

It is immediately obvious that Proposal 3.8 derives both the complement entailment and the presumption of effort associated with *manage*. Before diving into a close examination of implicative verbs, then, I present some additional motivation – from the perspective of our investigation into actuality inferences – for rejecting the 'standard' Karttunen and Peters account.

This motivation comes, in a somewhat roundabout fashion, from Bhatt's explanation of the ability-*manage* connection. He accounts for the similarities between actualized ability and *managed to* in a very direct manner, proposing simply that these similarities follow from semantic equivalence at the lexical level. For Bhatt, *be able* and ability modals, represented uniformly as ABLE, are themselves implicative verbs, and in particular share the underlying semantics of *manage*. Since *manage* always entails its complement proposition, this proposal hard-codes complement entailment into the semantics of ABLE.

(3.10) **ABLE as an implicative:** (Proposal; Bhatt, 1999)

For some agent S and a one-place predicate A, the claim that S ABLE A:

i. *Asserts:* S did A ($A(S) = 1$)

ii. *Presupposes:* Doing A was effortful for S

We can check that, as in the case of *manage*, the effort inference projects through negation of an ABLE claim:

(3.11) Juno **was** not **able** to open the door.

Licenses: Opening the door was effortful for Juno.

Proposal 3.10 achieves three desired results. First, it explains the close comparison between *manage* and actualized ability ascriptions. Second, in so doing, it derives the

inclined to classify it as presuppositional. A more thorough investigation of this issue is left for future work. I will refer to implicative 'presuppositions' throughout, but this can be taken to stand in for 'not-at-issue inferences' without consequences for the main analysis.

actuality entailments of perfectively-marked ability modals (instances of ABLE, for Bhatt). This follows directly from the asserted content in (3.10)-i, distinguishing Bhatt's proposal from subsequent accounts of actuality inferences, such as Hacquard's (2006), which aim instead to derive actuality in the composition of ability and aspect.

(1.7) a. **Boresa** na sikoso afto to trapezi, #ala δen to sikosa.
can.PST.PFV NA lift.NON-PST-PFV.1S this the table #but NEG it lift.IMPF
'I was able to lift this table, #but I didn't lift it.' Greek

b. Yusuf havaii-jahaaz uɽaa **sak-aa**, #lekin us-ne havaii-jahaaz nahĩĩ uɽaa-yii.
Yusuf air-ship fly can-PFV.MASC #but he-ERG air-ship NEG fly-PFV.FEM.
'Yusuf was able to fly the airplane, #but he didn't fly the airplane.' Hindi

(1.9b) *Marja **a pu** traverser le lac Nokomis à la nage, #mais elle ne l'a pas traversé.*
'Marja could-PFV swim across Lake Nokomis, #but she did not cross it.'
French

Second, by assigning the effort inference to presuppositional content, Proposal 3.10 predicts the aforementioned felicity contrast between (3.3a) and (3.3b):

(3.3) a. #/?A woman in Watertown **was able** to win 3 million dollars in the lottery yesterday.

b. After buying lottery tickets regularly for several years, a woman in Watertown **was** finally **able** to win 3 million dollars in the lottery yesterday.

In spite of these positive consequences, however, there are reasons to doubt that the semantics in Proposal 3.10 can be maintained.

As an analysis of ability modals like *boro, saknaa,* and *pouvoir* (examples 1.7a, 1.7b, and 1.9b, respectively), Bhatt's proposal diverges from the possible worlds semantics. If we assume – with good reason – that the premise semantics represents the right account of possibility modals on their non-abilitative construals, then adopting Proposal 3.10 forces us to accept that abilitative and non-abilitative uses of possibility modals do not involve the

same lexical item. This is, indeed, the position that Bhatt takes, insofar as he claims that ABLE is at base an implicative verb, and not an (ability) modal at all.

While this ambiguity is distinct from the 'did'/'had the ability' ambiguity, the objection raised in Chapter 1 to Thalberg's ambiguity is equally valid here.[4] In particular, the lexical split between ABLE and the possibility modal, like the 'did'/'had the ability' split, would require that the same ambiguity, involving a particular class of item, appears systematically across a wide range of languages. This remains less plausible than the type of account we are after, on which the cross-linguistic pattern of ability and actuality interpretations for possibility modals reflect (to some degree) a shared semantic core.

One possible way out of this conclusion – attempting to accommodate Proposal 3.10 in terms of the premise semantics for possibility – turns out to be a dead end. Since the possibility meaning (modal force) is fixed by the lexical entry for *can* and its counterparts, both the actuality entailment and the presumption of effort will need to be captured in terms of modal flavour – that is, by the choice of the conversational backgrounds relative to which possibility is evaluated. I do not see a way to do this. We can force an actuality entailment by requiring that ability claims invoke a totally realistic modal base: this guarantees that the domain of quantification for possibility includes only the evaluation world, which must then be the one in which the modal complement holds. There is no obvious reason that the interpretation of ability claims should be restricted in this way. Moreover, it does not seem possible to account for the effort presupposition in terms of conversational backgrounds.

Even if we set aside the question of ambiguity, Bhatt's proposal raises an obvious question: how do we account for non-implicative 'pure ability' interpretations of ABLE predicates? As we have seen, imperfectively-marked ability modals do not give rise to actuality entailments.

[4]Following Thalberg's suggestion leads to the conclusion that the abilitative construals of possibility modals are in themselves ambiguous ('[...] 'was able' sometimes means 'had the ability', and sometimes means 'did'." 1972; p.121), but does not necessarily divorce the pure ability cases from non-abilitative uses of the possibility modal. Bhatt's ambiguity does not split the abilitative meaning of possibility modals into two, but divorces ability modals from a unified group containing epistemic possibility modals, deontic possibility modals, and so on. On Bhatt's view, both actualized and pure ability interpretations can be derived from the *manage* semantics.

(3.12) *Jean pouvait s'enfuir, mais il ne s'est pas enfui.*
'Jean could-IMPF escape, but he didn't escape.'

We have already seen a version of Bhatt's explanation, in the previous chapter's discussion of Hacquard (2006). Specifically, Bhatt argues that non-entailing readings for *able* are generic readings.[5] On this view, the imperfective marker introduces a covert generic operator, which 'lifts' the hard-coded actuality entailment by quantifying over a set of normal worlds, to which the actual world need not belong.

The basic problem with this explanation is that, once the lexical semantics of ABLE has been identified with the lexical semantics of *manage/réussir*, then we expect compositional processes to affect both predicates in the same way. If covert GEN produces non-entailing readings for ABLE, then it should do the same for *manage*. Thus, Bhatt's proposal predicts the availability of non-entailing interpretations for implicatives, and in particular for *réussir*, under imperfective marking. But – as already established – no such interpretations exist.

(2.44a) *Jean **réussissait** à s'enfuir, #mais il ne s'est pas enfui.*
'Jean managed-IMPF to escape, #but he did not escape.'

[5]Bhatt justifies the localization of non-actualized interpretations to generic readings on the basis of Hindi data. Imperfectively-marked *saknaa*, like imperfectively-marked *pouvoir*, fails to entail the realization of its complement.

(1.8b) Yusuf havaii-jahaaz uɽaa **sak-taa** thaa, lekin vo havaii-jahaaz nahĩĩ
Yusuf air-ship fly can-IMPF.MASC be.PST.MASC, but 3SG air-ship NEG
uɽaa-taa thaa.
fly-PFV.MASC be.PST.MASC.
'Yusuf was able to fly airplanes, but he didn't fly airplanes.'

In Hindi, the imperfective marking is only compatible with a generic or habitual reading, and not with a progressive interpretation (which is possible for the imperfective in Greek, French, and a number of other languages). For Bhatt, this indicates that the generic imperfective is implicated in the absence of actuality entailments.

It turns out that the dedicated progressive marker in Hindi is altogether incompatible with an ability modal.

(i) *Yusuf havaii-jahaaz uɽaa **sak** rah-aa thaa.
Yusuf air-ship fly can PROG-MASC be.PST.MASC.
Intended: 'Yusuf was being able to fly airplanes.'

If we assume that (i) is reflective of the situation in other languages – that is, that progressive interpretations cannot be generated for ability modals in any language – then we conclude, as Bhatt does, that the generic/habitual imperfective must be solely responsible for the absence of an actuality entailment.

We have the same problem for *manage*, as compared to *be able*: despite the shared effort and complement inferences, the overall inferential patterns of these two predicates are not as well-matched as Proposal 3.10 predicts. Episodic contexts like (3.13a) favour the actualized interpretation for *was able*. However, (3.13b) shows that, with the right contextual support, the realization of the ability-complement is felicitously denied, and so cannot be classified as an entailment.

(3.13) a. This morning, Popeye was able to lift a fridge.

$\rightsquigarrow$ *Popeye lifted a fridge this morning.*

b. Due to a sudden increase in strength from eating spinach this morning, Popeye was able to lift a fridge, but he used his strength to hurl rocks instead.

$\not\rightsquigarrow$ *Popeye lifted a fridge this morning.*

On Bhatt's analysis, we might explain the inferential contrast in (3.13) by arguing that (3.13b) incorporates a covert generic, where (3.13a) does not. Again, however, since the semantic contribution of *be able* is taken to be precisely that of *manage*, we should expect to replicate the contrast with *manage*. (3.14) shows that we cannot.

(3.14) a. This morning, Popeye managed to lift a fridge.

$\vdash$ *Popeye lifted a fridge this morning.*

b. Due to a sudden increase in strength from eating spinach this morning, Popeye managed to lift a fridge, #but he used his strength to hurl rocks instead.

The contrast between *be able* and ability modals, on the one hand, and implicatives like *manage* and *réussir*, on the other, constitutes strong evidence against an account which equates the lexical semantics of the predicate ABLE with the standard Karttunen and Peters account of *manage*. Indeed, the data in (3.12)-(3.14) argue against any account of actuality inferences on which the ability-attributing predicates which license them are taken to be underlyingly implicative.

This leaves us in a tricky position. It appears that Proposal 3.10 is not tenable, but the comparison Bhatt observes between actualized ability ascriptions and *managed to* claims

remains striking, all the more so because it encompasses both entailed and not-at-issue content. Any account of actuality inferences will need to provide an explanation of this parallel.

In pursuing an account of implicative verbs, I take the view that the similarities noted by Bhatt are not just a matter of coincidence, but reflect a real point of contact between actuality entailments and implicative entailments. On this view, the problems with Bhatt's account ultimately pose a challenge to Karttunen and Peters's semantics for *manage* (Proposal 3.8), for the following reason.

If *manage* simply asserts the realization of its complement, then there is no way to 'break down' an implicative entailment into its component properties: no such component properties exist, and there is no way in which they might be distributed across ability and aspect in a compositional derivation. Thus, if the direct-assertion account is the correct analysis of *manage*, the only way for us to analyze actuality entailments as instances of implicative behaviour is the route taken by Bhatt. Since this route is untenable, there is only one other possibility: the complement entailment properties of implicative verbs are not hard-coded, but instead follow as a logical consequence of the meaning that an implicative actually encodes. This gives us a top-level answer to the question of how actuality inferences are drawn in the process of interpretation. The remainder of this chapter is devoted to establishing the lexical semantics that induces the particular calculation in which we are interested.

3.2 Assertion and presupposition in implicative meaning

Cross-linguistically, implicative verbs can be identified by their inferential profile. As shown in (3.15)-(3.16), *manage*, *dare*, and their Finnish counterparts (*onnistua* and *uskaltaa*, respectively) all generate entailments to the truth of their complements.

(3.15) English implicative entailments:

a. Morgan **managed** to solve the riddle. ⊢ *Morgan solved the riddle.*

b. Ana **dared** to enter the cave. ⊢ *Ana entered the cave.*

(3.16) Finnish implicative entailments:

a. Jean **onnistu-i** kuitenkin pakenema-an.
Jean succeed-PST.3SG however flee-INF.ILL
'Jean managed to flee.' ⊢ *Jean fled.*

b. 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.*

As Karttunen (1971) points out, these verbs can be distinguished from *factives*, which also license inferences about the truth of their complements, by their behaviour under negation. Factive verbs like *know* and *regret* presuppose the truth of their complements, and thus factive complement inferences project unchanged through matrix negation.

(3.17) Factive complement inferences:

a. Sarah knew that Juno opened the door. → *Juno opened the door.*

b. Sarah did not know that Juno opened the door. → *Juno opened the door.*

By contrast, negating an implicative verb reverses the polarity of the complement inference as well:

(3.18) English implicatives under negation:

a. Morgan did not **manage** to solve the riddle.
⊢ *Morgan did not solve the riddle.*

b. Ana did not **dare** to enter the cave. ⊢ *Ana did not enter the cave.*

(3.19) Finnish implicatives under negation:

a. Jean e-i **onnistu-nut** kuitenkaan pakenema-an.
Jean NEG-3SG succeed-SG.PP however flee-INF.ILL
'Jean did not manage to flee.' ⊢ *Jean did not flee.*

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.*

The two-way entailment pattern established by (3.15)-(3.16) and (3.18)-(3.19) sets up an interesting puzzle. Let I represent an arbitrary implicative verb, S its subject, and A its complement. Then, indicating the full proposition represented by the implicative complement as $A(S)$, we have the following relationships:

$$\text{(i)} \quad I(S, A) \vdash A(S)$$

$$\text{(ii)} \quad \neg I(S, A) \vdash \neg A(S)$$

In logical terms, entailment (ii) is the converse of entailment (i). Taken together, then, (i)-(ii) suggest that an implicative assertion and its complement are mutually entailing. This should give us the equivalence relation in (iii).

$$\text{(iii)} \quad I(S, A) \equiv A(S)$$

While entailments (i) and (ii) hold for *manage, dare* and their Finnish counterparts, (iii) does not. An implicative assertion is simply not interchangeable with the assertion of its complement proposition. The challenge for an analysis of implicatives, then, is to capture (i) and (ii) in a compositional manner, while avoiding the "intuitively unacceptable conclusion" in (iii) – that an implicative assertion is indistinguishable from the assertion of its complement (Karttunen, 1971, p.343).

3.2.1 Prerequisites and obstacles in implicative verbs

Karttunen's suggestion, which has been widely adopted, is that equivalence between an implicative assertion and its complement is blocked by presuppositional content associated with the implicative verb. The idea is that verbs like *manage* and *dare* place certain requirements or preconditions on a context of utterance. 'Bare' assertions of the implicative complements do not impose the same restrictions, meaning that these assertions of these propositions will often be felicitous in contexts which preclude the use of a full implicative statement. As a result, the use of an implicative verb is expected to have certain discourse effects, and in particular will license inferences about the utterance context that do not follow from the assertion of the complement alone.

This approach to the implicative puzzle appears promising. We have already seen evidence that *manage* imposes restrictions on its context of utterance, in particular presupposing that the realization of its complement required effort on the part of the sentential subject. This is reiterated in (3.20).

(3.20) Morgan **managed** to solve the riddle.

a. *Entails:* Morgan solved the riddle.

b. *Presupposes:* It required effort for Morgan to solve the riddle.

Similar sorts of 'requirement' inferences arise alongside the characteristic entailments of other English and Finnish implicatives.[6]

(3.21) English:

a. ᵞTempting fate, I **dared** to open an umbrella indoors.

⊢ *I opened an umbrella indoors.*

b. ᵞ[. . .] Mr. Sinha **condescended** to meet the tainted persons.

⊢ *Mr. Sinha met the tainted persons.*

(3.22) Finnish:

a. Hän e-i **viitsi-nyt** vastast-a.
he.NOM NEG-3SG bother-PP.SG answer-INF
'He didn't **bother** to answer.' ⊢ *He didn't answer.*

b. Marja e-i **iljen-nyt** katso-a.
Marja NEG-3SG bring.self-PP.SG look-INF
'Marja couldn't bring herself to look.' ⊢ *Marja didn't look.*

Dare in (3.21a) (as well as its Finnish counterpart *uskaltaa*; examples 3.16b and 3.19b), suggests that boldness or courage was required to realize the implicative complement; in (3.22a), *viitsia* ('bother') suggests that interest or engagement – an absence of apathy – was required from the subject. The use of *condescend* in (3.21b) suggests that meeting with 'the tainted persons' required Mr. Sinha to suppress or overcome some inherent disdain. Finally,

[6]Following a convention introduced in Horn (2010), I use the diacritic ᵞto indicate that a sentence was found on the internet. Sources for all naturally-occurring examples can be found in the appendix.

iljetä (roughly, 'bring-self') indicates that Marja had to overcome some internal shame or aversion in order to look.[7] Each of these implications projects through negation, as indicated for *dare* and *condescend* below:

(3.23) I did not **dare** to open an umbrella indoors.

a. *Entails:* I did not open an umbrella indoors.

b. *Licenses:* Opening an umbrella indoors required courage.

(3.24) Mr. Sinha did not **condescend** to meet with the tainted persons.

a. *Entails:* Mr. Sinha did not meet with the tainted persons.

b. *Licenses:* Mr. Sinha had to suppress disdain in order to meet with the tainted persons.

These implicative presuppositions are united by a common thread: in each case, they invoke some condition that plays a role in determining whether or not the sentential subject can realize the complement proposition. The precise content of this condition varies from verb to verb, but in each case establishes a *prerequisite*. In general, then, implicatives seem to presuppose the existence of some kind of difficulty or potential 'obstacle' for the realization of the implicative complement (see also Karttunen, 2014). As the range of meaning in (3.21)-(3.22) demonstrates, implicatives can vary widely in terms of what they lexicalize about the nature of an obstacle. Compared to implicatives like *dare*, *condescend*, *viitsia* ('bother'), and so on, *manage* (along with its Finnish counterpart *onnistua*; examples 3.16a and 3.19a) evidently represents something of a general case – the effort presupposition suggested by Karttunen and Peters can be interpreted as indicative of the presence of a potential obstacle, without providing any specification as to its nature.

Based on the evidence we have seen so far, I take the following to be the central facts about implicative verbs:

[7] According to L. Karttunen (p.c.), *iljetä* is a difficult verb to translate accurately. The sense of aversion or the baked-in notion that the implicative complement is something that one would need to 'bring oneself' to do is imported from the speaker's perspective, and does not necessarily reflect the attitude of the subject towards the complement event.

(A) An assertion $I(S, A)$ conditions $A(S)$ on S's overcoming some potential obstacle. (This will ultimately block entailment from $A(S)$ to $I(S, A)$.)

(B) Given both (i) $I(S, A) \vdash A(S)$ and (ii) $\neg I(S, A) \vdash \neg A(S)$, surmounting the obstacle must be both sufficient and necessary for $A(S)$ in context.

(C) An assertion of $I(S, A)$ non-defeasibly conveys $A(S)$; its negation, $\neg I(S, A)$, conveys $\neg A(S)$

In developing an account of implicative verbs, the task is to determine what division of labour between at-issue and not-at-issue content will capture the above facts.

3.2.2 The 'direct assertion' account

As we have seen, Karttunen and Peters (1979) aim to capture Fact (C) by making the at-issue content of an implicative utterance $I(S, A)$ equivalent to that of its (reconstructed) complement, $A(S)$. This move takes its justification from Karttunen's observation that "all that takes place when John *manages to do* something is that he does it [...] *managing to do* is inseparable in time and space from *doing*; it is the same event" (1971; pp.349–350),[8] I repeat the proposal here.

(3.8) **The 'direct assertion' account:** (Proposal; Karttunen and Peters, 1979). For an agent S and a one-place predicate A, the claim that S *managed to* A:

i. *Asserts:* S did A ($A(S) = 1$)

ii. *Presupposes:* Doing A was effortful for S

On Proposal 3.8, the not-at-issue content of *manage* is taken to be the presumption that the *manage*-complement required effort. We have already seen evidence supporting this

[8] It is not difficult to see why this might suggest that $manage(S, A)$ and its complement are assertorically equivalent, but it is not at all clear that Karttunen himself takes this view in the 1971 paper. He goes on to say that an "affirmative assertion [of an implicative] states, according to the speaker's supposition, that a sufficient condition for the truth of the complement is fulfilled," and that a "negative assertion claims that a necessary condition for the truth of the complement is not fulfilled [...]" (p.352), which indicates instead that he takes the truth or falsity of $A(S)$ to follow as a conclusion on the basis of the main implicative statement, rather than being literally contained within it. This view aligns well with the account I develop here.

proposal, including that the effort inference projects through matrix negation. Karttunen and Peters additionally test the not-at-issue status of an effort requirement by embedding a *manage* claim under the presupposition 'hole' *discover* (Karttunen, 1973). In (3.25), the embedding verb applies to the complement entailment, but does not transfer to the presumption of effort: someone uttering (3.25) is committed to (3.25a), but not to (3.25b). The proposed presupposition of effort instead survives intact, *sans* any modification.

(3.25) 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 required effort for Solomon.

c. *Licenses:* Building the temple required effort for Solomon.

A problem for direct assertion

In Section 3.1, I suggested that the close comparison between *manage* and actualized ability observed by Bhatt gives us a reason to question the 'direct assertion' component of Karttunen and Peters's proposal. Another problem created by the proposed assertion in Proposal 3.8-i has to do with the interaction between an implicative verb and adverbial modifiers. Karttunen (1971) shows that temporal modifiers attached to the main implicative claim seem to be 'inherited' by the complement proposition.

(3.26) Yesterday, Morgan **managed** to solve the problem.

$\vdash$ *Yesterday, Morgan solved the problem.*

The same thing happens with locative modifiers:

(3.27) At the door, Juri finally **managed** to apologize.

$\vdash$ *At the door, Juri finally apologized.*

The facts in (3.26) and (3.27) are consistent with the hypothesis that *manage* simply asserts its complement proposition, since we expect the temporal and locative adverbials in these examples to modify asserted content.

The problem arises when we consider a specific type of modifier: clauses introduced by *because*. Karttunen points out that modifying an implicative claim with a *because*-clause does not produce the same results as modifying the claim with a temporal or locative adverbial. Instead, there is a contrast in the way that *because*-clauses are interpreted when they attach to an implicative statement versus directly to the complement proposition.

(3.28) a. Juno **managed** to open the door because it was unlocked.

b. Juno opened the door because it was unlocked.

In (3.28a), the *because*-clause is most naturally interpreted as explanatory, in the sense that it indicates how or why Juno was able to open the door. Linking this to the notion of implicative obstacles, the *because*-clause seems to indicate how it came about that the potential obstacle (presumably the door's potential to be locked) was circumvented. In (3.28b), on the other hand, the same clause appears instead to provide information about Juno's motivation for opening the door – suggesting, for instance, that her action was guided by a tendency towards idle curiousity. While the explanatory reading may be (very marginally) available in (3.28b), the motivational interpretation is ruled out in (3.28a).

This is unexpected on a direct assertion account. If *manage* and its complement make identical at-issue contributions, then we expect the full implicative claim and the complement claim to behave the same way under any operation that modifies asserted content. The simplest explanation for the contrast in (3.28) is that either the implicative or its complement contributes something to at-issue content that the other does not.

Malleable presuppositions

The other half of Karttunen and Peters's proposal – the presupposition of effort – also turns out to be problematic. The effort inference readily arises from an example like (3.29), and moreover behaves in the expected manner for not-at-issue content. However, it is not the only inference that has this sort of relationship with *manage* claims. For instance, Givón (1973) suggests that *manage* presupposes that its subject tried, or made an "active attempt" to bring about the complement proposition. A similar, but slightly weaker, inference is that

the subject of a *manage* claim intended to bring about the complement. Both of these seem to be reasonable proposals:

(3.29) 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.

To make matters worse, Coleman (1975) observes that there are perfectly good uses of *manage* which fail to background either effort or intention:

(3.30) 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 German exam.

(3.30a) explicitly denies that Harry made an attempt to insult Ursula – and, accordingly, suggests that it did not take effort for him to do so. (3.30b) is perfectly compatible with an interpretation on which the dog does not have the intention of waking Harry up, and in (3.30c), it need not be the case that the neighbors intended to cause me problems, nor that it took any particular effort from them to schedule their party on the night they chose.

To explain what is going on in (3.30), Coleman suggests that, in each case, the "vanishing" effort or intention presuppositions are supplanted by something weaker – specifically, the inference that realizing the complement was *a priori* unlikely. Her idea is that the presuppositional contribution of *manage* varies in a systematic manner between the three options spelled out in (3.31): intention, effort/difficulty, and unlikelihood.

(3.31) 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, the variation is governed by a strength ordering among (3.31a)-(3.31c), with intention representing the strongest possible presupposition, followed by effort, and last by unlikelihood. In any given context, the strongest tenable presupposition is expected to hold, subsuming the weaker ones. For an example like (3.30a), where intention is denied, we next check for effort or difficulty.[9] If the context also fails to support the presumption of effort, then it must support unlikelihood. On this account, *manage* is predicted to be infelicitous in case – and only in case – unlikelihood (the weakest possible presupposition) fails.

This proposal seems to work for the examples we have so far seen, but recent work by Baglini and Francez (2016) shows that a strength-based hierarchy cannot explain the malleability of *manage*'s not-at-issue content in the general case. It is crucial for Coleman's proposal that the validity of a stronger presupposition necessitates the validity weaker ones. Against this requirement, Baglini and Francez provide a range of naturally-occurring examples which illustrate the acceptability of *manage* in contexts where any one of the intention, effort, or unlikelihood conditions is supported, but the others are precluded.[10] The examples in (3.32) illustrate this point: in each case, one or more of the proposed presuppositions is ruled out, but the other(s) are left intact.

(3.32) a. #Without intending to, Ms. Streisand actually managed to synthesize the problem of diversity mania.

$\not\rightsquigarrow$ intention, $\not\rightsquigarrow$ difficulty, $\rightsquigarrow$ unlikelihood

[9] While the majority of her discussion is focused on *manage*, Coleman also argues that implicatives like *happen* and *fail* also invoke strength-ordered presuppositional content. This type of presupposition, on her view, is to be seen, along with complement entailment, as a feature of the implicative class.

[10] Examples (i)-(ii) are from Baglini and Francez (2016): (i) explicitly denies difficulty, but nevertheless presumes effort, and (ii) denies any unexpectedness, but again leaves effort or intention untouched.

(i) Clad in civilian clothes and having passports, they easily **managed** to get back over the Volga.

(ii) Now it's becoming obvious that Fork will **manage** to kill someone important.

b. #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.

$\rightsquigarrow$ intention, $\not\rightsquigarrow$ difficulty, ? $\rightsquigarrow$ unlikelihood

c. #The social democrats (Socialdemokratiet) managed to strengthen their position as Denmark's strongest political force as expected during local elections.

$\rightsquigarrow$ intention, ? $\rightsquigarrow$ difficulty, $\not\rightsquigarrow$ unlikelihood

Ultimately, then, while it seems clear that *manage* places some restrictions or preconditions on its utterance context, it is not at all clear what unites these restrictions from case to case, if indeed they can be captured and described in a unified manner. At the very least, however, it is clear that the presupposition of effort set out on the direct assertion account of *manage* will not be equal to the task.

3.2.3 An alternative approach

The discussion in Section 3.2.2 suggests that we will need to look beyond Karttunen and Peters's proposal to fully capture the implications of *manage*. Baglini and Francez's (2016) recent proposal offers a different way of dividing up the asserted and presuppositional content of an implicative.

Baglini and Francez argue that the apparently capricious behaviour of *manage*'s presuppositions indicates that the not-at-issue content of *manage* must be relatively abstract, in essence 'distilling' the intention, effort, and unlikelihood conditions down to some content that they have in common. Moreover, since examples like the ones in (3.30) and (3.32) show that context affects the way in which *manage*'s presuppositional content is interpreted, the more abstract presupposition must, in some way, be subject to input from the discourse context.

Baglini and Francez also discuss the *because*-clause contrast illustrated in (3.28). They arrive at the same conclusion as we did above: the *because* contrast shows that the at-issue content of a *manage* statement differs non-trivially from the content of its complement.

This means that the complement entailments which characterize implicative verbs cannot arise directly as asserted content, but instead must follow in some process of reasoning from the meaning of a *manage* claim. In other words, where the direct assertion account simply stipulates Fact (C), the account developed by Baglini and Francez will instead need to derive this fact.

The central insight behind Baglini and Francez's proposal is that the relationship between an implicative and its complement is one of **causal dependence**. The idea, roughly, is this: if the realization of an implicative complement is derived as a causal consequence of the main assertion, we have a way of differentiating the at-issue content of the implicative and complement propositions, as desired, while maintaining a straightforward explanation for the characteristic entailment patterns. On this approach, the not-at-issue contribution of *manage* will simply be to background the existence of the relevant causal relationship; since different contexts will supply different ways of fleshing out the basic relationship, we expect the precise content of *manage*'s 'presupposition' to vary from one case to another. Baglini and Francez's proposal is given below:

(3.33) **The catalyst account:** (Proposal; Baglini and Francez, 2016)

For an agent S and one-place predicate A, the claim that S *managed to* A:

i. *Presupposes:* The familiarity (salience and truth) of a **catalyst**, or *causally necessary but causally insufficient situation*, for the truth of $A(S)$

ii. *Asserts:* The catalyst **actually caused** $A(S)$

The asserted relation of *actual cause* will, presumably, derive the desired complement entailments. Even better, the notion of a causally necessary but causally insufficient catalyst seems, at least at first glance, to capture the idea that implicatives invoke the existence of some sort of obstacle for the realization of their complements. In particular, each of the implicative verbs discussed in Section 3.2.1 indicates that there is particular requirement for overcoming this obstacle. This notion of a prerequisite is realized in Proposal 3.33 as the causal necessity of the catalyst for the implicative complement. Roughly speaking, then, it

seems as if an implicative like *dare* or *viitsia* ('bother') will impose specific features on a backgrounded catalyst; *manage* represents a more general case.

The real weight of Proposal 3.33 lies in the precise formulations of the three causal dependence relations: causal necessity, causal sufficiency, and actual cause. In order to check that our intuitions about the catalyst account are borne out, and to investigate any further consequences of this analysis, we will first need to see how these relations are cashed out. Baglini and Francez formalize their proposal in terms of the **causal dynamics** framework of Schulz (2007, 2011), which I now discuss.

3.3 Modeling causal dependencies

In this section, I take a step back from the main plot of the chapter, and introduce in some detail the causal framework in which we will formalize the specific dependency relations in which we are interested. Schulz's causal dynamics belongs to the class of *interventionist* or *structural equation* causal models, and is largely based on the model developed by Pearl (2000). Structural equation models are not the only available option for representing causal networks, nor the only type of model which can support a pluralist approach to causation as it is encoded in semantics and grammatical structure.[11] As far as I am aware, nothing hinges on the use of a particular framework for representing causal information, and my choice to work with Schulz's dynamics is motivated primarily by a desire for continuity with existing research. In this dissertation, my aim is simply to establish that the types of relationships that can be formally articulated in a causal model are explanatory and predictive with respect to the lexical semantics of implicative verbs (and ultimately, of ability predicates). I leave it for future research to compare and contrast the consequences of particular modeling choices.[12]

[11] In this context, a pluralist approach is one which argues that language draws on a set of basic and contrasting causal relations – such as causal necessity and causal sufficiency – rather than a single concept of causal dependence, as in the work of Dowty (1979). The *force dynamics* approach to causation, introduced by Talmy (1988), and developed by Phillip Wolff and colleagues (Wolff and Song, 2003; Wolff, 2007; Wolff et al., 2010a,b), is one prominent example of a pluralist approach to causation.

[12] For some experimental work in this area, see Wolff and Song (2003); Sloman et al. (2009) and Livengood and Rose (2016).

3.3.1 Preliminary remarks

The notions of causal necessity and causal sufficiency we define in the causal framework are not reducible to the more familiar alethic relations of logical necessity and sufficiency, nor identifiable with metaphysical variants of these relations. Specifically, causal necessity will not be equated with counterfactual necessity (*à la* Lewis 1973), and causal sufficiency will not be equated with *metaphysical* settledness (truth in all possible courses of events). The challenges associated with defining causation in terms of counterfactual dependence are well known from the philosophical literature (see Menzies 2017, Paul and Hall 2013, Sosa and Tooley 1993, and references therein). These include the problems posed by a range of so-called 'pre-emption' scenarios, in which counterfactual dependence fails to hold between two facts or events C and E, but C is nevertheless judged to be a cause (or even *the* cause) of E.[13] In a similar vein, a causal sufficiency relation defined in terms of metaphysical settledness would be much too strong. Intuitively, if an event C was causally sufficient for another event E, we can think of C as the occurrence which *guaranteed* that E would occur, given the actual way in which other events in the world unfolded. This is a strictly weaker notion than metaphysical settledness, in that we only need to make reference to a particular subset of all of the possible courses of events.

In defining causal necessity and causal sufficiency, then, a first task is to characterize the set of courses of events that are taken into account in interpreting causal claims. Intuitively, these are the courses of events in which the world proceeds 'as expected,' based on what is known at evaluation time, both about the state of the world (i.e. what facts are established), and what is known about the (typical) causal consequences of this state. In

[13] One variant of a frequently-discussed pre-emption scenario is as follows:

(i) Billy and Suzy throw rocks at a bottle. Suzy throws slightly before Billy, so her rock gets there first and shatters the bottle. If Suzy's throw had not hit the bottle, Billy's throw would have shattered it, so the bottle would have shattered regardless of Suzy's action. However, Suzy's throw is felt to be the cause of the bottle's shattering, while Billy's throw is not.

I will not have anything further to say about pre-emption, but various authors, including Hall (2004), Paul and Hall (2013), Copley and Wolff (2014) examine how causal modeling approaches can deal with the problems such scenarios raise for theories of causation which attempt to work solely with counterfactual necessity in the standard logical sense.

order to evaluate causal statements, then, we will need three things: a context or set of facts about the evaluation world, a means of representing or encoding knowledge about causal relationships in the world, and a mechanism for applying the latter to the former to work out the predictable (causal) consequences.

Such a representation of causal information, both generalized and situation-specific, is what I mean in referring to a **causal model**. I take such a model to have as its basic components propositions (which represent events, anchored to specific times and worlds), and causal links: it is a network of (one-way) links between propositions, in which a link represents the information that the proposition at which it originates is causally relevant for the proposition it points to. For current purposes, a causal link is an atomic concept, which is not further decomposable. In drawing on a causal model to define elements of lexical semantic representation, I take this type of network to be part of a language user's knowledge about the world. In the type of system outlined here, the causal relations encoded by specific lexical items are neither themselves unanalyzable, nor defined in terms of logical relationships, but instead pick out certain structural configurations over a network of (unanalyzable) causal-relevance links. In other words, causal necessity and causal sufficiency (and other potential causal dependence relations) are simply concise labels for structural configurations in a complex causal network.

3.3.2 Dynamics for causal entailment

Consider the following example, due to Lifschitz (1990):

(3.34) **The circuit example.**

a. Suppose there is a circuit with two switches and one lightbulb, such that the light comes on just in case both switches are in the same position (either both up or both down).

b. At the moment, both switches are up.

(3.34) contains two kinds of information. (3.34a) sets out the 'rules' of the system – that is, a set of cause-and-effect relations that are known to obtain between relevant facts. (3.34b)

describes a particular context in which the causal laws in (3.34a) may come into effect, by settling or fixing certain of the relevant facts.

Crucially, the situation described in (3.34b) does not fix all of the facts of the circuit system: it tells us the position of the switches, but does not inform us about the state of the light (perhaps the switches are in one room, where we can observe them, but the bulb is in another, and is out of view). A *situation* in this sense is a part or a partial description of a world:[14] in a possible-worlds setting, it corresponds to a set of one or more worlds. Based on the set of relevant facts in (3.34), the situation in (3.34b) picks out two possible worlds: one in which (3.34b) holds and the light (when we go to check on it) turns out to be on, and another in which (3.34b) holds, but the light turns out to be off.

Intuitively, of course, only one of these two worlds is a reasonable possibility. This follows from what we know about causation in the circuit system: if the information provided in (3.34a) is correct and complete, we expect that the light will be on. A world in which (3.34b) holds but the light is off violates the causal laws as we know them: since this is an abnormal outcome, it typically will not figure into our reasoning about causal consequences. More generally, once we have established a set of causal laws, we expect that events in the (actual) world will unfold in accordance with these laws. Causal laws, thus allow us to work out what the expected or *normal causal developments* of a particular situation will be. This is an extremely natural – and extremely familiar – way to reason about the world.

Of course, we might well walk into the other room to check on the state of the light, and find, contrary to expectation, that it is off. This might be explained by any number of eventualities which are not accounted for in (3.34): for instance, the circuit may have shorted, or the bulb may have burned out. The fact that contingencies like these are not included in (3.34) reflects the assumption that they are unexpected or unusual events, which have not been taken into account in the context that is taken to be relevant with respect to (3.34b).

Reasoning about normal causal developments, then, is a form of closed-world reasoning

[14]This view of situations appears in a variety of treatments of situation semantics, including Barwise and Perry (1981) and Kratzer (1989, et seq).

(Reiter, 1978). The implicit assumption in the Lifschitz example and other similar scenarios is that what you see is what you get: the facts represented or made salient by a discourse context comprise all of the relevant ones, and what happens in the course of normal causal developments (and in the actual world, which we assume to be causally normal) will depend only on this information. Put another way, the normality assumption is equivalent to the assumption that our model of causality is complete and contains all of the relevant information. Causal inference is thus inherently defeasible, but in a particular, self-correcting way. If we find that the actual world violates a causal law, we do not usually throw up our hands and conclude that the causal laws have broken down. Instead, we infer that some relevant information is missing from our model, and may then go on to revise the set of relevant facts and/or laws to take account of new information.[15] For example, if we discover that the light in (3.34) is off, and work out that this is due to the presence of a master switch that we were previously unaware of, we will update our model of the situation: any subsequent communication or reasoning about the circuit system will include this update.

The formal system

The causal **dynamics** is a framework for representing causal information of the sort provided in (3.34), and in which causal consequences (or normal causal developments) can be formally computed. Within this framework, Schulz defines a central notion of **causal entailment**, which I use in turn to define notions of **causal necessity** and **causal sufficiency**. This is similar to the way in which logical necessity and sufficiency are built from the standard notion of logical entailment or consequence.

A dynamics encodes what we know about causal structure and causal relationships with respect to a (closed) system, or a finite set of salient propositions P. As we have seen, this type of representation can be manipulated and updated as time (or a discourse) progresses.

[15] Certain formal systems for representing causal knowledge build this defeasibility into the model, for instance, by means of a generalized 'abnormality' predicate $\mathbf{AB}$ (see, e.g., Hobbs, 2005). In such a system, if what we know is that events A and B (typically) jointly bring about event C, we can capture this by taking the conjunction of A, B, and $\neg\mathbf{AB}$ to be causally sufficient for C. If we find, looking at the world, that A and B occurred, but C did not, we will conclude that $\neg\mathbf{AB}$ is false and from there go on to reason about what abnormality may have arisen.

Thus, it can be thought of as a contextual parameter which keeps track of and responds to what is known, assumed, backgrounded, or overtly communicated about causal relationships. For example, discovering that the second switch in the Lifschitz circuit has become disconnected from the bulb will push us to revise our causal laws; similarly, if someone tells us that they have installed a master switch which overrides the two we know about, we will add at least one new proposition to the set P. Going forward, I treat a dynamics as a parameter which can be augmented, queried, and modified by (both at-issue and not-at-issue) discourse contributions, in the same way as other features of the context or the common ground (see also Baglini and Francez, 2016; Lauer and Nadathur, 2018, 2019).

We start from a (finite) set of proposition P and define a language:

Definition 3.1 (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 $\vee$.*

Given a finite set of propositions P, Schulz defines a **dynamics** for $\mathcal{L}_P$:

Definition 3.2 (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. $f_X : \{0,1\}^n \to \{0,1\}$ *is a two-valued truth function from n-tuples on $\{0,1\}$ to $\{0,1\}$*

F *is* rooted *in B.*

Background (or *exogenous*; Pearl 2000) variables represent propositions which are taken to be causally independent of any and all other propositions in P. The complement set I of *inner* or *endogenous* variables thus contains those propositions which depend causally on one another, and on the background variables. Definition (3.2) indicates that dependent variables are associated in $\mathcal{D}$ with a function that identifies their set of immediate causal ancestors (Z_X), as well as the nature of the direct dependencies. The requirement that this function F be *rooted* in B prevents cyclicity in causal dependencies, by ensuring that a 'backwards walk' through the causal ancestors of any variable always ends in B.

Definition 3.3 (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.*

For truth and falsity, Schulz works with the strong three-way Kleene logic, in which propositions are valued from $\{u, 0, 1\}$. The truth table for this logic is given in Table 3.1. A 0 or 1 (false or true) valuation of a proposition will be referred to as a **determination**, while a variable assigned the value of u is **undetermined**. The set of truth values is assigned a partial order $u \leq 0$, $u \leq 1$, to indicate that undetermined variables can evolve or grow into propositions that are either true or false. Based on this system, we define **worlds** and **situations** as suggested by the informal presentation above.

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 3.1: Strong three-valued logic

Definition 3.4 (Worlds and situations)**.** *For a language $\mathcal{L}_P$ over P:*

(a) A ***world*** *for $\mathcal{L}_P$ is any function $w : P \to \{0, 1\}$*

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

Thus, a situation is a three-way valuation of P, which may leave certain relevant propositions undetermined. Given a situation s, and the causal laws as represented in a dynamics $\mathcal{D}$ for $\mathcal{L}_P$, we would like to check whether the settled facts of s have any causal consequences

(in other words, we would like a method for calculating the normal causal developments of s).

To do this, Schulz defines an operator $\mathcal{T}_\mathcal{D}$ which 'runs' the dynamics for one step.

Definition 3.5 (Causal update)**.** *Let $\mathcal{D}$ be a dynamics, with s a situation. We define the situation $\mathcal{T}_\mathcal{D}(s)$ by:*

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

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

i. if $s(X) = u$ and $f_X(s(X_1), \ldots, s(X_n))$ is defined,
$\mathcal{T}_\mathcal{D}(s)(X) = f_X(s(X_1), \ldots, s(X_n))$

ii. if $s(X) \neq u$ or $f_X(s(X_1), \ldots, s(X_n))$ 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 necessarily exhaust the set of consequences of a given starting situation s, producing a *fixed point* (see Schulz 2011 for the proof of this claim). This result allows Schulz to define causal entailment as follows:

Definition 3.6 (Causal entailment)**.** *Let $\mathcal{D}$ be a dynamics. A situation s* ***causally entails*** *a proposition ϕ iff ϕ is true at the least fixed point s^* of $\mathcal{T}_\mathcal{D}$ relative to s:*

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

In other words, a situation s (which can, equivalently, be thought of as 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) causally entails a proposition ϕ if and only if the maximal normal causal development of s determines (assigns a 0-1 value to) ϕ.

Causal necessity and causal sufficiency

We are interested in the way in which – given a context of utterance or background situation – one fact or event is causally involved in bringing about another. In reality, causes do not act alone. Any claim that one event C brought about another event E will be evaluated with respect to a set of established facts: what we do when we evaluate causative claims is

consider whether adding the causing event to the set of background facts has a particular sort of consequence for the occurrence (or non-occurrence) of the relevant effect event E.[16] Thus, our first goal is to define relations of causal necessity and sufficiency that hold between two facts *relative* to a background situation.

Definition 3.7 (Facts in a dynamics)**.** *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 3.8 (Augmenting a situation with a fact)**.** *Given a situation s and a fact $\langle X, x \rangle$, the situation $s[X \mapsto x]$ is given by the situation s' which reassigns the value of X to x, but is otherwise identical to s.*

As I define it here, augmenting a situation with a fact overrides an existing determination of the relevant variable in s. For the most part we will be concerned with cases where s does not already contain a determination of the variable in question.

Definition 3.9 (Domain of a situation)**.** *For any situation s, the **domain** of s is given by*

$$\mathrm{dom}(s) = \{X \in P | s(x) \neq u\}$$

Finally, I define consistency relative to the causal structure:

Definition 3.10 (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 $X \in \mathrm{dom}(s)$, we have:*

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

[16] Essentially, to check whether C brought about E in some way, we first want to add the information that C occurred to the stock of background facts, and then compare the consequences of this to the consequences of the background facts alone. Conceptually, this is similar to the type of reasoning we perform in evaluating conditional statements according to the *Ramsey test* (Ramsey, 1931): given a statement of the form *If p, then q*, we first 'add' p to the established facts, and then check the status of q.

In other words, a situation is internally causally consistent if there is no inner variable whose determination 'breaks the rules' of $\mathcal{D}$ with respect to the other determined variables.

With this notions in hand, we can define the causal necessity and sufficiency of one fact for another relative to a situation. Causal sufficiency of a fact $\langle X, x\rangle$ for another fact $\langle Y, y\rangle$ reduces to causal entailment. Given a set of facts s, we want the causal necessity of $\langle X, x\rangle$ for $\langle Y, y\rangle$ to capture the idea that the only causally consistent paths going from s to $\langle Y, y\rangle$ involve (first) validating $\langle X, x\rangle$.

Definition 3.11 (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 $s \not\models_{\mathcal{D}} (X = x), s \not\models_{\mathcal{D}} (Y = y)$. Then:*

*(a) $\langle X, x\rangle$ is **causally sufficient** for $\langle Y, y\rangle$ relative to s ($\langle X, x\rangle \blacktriangleright_s \langle Y, y\rangle$) iff $s[X \mapsto x] \models_{\mathcal{D}} (Y = y)$:*

*(b) $\langle X, x\rangle$ is **causally necessary** for $\langle Y, y\rangle$ relative to s ($\langle X, x\rangle \blacktriangleleft_s \langle Y, y\rangle$) iff:*

i. there is a consistent supersituation s' of $s[X \mapsto x]$ such that $Y \notin \mathrm{dom}(s')$ and $s' \models_{\mathcal{D}} (Y = y)$

ii. there is no consistent supersituation s' of s such that $Y \notin \mathrm{dom}(s')$ and $s' \models_{\mathcal{D}} (Y = y)$ but $s' \not\models_{\mathcal{D}} (X = x)$

The similarity between Definition 3.11 and a counterfactual notion of necessity is evident; crucially, however, the necessity of one fact for another relative to a situation does not require that the negation of $\langle Y, y\rangle$ is (causally) entailed in case $\langle X, x\rangle$ is false or undetermined.

These definitions capture intuitive ideas about how necessity and sufficiency should work. Causal necessity 'opens up' the possibility of a particular outcome $\langle Y, y\rangle$, which can be thought of in the context of a dynamics as 'opening up' a causal pathway or pathways that may lead to $\langle Y, y\rangle$ without breaking any of the causal laws. However, causal necessity does not by itself ensure the realization of $\langle Y, y\rangle$, since it does not ensure the realization of a complete pathway to $\langle Y, y\rangle$. Causal sufficiency, on the other hand, guarantees the completion of a pathway to the effect in question, thus guaranteeing the effect as well.

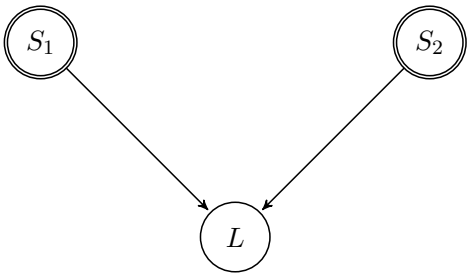
It is important to note that Definition 3.11 restricts the evaluation of causal necessity

and sufficiency relative to a situation to background situations which are not by themselves sufficient for either the causing fact or the effect. This is essential for reasonable definitions of these notions. 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). If we allow both facts to be entailed by the background situation, then any fact in a cause-entailing background situation will be sufficient for the effect, even if it is not a causal ancestor of the effect. If we allow only the effect to be entailed by the background situation, then any fact not entailed by the background situation will be sufficient for the effect, again regardless of its causal connections. In the case of causal necessity, the insufficiency of the background situation follows from the definition. If we allow the background situation to entail the cause, then in a real sense a causal pathway to $\langle Y, y\rangle$ was already open, and the cause was not by itself necessary.

I return to the circuit example (3.34) to illustrate how Definitions 3.11a-b work in practice. Figure 3.1 provides a graphical representation of the relevant dynamics.[17] The three nodes S_1, S_2, and L represent the three relevant propositions for the circuit system: S_1 encodes whether the first switch is up ($S_1 = 1$) or down ($S_1 = 0$), S_2 encodes whether the second switch is up or down, and L encodes whether the light is on ($L = 1$) or off ($L = 0$). The arrows represent causal links between propositions, with the direction of the arrow indicating the direction of causal influence: thus S_1 and S_2 are causal ancestors of L, but L is not a causal influencer of either of the other propositions. The truth table accompanying the graph specifies the causal laws as stated in (3.34a), by defining f_L: it tells us what the value of L is expected to be for any combination of valuations for S_1 and S_2. Note that we might also express f_L in terms of a logical equation, in this case $L := (S_1 \wedge S_2) \vee (\neg S_1 \wedge \neg S_2)$. In Figure 3.1 and other graphical representations, I indicate background variables with a double enclosing circle.

In place of (3.34b), let us consider a new background situation which fixes the position of the first switch as up, but leaves the state of the second switch and the light undetermined:

[17] As noted, the fact that the function F is rooted in B, as in Definition 3.3, prevents cyclicity in the causal dependencies. Consequently, the network of causal links over a set of propositions will always be represented by a *directed acyclic graph*.



$f_L =$

S_1	S_2	L
0	0	1
0	1	0
1	0	0
1	1	1

Figure 3.1: Graphical representation of the circuit example

$s = \{\langle S_1, 1\rangle, \langle S_2, u\rangle, \langle L, u\rangle\}$. Relative to s, the fact $\langle S_2, 1\rangle$ is both causally necessary and causally sufficient for $\langle L, 1\rangle$ – that is, setting the second switch to the up position is both causally necessary and causally sufficient for the light to be on:

(3.35) Given the background situation $s = \{\langle S_1, 1\rangle, \langle S_2, u\rangle \langle L, u\rangle\}$:

a. *Claim:*$\langle S_2, 1\rangle \blacktriangleright_s \langle L, 1\rangle$.

We show this by showing that $s[S_2 \mapsto 1] \models_{\mathcal{D}} (L = 1)$

1. $s[S_2 \mapsto 1] = \{\langle S_1, 1\rangle, \langle S_2, 1\rangle \langle L, u\rangle\}$
2. $s_1 = \mathcal{T}_{\mathcal{D}}(s[S_2 \mapsto 1]) = \{\langle S_1, 1\rangle, \langle S_2, 1\rangle \langle L, 1\rangle\}$
3. s_1 determines all of the relevant propositions, so s_1 is the least fixed point of s with respect to $\mathcal{T}_{\mathcal{D}}$; $s_1 \models_{\mathcal{D}} (L = 1)$.

Thus, $s[S_2 \mapsto 1] \models_{\mathcal{D}} (L = 1)$, and we have $\langle S_2, 1\rangle \blacktriangleright_s \langle L, 1\rangle$.

b. *Claim:* $\langle S_2, 1\rangle \blacktriangleleft_s \langle L, 1\rangle$.

1. Since $\langle S_2, 1\rangle \blacktriangleright_s \langle L, 1\rangle$, condition (i) is met.
2. For condition ii, we have two alternative situations to consider:

(a) $s' = \{\langle S_1, 1\rangle, \langle S_2, u\rangle, \langle L, u\rangle\}$

$\mathcal{T}_{\mathcal{D}}(s') = s'$, so s' is its own fixed point, and $s' \not\models_{\mathcal{D}} (L = 1)$.

(b) $s' = \{\langle S_1, 1\rangle, \langle S_2, 0\rangle, \langle L, u\rangle\}$

In this case, $\mathcal{T}_{\mathcal{D}}(s') = \{\langle S_1, 1\rangle, \langle S_2, 0\rangle, \langle L, 0\rangle\}$. This new situation

determines all available variables, so is its own fixed point, and $\mathcal{T}_{\mathcal{D}}(s') \not\models_{\mathcal{D}} (L = 1)$.

Thus, condition ii is satisfied

Both conditions for causal necessity are met, so $\langle S_2, 1\rangle \blacktriangleleft_s \langle L, 1\rangle$.

In light of Baglini and Francez's catalyst proposal, we are interested in two additional relations: causal necessity and causal sufficiency between situations and facts. Causal sufficiency is again straightforwardly defined on the basis of causal entailment, but causal necessity turns out to be somewhat less intuitive, since it requires considering the consequences of revising the valuations of (causally-relevant) facts from the established context.

Definition 3.12 (Causal ancestors)**.** *Let $\mathcal{D}$ be a dynamics for $\mathcal{L}_P$. Given a variable $X \in P - B$, the set A_X of **causal ancestors** of X is given by $A_X = \{Y \in P \mid R_F^T(X, Y)\}$.*

Definition 3.13 (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 $\langle X, x\rangle$ ($s \blacktriangleright \langle X, x\rangle$) iff $s \models_{\mathcal{D}} (X = x)$.*

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

i. $\mathrm{dom}(s) \cap A_X \subseteq \mathrm{dom}(s') \cap A_X$ *and*

ii. $\exists Y \in \mathrm{dom}(s) \cap A_X$ *with* $s(Y) \neq s'(Y)$ *and*

iii. $s'(X) \neq x$

we have $s' \not\models_{\mathcal{D}} (X = x)$.

A note on causal necessity

My focus in this chapter is on the idea that relations of causal necessity and causal sufficiency are of relevance to – and referenced by – the lexical semantics of natural language expressions, and in particular the lexical semantics of implicative verbs. Accordingly, I set aside a serious treatment of a number of issues associated with the semantics (and metaphysics) of *cause* (or CAUSE) and causal necessity; however, a few points regarding the modeling choices relevant for Definition 3.13 are nevertheless in order.

Although the definition of causal necessity for situations may not seem intuitive at first, it follows naturally from the process of formalizing common-sense intuitions about the meaning of necessity over the type of causal structures we deal with here.

Definition 3.14 (Realizability)**.** *Given a dynamics D with $X \in P - B$, a fact $\langle X, x\rangle$ is* ***causally realizable*** *if there is at least one situation s such that s is internally consistent,* $\mathrm{dom}(s) \neq \{X\}$*, and $s \models_{\mathcal{D}} (X = x)$. We call such a situation s a* ***causal route*** *to $\langle X, x\rangle$.*

Note that if $\langle X, x\rangle$ is not causally realizable, then D must be defined so that there is no 0-1 assignment $\vec{z}$ to Z_X such that $f_X(\vec{z}) = x$. In other words, f_X is the constant function at either 0 or 1. If $X = x$ is false regardless of the determinations of its causal ancestors, then it does not in any real sense depend on them. I will treat any dynamics permitting such an arrangement to be degenerate, and assume that, in any permissible dynamics, all inner variables are causally realizable.

Given a causally realizable fact $\langle X, x\rangle$ associated with an inner variable X, causal necessity should (intuitively) pick out facts that *must* hold in order for $\langle X, x\rangle$ to be realized. This follows by analogy with analytic necessity. Any causal route to $\langle X, x\rangle$ must 'go through' these facts. Since, by construction of a dynamics, we can freely vary the values of variables on which X does not depend (those in $P - A_X$), the facts under consideration are restricted to determinations of variables from A_X. In other words, the relevant facts are those determinations of variables in A_X which are causally entailed by the situation m_X, defined as the intersection of all causal routes m to $\langle X, x\rangle$. (Here, I define the intersection s of two situations s_1 and s_2 as the situation which contains all of the determinations that appear in both s_1 and s_2, and which assigns u to all other variables in P.)

Since the values of variables in $P - A_X$ do not affect the value of X, we are presented with a modeling choice. No determination outside of A_X will be entailed by *all* causal routes to $\langle X, x\rangle$ (that is, by m_X). One possibility would be to treat all situations which determine variables in $P - A_X$ as unnecessary for $\langle X, x\rangle$. This restriction, while in some respects reasonable, would mean that we cannot talk about necessity in any situation in which facts irrelevant to the effect under discussion are part of the background or common ground. In

practice however, we often describe such situations as necessary for some subsequent event, on the basis of the facts they contain which are relevant. This suggests that we would like a definition for necessity that extends beyond situations determined only on A_X. Concretely, I follow Baglini and Francez (2016) here in assuming that the presence of 'irrelevant' facts in a situation does not count towards the assessment of causal necessity.

These constraints lead to Definition 3.13. Let s be a situation which contains a fact $\langle Y, y\rangle$ with $Y \in A_X$ such that $m_X \not\models_{\mathcal{D}} \langle Y, y\rangle$. Then there is some causal route m to $\langle X, x\rangle$ such that $m \models_{\mathcal{D}} \neg\langle Y, y\rangle$. But, by Definition 3.14 (of causal routes), the existence of m guarantees the existence of another route, m', with $\neg\langle Y, y\rangle \in m'$. We can, therefore, 'flip' some set of determinations in s and arrive at a new situation s' (with $\mathrm{dom}(s) \cap A_X \subseteq \mathrm{dom}(s') \cap A_X$) such that $s' = m'$; by definition, $s' = m' \models_{\mathcal{D}} (X = x)$. Conversely, if s only contains determinations of A_X that are entailed by m_X, then every causal route to $\langle X, x\rangle$ entails these determinations, and there is no situation s' with $s' \models_{\mathcal{D}} (X = x)$ which entails (or contains) the negation of one of these determinations.

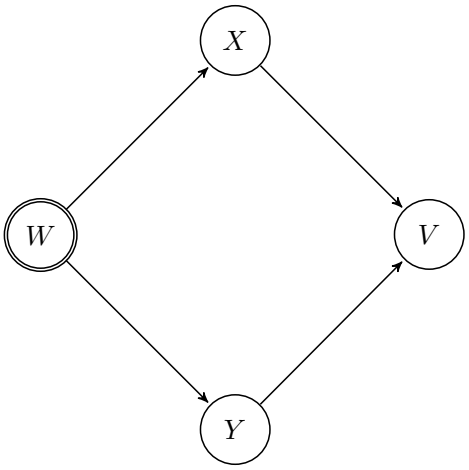
This definition has several positive consequences:

Fact 3.15. *If a situation s is such that $s \models_{\mathcal{D}} \neg(X = x)$, s is not necessary for $\langle X, x\rangle$.*

Proof. Suppose $x = 1$. If $s \models_{\mathcal{D}} \neg(X = 0)$, then s entails (pointwise) a vector $\vec{z}$ of values for the variables in Z_X such that $f_X(\vec{z}) = 0$. Since $\langle X, 1\rangle$ is causally realizable, there is at least one vector $\vec{z}_1$ such that $f_Z(\vec{z}_1) = 1$, with $\vec{z}_1 \neq \vec{z}$. If s determines all of the variables in Z_X, then let $s' = s[Z_X \mapsto \vec{z}_1]$; $s' \models_{\mathcal{D}} (X = 1)$, and s is not necessary for $\langle X = 1\rangle$. If s does not determine all of Z_X, then $\exists Y \in A_X$ such that s determines Y; let $\langle Y, y\rangle$ represent this determination. Then define the alternative situation $s' = s[Y \mapsto \neg y][Z_X \mapsto \vec{z}_1]$: $\mathrm{dom}(s') \cap A_X \supseteq \mathrm{dom}(s) \cap A_X$ and $s' \models_{\mathcal{D}} (X = 1)$. The proof for the case where $x = 0$ follows by symmetry. □

In a special set of cases, where $\langle X, x\rangle$ is causally but not consistently realizable, the predictions made by Definition 3.13 accord with intuition. A toy example illustrates:

(3.36) Consider a dynamics $\mathcal{D}$ as in Figure 3.2. Any internally consistent valuation of P has $V = 0$, since $V = X \wedge Y$, but $X = W$ and $Y = \neg W$. By Definition 3.13, the



$f_X =$

W	X
0	0
1	1

$f_Y =$

W	Y
0	1
1	0

$f_V =$

X	Y	V
0	0	0
0	1	0
1	0	0
1	1	1

Figure 3.2: A toy dynamics where X is not consistently realizable

following three situations are necessary for $\langle V, 1\rangle$:

$$s_{X,u} = \{\langle W, u\rangle, \langle X, 1\rangle, \langle Y, u\rangle, \langle V, u\rangle\}$$
$$s_{X,0} = \{\langle W, 0\rangle, \langle X, 1\rangle, \langle Y, u\rangle, \langle V, u\rangle\}$$
$$s_{XY} = \{\langle W, u\rangle, \langle X, 1\rangle, \langle Y, 1\rangle, \langle V, u\rangle\}$$

The situation $s_{X,1} = \{\langle W, 1\rangle, \langle X, 1\rangle, \langle Y, u\rangle, \langle V, u\rangle\}$ is not necessary for $\langle V, 1\rangle$.

a. $\mathrm{dom}(s_{X,u}) = \{X\}$, and $s_{X,u}(X) = 1$ so the only allowable alternative s' must have $s'(X) = 0$. But $V = X \wedge Y$, so no s' with $s'(X) = 0$ is such that $s' \models_{\mathcal{D}} (V = 1)$.

b. $\mathrm{dom}(s_{X,0}) = \{X, W\}$. The allowable alternatives s' either have $s'(X) = 0$ or $s'(W) = 1$. If $s'(X) = 0$, $s' \not\models_{\mathcal{D}} (V = 1)$ as above. If $s'(W) = 1$, then $s' \models_{\mathcal{D}} (Y = 0)$, and since $V = X \wedge Y$, $s' \not\models_{\mathcal{D}} (V = 1)$.

c. $\mathrm{dom}(s_{XY}) = \{X, Y\}$. The allowable alternatives s' either have $s'(X) = 0$ or $s'(Y) = 0$; by the above reasoning, neither type of situation can entail $V = 1$.

d. $\mathrm{dom}(s_{X,1}) = \{X, W\}$. The situation $s_{X,0}$ is an allowable alternative to $s_{X,1}$,

and $s_{X,0} \models_{\mathcal{D}} (Y = 1)$. Since $s_{X,0}(X) = 1$, then $s_{X,0} \models_{\mathcal{D}} (V = 1)$. The non-necessity of $s_{X,1}$ for $\langle V, 1\rangle$ follows directly from the fact that $s_{X,1} \models_{\mathcal{D}} (V = 0)$; this means that we can change a variable determination in $s_{X,1}$ and reach a situation which contains a causal route to $\langle V, 1\rangle$.

Definition 3.13 differs in a small but important way from the version of causal necessity for situations in Baglini and Francez (2016). Translated into the notation used here, they propose the following:

Definition 3.16 (Causal necessity of situations, Baglini and Francez 2016)**.** *A situation s is **causally necessary** for a fact $\langle X, x\rangle$ about an inner variable $X \in P - B$, iff, for any alternative situation s' such that:*

i. $\mathrm{dom}(s) \cap A_X = \mathrm{dom}(s') \cap A_X$ *and*

ii. $\exists Y \in \mathrm{dom}(s) \cap A_X$ *with* $s(Y) \neq s'(Y)$ *and*

iii. $s'(X) \neq x$

we have $s' \not\models_{\mathcal{D}} (X = x)$.

The crucial difference between this definition and the one I offer in Definition 3.13 is in the first clause. Baglini and Francez require only that we consider alternative situations which determine precisely the same set of causal ancestors (for the effect $\langle X, x\rangle$) as s does. Defnition 3.13 also permits alternative situations s' which determine new (additional) causal ancestors of X, as long as these also change a relevant determination in s. This change is motivated by examples such as the following:

(3.37) Consider a simple dynamics with three variables. Let $B = \{W, X\}$, and let $Y \in I$ with $Z_Y = B$ and $f_Y = W \vee X$. Intuitively, $\langle W, 1\rangle$ and $\langle X, 1\rangle$ are individually sufficient for $\langle Y, 1\rangle$, and neither $\langle W, 1\rangle$ nor $\langle X, 1\rangle$ is necessary.

Given this dynamics, two conclusions follow from Definition 3.16:

(3.38) a. The situation $s_{WX} = \{\langle W, 1\rangle, \langle X, 0\rangle, \langle Y, u\rangle\}$ is not necessary for $\langle Y, 1\rangle$, as desired.

The relevant alternative situations are the ones which 'flip' the value of W, X, or both. Consider, for instance, $s' = s_{WX}[X \mapsto 1]$. Then $s' \models_{\mathcal{D}} (Y = 1)$.

b. The situation $s_W = \{\langle W, 1\rangle, \langle X, u\rangle, \langle Y, u\rangle\}$ is necessary for $\langle Z, 1\rangle$, counter to intuition.

The situation s determines only one variable, so there is only one alternative situation to consider: $s' = s_W[W \mapsto 0]$. But s' is its own least fixed point; in the absence of a determination for X, the dynamics does not allow us to determine Y, so we have $s' \not\models_{\mathcal{D}} (Y = 1)$, as required by 3.16.

In other words, it follows from Definition 3.16 that an intuitively unnecessary situation can become necessary simply in the absence of a determination for a crucial variable in an alternative pathway to the effect under consideration. This unfortunate contrast is neutralized in the updated definition, which imposes a less strict clause (a) requirement on alternative situations: $\mathrm{dom}(s) \cap A_X \subseteq \mathrm{dom}(s') \cap A_X$.

(3.39) By Definition 3.13, neither s_W nor s_{WX} is necessary for Y:

The situation $s' = \{\langle W, 0\rangle, \langle X, 1\rangle, \langle Y, u\rangle\}$ is an allowable alternative to either s_W or s_{WX}. $\mathrm{dom}(s_W) \cap A_Y \subset \mathrm{dom}(s') \cap A_Y, \mathrm{dom}(s_{WX}) \cap A_Y = \mathrm{dom}(s') \cap A_Y$, and s' flips the value of X from its previous determination in either case. Since $s'(W) = 1, s' \models_{\mathcal{D}} (Y = 1)$.

The fact that neither s_W nor s_{WX} is necessary for $\langle Y, 1\rangle$ is the formal realization of our intuition that $\langle W, 1\rangle$ is not necessary for $\langle Y, 1\rangle$ in the given dynamics. (The fact that $\langle X, 1\rangle$ is unnecessary follows from symmetric reasoning.)

3.4 A closer look at the catalyst proposal

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

(3.33) **The catalyst account:** (Proposal; Baglini and Francez, 2016)

For an agent S and one-place predicate A, the claim that S *managed to* A:

i. *Presupposes:* The familiarity (salience and truth) of a **catalyst**, or *causally necessary but causally insufficient situation*, for the truth of $A(S)$

ii. *Asserts:* The catalyst **actually caused** $A(S)$

We now have the appropriate definitions of causal necessity and causal sufficiency (Definition 3.13), but Proposal 3.33 invokes one more dependence relation. Baglini and Francez define *actual cause* as follows (see also Pearl 1998, Halpern and Pearl 2005 and subsequent work):

Definition 3.17 (Actual cause)**.** *Given a dynamics D and a world w, a situation s* ***actually causes*** *a proposition $X \in P - B$ if $s(X) = u$, $w(X) = 1$, and w is consistent with the least fixed point of $\mathcal{T}_D$ on s.* (Baglini and Francez, 2016, p.554)

With this definition in hand, we check that Proposal 3.33 derives the desired results.

Based on the catalyst presupposition, assertions of $manage(S, A)$ or $\neg manage(S, A)$ are only felicitous when the context establishes the truth of a causally necessary but insufficient situation, call it C, for $A(S)$; as anticipated by Karttunen (1971), the presuppositional content of *manage* will block an entailment from $A(S)$ to the implicative assertion.

The at-issue question for $manage(S, A)$ is whether or not the relationship of actual cause holds between C and $A(S)$. A positive assertion, $manage(S, A)$ answers in the affirmative. Thus, since the catalyst situation holds in any context where *manage* is felicitous, the definition of actual causes ensures that $A(S) = 1$ in the world of evaluation. This gives us the desired entailment from *manage* to its complement. Conversely, a negative assertion, $\neg manage(A, S)$, denies that C actually caused $A(S)$. Again, since C is presupposed to hold, we conclude that $A(S) = 0$ in the world of evaluation, and this gives us the entailment from $\neg manage(A, S)$ to $\neg A(S)$.

Consequences of the catalyst presupposition

Recall the central facts about implicative verbs:

(A) An assertion $I(S, A)$ conditions $A(S)$ on S's overcoming some potential obstacle. (This will ultimately block entailment from $A(S)$ to $I(S, A)$.)

(B) Given both (i) $I(S, A) \vdash A(S)$ and (ii) $\neg I(S, A) \vdash \neg A(S)$, surmounting the obstacle must be both sufficient and necessary for $A(S)$ in context.

(C) An assertion of $I(S, A)$ non-defeasibly conveys $A(S)$; its negation, $\neg I(S, A)$, conveys $\neg A(S)$

The positive and negative complement entailments capture Fact (C). The presupposition of a contextually familiar causal catalyst also appears to capture Facts (A)-(B). Since C is causally insufficient for $A(S)$, the problem of achieving sufficiency (in context) can be construed as Karttunen's potential obstacle, and since C is necessary for $A(S)$, the conditioning relationship ultimately involves both necessity and sufficiency. Crucially, Baglini and Francez argue that defining the presupposed content of *manage* purely in terms of causal dependencies in a dynamics allows them to account for the context-sensitivity noted by Coleman and to handle the cases where her hierarchy breaks down, while simultaneously preserving Karttunen's intuitions about the relationship between *managing* and *doing*.Broadly speaking, the context-dependence of a dynamics allows the precise composition of the catalyst C to variously invoke notions of effort, difficulty, or unlikelihood, as supported by the discourse context. (3.40) illustrates.

(3.40) Maya **managed** to sit through an opera.

Suppose we know the following: Maya has a strong aversion to opera (AVR). Her best friend, however, really enjoys it, and has bought them tickets to go. Maya never says no to her friend, so she'll go if she is asked; suppose she has been asked. In this scenario, the following variables might form a familiar catalyst: the purchase of the tickets (TKT), and the request (ASK) from the friend. These variables form a causally necessary situation for Maya to attend the opera (ATT), but they are insufficient to ensure that she sits through it (STT): this depends on other factors such as the length of the opera (LEN), and whether or not she has a drink beforehand (ALC). A graphical representation for this example is given in Figure 3.3. To preserve readability, I omit the specification of the associated structural equations.

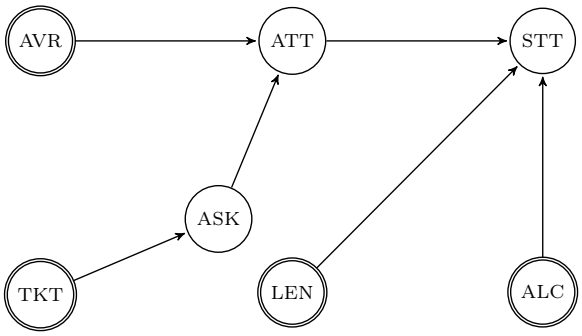


Figure 3.3: A dynamics for the opera example

From the truth of the catalyst (TKT $\wedge$ ASK $= 1$), we can infer directly that Maya will make the attempt. In this scenario, we get the inference that sitting through the opera will be difficult for Maya, given her dislike of opera, represented by the background variable AVR. This inference is not affected by the truth or falsity of the full implicative assertion. We might also arrive at an inference of unlikelihood – it was unlikely that Maya would go, given her aversion.

If the dynamics is constructed differently, we will get a slightly different set of inferences. For instance, suppose Maya knows nothing about opera, so she neither likes nor dislikes it (AVR is undetermined, but might evolve to be true or false at a later time). It might still be unlikely, then, that she would go on her own, but we know that she'll try it out if her friend asks her to go. The presupposition of trying or effort is thus preserved, but we lose the inference that sitting through an opera is necessarily difficult for Maya. In this altered scenario, it seems felicitous to utter (3.41):

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

In this way, the previously mysterious malleable nature of *manage*'s presuppositions is explained by the context-dependent way in which the dynamics sorts the complement proposition's causal ancestors into those which belong to the familiar catalyst C, and those which do not.

Turning to asserted content, Proposal 3.33 is distinguished from the standard account by the claim that the at-issue content of $manage(A, S)$ is not simply the entailed proposition

$A(S)$. According to Baglini and Francez, this provides an explanation of the facts about *because*-clauses. Since the at-issue content of the implicative statement deals with a causal chain for $A(S)$, it follows that the *because*-clause in (3.28a) addresses how or why $A(S)$ was *actually caused*, rather than the how or why of $A(S)$ itself, as in (3.28b).

(3.28) a. Juno **managed** to open the door because it was unlocked.

b. Juno opened the door because it was unlocked.

If this is correct, (3.28a) implies both that a discourse-familiar catalyst *actually caused* Juno to open the door, and that the relation of actual cause came about as a result of the door's being unlocked. For simplicity, assume that the catalyst in this context is just the attempt to open the door (e.g., turning the knob and pushing). Making this attempt is certainly a necessary condition for Juno to open the door, but it could be insufficient for any one of several reasons – the door might be particularly heavy, or have boxes piled against it, or it might simply be locked. The positive *manage* assertion (3.28a) conveys that the attempt to open the door was effective in context, and we conclude that the potential obstacle was avoided. Moreover, if the *because*-clause modifies the assertion of actual cause as suggested, it must convey that the contextual sufficiency of the attempt followed from the door's being unlocked – that is, that the contextually-relevant potential obstacle was the state of the lock. The fact that it was unlocked was, therefore, the decisive factor permitting the relation of actual cause to go through. As a result of this, (3.28a) conveys that no other relevant causal factors were open or in question with regards to opening the door. Since *manage* presupposes the truth of the catalyst regardless of matrix polarity, it seems that the door not being locked (when it might well have been) is in fact the proximate cause of $A(S)$, not Juno's attempt to open the door. Thus, following this reasoning to its natural conclusion, it turns out that the question of whether or not the door was successfully opened does not hinge (in context) on the catalyst, but rather on a catalyst-independent causal factor: the state of the lock.

This reveals something important about Baglini and Francez's proposal. The preceding discussion illustrates that the way in which the catalyst presupposition is formulated in

Proposal 3.33 winds up mandating the existence of a catalyst-independent causal ancestor (or set thereof) for $A(S)$ which, in the context of utterance, constitutes the decisive factor for the realization of the implicative complement. Since the catalyst itself is insufficient for $A(S)$, the relation of actual cause will only hold if all catalyst-external causal ancestors for $A(S)$ are set in a way conducive to $A(S)$. In a negative *manage* statement, we must assume that these variables were set in a way that prevents $A(S)$: the background situation causally entails $\neg A(S)$, regardless of the catalyst. In other words, an important consequence of Proposal 3.33 is that, in any context where an assertion of *manage* or its negation is made felicitous by the truth of a catalyst C, there must be some factor (a variable or situation) which is causally independent of C, and is simultaneously both necessary and sufficient for $A(S)$ with respect to the utterance context. This factor is, then, the proximate cause of $A(S)$.

It seems, therefore, that as anticipated in Section 3.2.3, the catalyst presupposition does indeed relate to the notion of a potential obstacle for the implicative complement. It does so in a rather roundabout way, however. The catalyst itself cannot represent the obstacle. Rather, it is the *insufficiency* of the catalyst that represents the obstacle – but this, as we have seen, translates into the observation that the resolution of some catalyst-external factor fully determines the truth of $A(S)$ in context. Ultimately, then, it is this factor which represents an implicative's backgrounded prerequisite, and the possibility that it will be resolved negatively which represents a potential obstacle for the realization of the implicative complement.

3.5 Beyond *manage*

3.5.1 Catalyst-external causes

As noted, *manage* is semantically bleached compared to the majority of implicatives. In particular, where the verbs in (3.21)-(3.22) clearly indicate the nature of the prerequisite/potential obstacle for their complements, *manage* does not. As a result of this, the catalyst presupposition in Baglini and Francez's proposal causes problems when we try to

extend their account to more specific predicates.

(3.42) 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.*

(3.43) 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.*

Dare and *hennoa* ('have the heart') highlight a particular causal prerequisite as the determining factor for their complements. In (3.42), the presence or absence of courage decides the cat's fat, while in (3.43) it is the presence or absence of 'heart' (something like emotional forbearance, perhaps). From these examples, we see that it is the factor that is lexically specified by an implicative whose potential absence represents the potential obstacle in an implicative utterance. In contexts which license (3.42) or (3.43), the unresolved state of a courage or 'heart' variable, respectively, can be compared to the status of the lock in (3.28a).

The catalyst presupposition cannot account for this. We expect the presuppositional component of an implicative verb to highlight the features of the context which make the implicative felicitous; the 'named' elements in (3.42)-(3.43) do just this. In order to extend Proposal 3.33 to the full implicative class, then, we would like the catalyst to subsume courage and 'heart', respectively. But doing this produces the wrong inferences! The catalyst, on Baglini and Francez's view, holds regardless of matrix polarity, but the named factor does not. In (3.42)-(3.43), the required courage or 'heart' is present *only* in positive matrix contexts; the negative assertion conveys their absence. Moreover, it is this absence that prevents the actualization of the implicative complement $A(S)$. The same is true for *bother* and *malttaa* ('have the patience'): (3.44a)-(3.44b) suggest that the deciding factor was apathy, or lack thereof, and (3.45a)-(3.45b) that it was patience.

(3.44) 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.*

(3.45) a. Hän **maltto-i** odotta-a
he.NOM have.patience-PST.3SG wait-INF
'He had the patience to wait.' ⊢ *He waited.*

b. Hän e-i **maltta-nut** odotta-a
he.NOM NEG-3SG have.patience-SG.PP wait-INF
'He did not have the patience to wait.' ⊢ *He didn't wait.*

In general, then, implicative verbs highlight the fact that a specific, determinative causal factor for $A(S)$ is in question or open in the discourse context. That is, implicative presuppositions focus our attention directly on the potential obstacle, rather than on an insufficient catalyst situation.

Coleman's problem now comes back to the forefront. If implicatives describe the obstacle for their complements, we still need to account for the 'vanishing' presuppositions of *manage*. I suggest that *manage* represents a special case. Like other implicatives, *manage* highlights the existence of a potential obstacle (i.e. a contextually determinative factor which is in question) for its complement, but it deviates from lexically-specific verbs in failing to specify what this factor constitutes. Finnish *onnistua* ('manage', 'succeed') is similar. In either case, matrix polarity determines whether the obstacle was overcome. The lack of specificity in *manage* and *onnistua* allow the discourse context to supply information about the nature of the obstacle, leading variously to presumptions of effort, difficulty, unlikelihood, etc.

This view preserves the key gains of Proposal 3.33. Since the relationship between a potential obstacle and an implicative complement is causal in nature, we retain Baglini and Francez's explanation for Coleman's variable presuppositions. Similarly, we retain the causal account of the facts about *because*-clause modification. Instead of adopting the catalyst presupposition, I show that the existence of a catalyst actually follows from a more direct characterization of the implicative obstacle. Ultimately, this will allow a causal-dependence account to extend to implicatives other than *manage*. In a situation that licenses the use of

an implicative verb, it need not be the case that either the composition of a catalyst or the nature of a potential obstacle is established; the choice of one implicative verb over another will be governed by what, if anything, is known. *Manage* and its counterpart *onnistua* come into the picture as nonspecific choices, to be used when a speaker is either uncertain or does not wish to communicate anything about the nature of the obstacle for the actualization of the implicative complement.

3.5.2 One-way implicatives

Further complications for Proposal 3.33 arise when we consider predicates that entail only in one direction, such as Finnish *pystya* ('be able').[18] These **one-way** implicatives share the overall inferential pattern of their two-way cousins. However, while the inferences generated under negative matrix polarity remain entailments, as shown in (3.46b), the complement inference under positive matrix polarity is at best a defeasible implicature.

(3.46) a. Hän **pysty-i** tappelema-an.
he.NOM able-PST.3SG fight-INF
'He was able to fight.' $\not\vdash (\rightsquigarrow)$ *He fought.*

b. Hän e-i **pysty-nyt** tappelema-an.
he.NOM NEG-3SG able-SG.PP fight-INF
'He was not able to fight.' $\vdash$ *He did not fight.*

Neither the direct assertion account nor Baglini and Francez's proposal can account for the behaviour of one-way implicatives. The direct assertion account, as named, requires that a positive implicative claim asserts its complement directly; there is no way to make this inference defeasible. On the catalyst account, the asserted relation of actual cause ensures the positive entailment, which we do not want.

In order to avoid this entailment, we will need to make the at-issue content of *pystya* ('be able') weaker than actual cause. If we look more closely at how this relation is defined, then it becomes clear that – since the truth of the catalyst is backgrounded – the only at-issue

[18]The translation of this verb is rather suggestive, given the broad goals of this investigation. In fact, Karttunen (1971) includes English *be able* in the class of one-way implicatives. This is discussed at the end of the chapter.

content added by the matrix verb on Proposal 3.33 is that the implicative complement $A(S)$ also holds. If we take this away to capture the one-way implicative pattern, we are forced to include that a one-way implicative contributes nothing to asserted content. This would be rather startling. Moreover, since this means that negating a one-way implicative also does not introduce at-issue content, we lose both the negative complement entailment, which we want to preserve, and any means of distinguishing between the meaning of a positive and negative one-way claim. This obviously will not do.

Attempting to modify the presuppositional content of Proposal 3.33 instead does not help. Catalysts are already insufficient, so our only option is to change the presumption of necessity. It turns out that eliminating the requirement of causal necessity between a catalyst and the implicative complement has no effect on complement entailments. The negative entailment, $\neg I(A, S) \vdash \neg A(S)$, still follows from the definition of actual cause. The only way to satisfy the negation of the actual cause relationship between the familiar catalyst and the implicative complement is for $A(S)$ to be false, since the catalyst is presupposed to hold. The unwanted positive entailment follows for the opposite reason: actual cause requires that $A(S)$ is true in the presence of the catalyst.

One obvious way around the problem would be to argue that one-way predicates like *pystya* ('be able') do not belong to the implicative class at all; that is, that there is no such thing as a one-way implicative. The empirical evidence does not support this conclusion. There are a number of complement-taking predicates in Finnish which both share the one-way inferential pattern in (3.46), and seem to specify prerequisites/potential obstacles in the same way as lexically-specific two-way implicatives.

(3.47) a. Hän **jakso-i** noust-a.
he.NOM have.strength-PST.3SG rise-INF
'He had the strength to rise.' ⇝ *He rose.*

b. Hän e-i **jaksa-nut** noust-a.
he.NOM NEG-3SG have.strength-PP.SG rise-INF
'He did not have the strength to rise.' ⊢ *He did not rise.*

(3.48) a. Hän **mahtu-i** kulke-ma-an ove-sta.
he.NOM fit-PST.3SG go-INF-ILL door-ELA
'He was small enough to go through the door.'

$\rightsquigarrow$ *He went through the door.*

b. Hän e-i **mahtu-nut** kulke-ma-an ove-sta.
he.NOM NEG-3SG fit-PP.SG go-INF-ILL door-ELA
'He was not small enough to go through the door.'

$\vdash$ *He did not go through the door.*

This suggests a unity between one- and two-way implicatives, which a full account of implicative semantics ought to capture. While Baglini and Francez's proposal makes great strides over the direct assertion account, we have seen here that it leaves something to be desired in its treatment of other two-way implicatives, and that it cannot account for the behaviour of one-way verbs like *jaksaa* ('have the strength'), in (3.47) and *mahtua* ('fit', 'be small enough'), in (3.48), at all.

3.6 Causal necessity and causal sufficiency in implicativity

What we are after is an account of implicative behaviour – *implicativity* – that preserves the causal component introduced by Baglini and Francez (2016), but which focuses on the potential obstacle (i.e. the in-question, contextually-decisive prerequisite) instead of on a contextually-established catalyst. This account should derive Facts (A)-(C), restated below, with the caveat that one-way implicatives do not exhibit the positive entailment $I(S, A) \vdash A(S)$. We have seen, in Section 3.5.2, that one-way implicatives parallel two-way implicatives in making the actualization of the complement contingent on the resolution of a specific prerequisite. This suggests that the at-issue contribution of one-way implicatives is the same as the at-issue contribution of two-way predicates. Consequently, the difference between one- and two-way implicatives must follow from a (minimal) difference in their not-at-issue contributions.

(A) An assertion $I(S, A)$ conditions $A(S)$ on S's overcoming some potential obstacle. (This will ultimately block entailment from $A(S)$ to $I(S, A)$.)

(B) Given both (i) $I(S, A) \vdash A(S)$ and (ii) $\neg I(S, A) \vdash \neg A(S)$, surmounting the obstacle must be both sufficient and necessary for $A(S)$ in context.

(C) An assertion of $I(S, A)$ non-defeasibly conveys $A(S)$; its negation, $\neg I(S, A)$, conveys $\neg A(S)$

As it turns out, the basic structure of the account we want was anticipated by Karttunen (1971) in his original paper on implicatives. In the wake of the direct assertion account (Karttunen and Peters 1979, which perhaps supplanted Karttunen's earlier ideas), the following passage has not received much attention:

> "In the following, 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)

While this schema is underspecified from our current perspective, it is easy enough to see that it captures Facts (A)-(C).

To flesh out the lexical details of Karttunen's schema, we need to answer the following question: what exactly is the "central part of the proposition"? In other words, what (if anything) does an implicative specify about the nature of the necessary and sufficient condition it presupposes, and whose truth it asserts? We have already seen what the answer

must be. The central part of an implicative proposition, and the necessary and sufficient condition for the implicative complement is just that unresolved prerequisite, whose status is resolved by the implicative assertion.

We can at this point add something further to Karttunen's schema: the connection between the central part of the proposition and the implicative complement involves *causal* necessity and sufficiency, in particular. We have already seen that introducing a causal component allows us to account for certain aspects of the interpretation of *manage* and other implicatives which resisted explanation on the direct assertion account. To cement the importance of causal dependence with respect to Karttunen's schema, consider (3.49).

(3.49) *Context:* In the United States, being (at least) 21 years of age is a necessary and sufficient condition for the legal consumption of alcoholic beverages. 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.

This example backgrounds a salient necessary and sufficient condition for the implicative complement. Rather than a causal condition, however, the context in (3.49) involves legal (deontic) necessity and sufficiency. As the judgement in (3.49a) shows, the deontic condition does not on its own license the use of *manage*. In order to make sense of the implicative claim, we wind up making inferences about non-legal conditions that might hold in context: for instance, we might wonder if it was particularly logistically difficult for Amira to procure wine, or that some physical condition or perhaps distaste made it difficult for her to drink the entire glass. In other words, despite the salience of a deontically necessary and sufficient condition for the implicative complement, the use of *manage* encourages us to speculate about possible necessary and sufficient conditions which are *causally* involved in Amira's wine-drinking – that is, conditions which, unlike legal regulations, concretely precipitate or preclude the complement event.

3.6.1 The proposal

Putting all of the pieces together, we arrive at the following precisification of the implicative semantic template:

(3.50) **The prerequisite account of implicatives.** (Proposal)
For a two-way implicative verb I, an agent S, a one-place predicate A, and a background situation c, the proposition $I(S, A)$:

i. *Presupposes:* The existence of a predicate H such that $H(S)$ is *causally necessary* for $A(S)$ in the utterance context. $H(S) \blacktriangleleft_c A(S)$

ii. *Asserts:* $H(S)$

iii. *Presupposes:* $H(S)$ is the only unmet causally necessary condition for $A(S)$ in context (so $H(S)$ is *causally sufficient* for $A(S)$ relative to c) $H(S) \blacktriangleright_c A(S)$

On the prerequisite account, the presupposed condition $H(S)$ is, crucially, unresolved in the discourse context (this can be contrasted with Baglini and Francez's established catalyst). As a result, the presuppositional content of an implicative, per Proposal 3.50, highlights that, given what the speaker knows about the causal ancestors of $A(S)$, $H(S)$ is not only causally necessary for $A(S)$ with respect to the background situation, but is also undetermined by this situation. It is worth noting that the intuition that $H(S)$ remains unresolved at utterance time in not explicitly encoded in the presuppositional content in Proposal 3.50. I suggest instead that this inference arises as an implicature from the use of an implicative construction $I(S, A)$ instead of a salient simpler alternative, the bare complement $A(S)$. In other words, the inference that $H(S)$ is unresolved comes about as a sort of 'justification' for the implicative construction. This is, in a sense, the source of the 'obstacle' impression. We generally conceive of actions and events in the world as embedded in causal chains. Using an implicative, especially a lexically-specific implicative, draws attention to a particular piece of this chain. It is hard to recover a reason for doing this if the relevant piece is already resolved in the discourse context – consequently, we infer

that it is not.[19]

On Proposal 3.50, the characteristic entailments of implicative verbs are derived in the joint contribution of presupposition and assertion. Taking the negative direction first, the presupposition of causal necessity, (3.50-i), establishes that if $H(S)$ is not realized, $A(S)$ cannot be actualized. According to (3.50-ii), the at-issue content of a negative implicative claim, $\neg I(S, A)$, tells us that $H(S)$ is false. It follows that $A(S)$ did not occur. To take an example, suppose we are dealing with the implicative verb *uskaltaa* ('dare'):

(3.19b) 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.' $\vdash$ *Juno did not open the door.*

Here, H represents something like the deployment of courage. All that (3.19b) asserts is that Juno did not deploy this courage. Since courage is a prerequisite for Juno to open the door, we conclude that she did not open the door, and that her failure to do so was due to her lack of courage, as desired. The negated complement is not an explicit piece of the asserted content in (3.19b), but instead is calculated as a causal consequence of this content (in any context where *uskaltaa* is felicitous).

Turning to the positive assertion, $I(S, A)$ tells us that $H(S)$ is true. If all we have is the necessity presupposition in (3.50-i) and the asserted content in (3.50-ii), we cannot conclude anything about the truth of $S(A)$. This is exactly what we want for one-way predicates like *jaksaa* ('have the strength'). The assertion $H(S)$ may defeasibly implicate that $A(S)$ occurred, since it removes at least one potential barrier to $A(S)$, but it does not entail $A(S)$.

On the other hand, if I is a two-way implicative, we have some additional not-at-issue information: the causal sufficiency presupposition in (3.50-iii). Given the way in which this presupposition is formulated in Proposal 3.50, the positive assertion of a two-way implicative will convey that the only unresolved necessary condition for $A(S)$ was resolved positively. Since, in this case, the negation of $H(S)$ is the only potential obstacle for $A(S)$, its positive resolution will (causally) entail $A(S)$. The positive entailment, again, is derived, using

[19]This type of reasoning can be explained rather nicely as an example of Lauer's (2013) *Need-a-Reason* implicatures.

presupposed information, as a causal consequence of what is actually asserted.

Given Proposal 3.50, we can straightforwardly encode the additional contribution of lexically-specific implicatives as constraints on possible candidates for the predicate H. For example, where *jaksaa* ('have the strength') establishes that H involves the use of strength, *dare*/*viitsiä* instead names courage or perhaps temerity. Implicatives vary not only in the types of condition they encode, but also in their degree of specificity: a verb like *mahtua* ('fit', 'be small enough') is extremely specific about H, but *pystya* ('be able') is much less precise, and *manage*/*onnistua* essentially convey only what is given in Proposal 3.50.

An illustration: the modified Dreyfus scenario

Let us consider a fictionalized version of the Dreyfus scenario, adapted from Baglini and Francez (2016). Suppose the following conditions hold:

(3.51) If Dreyfus intends (INT) to spy for the Germans (SPY), then:

a. he will collect secrets about the French (SEC) $\text{SEC} = \text{INT}$

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 $\text{MSG} = \text{INT} \wedge \text{NRV}$

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) $\text{COM} = \text{MSG} \wedge \text{LST} \wedge \neg\text{BRK}$

d. he will use the line to pass information to the Germans, thus spying for them $\text{SPY} = \text{SEC} \wedge \text{COM}$

The structure of the causal dynamics described in (3.51) is represented graphically in Figure 3.4. The background variables in this example 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).

Suppose we are in a context which establishes that Dreyfus intends to spy, and has in fact already collected secret information. Then the relevant background situation s has INT

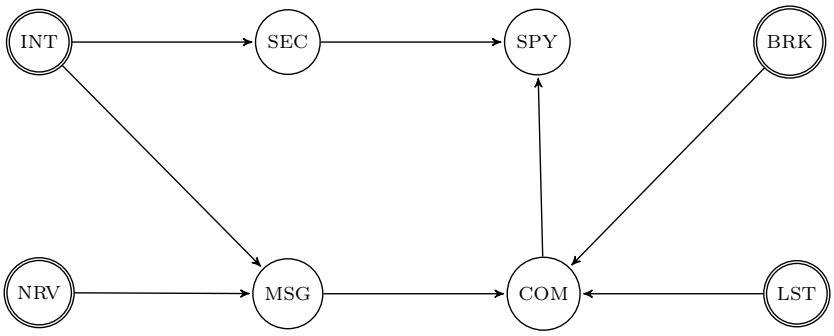


Figure 3.4: A dynamics for the Dreyfus example

= SEC = 1. In this context, we have the following intuitive judgements about the felicity of (3.52a)-(3.52d).

(3.52) 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 make contact with the Germans.

d. ?/#Dreyfus dared to spy for the Germans.

Proposal 3.50 correctly predicts the judgements in (3.52a) and (3.52b). In context, by virtue of being the only undetermined condition for MSG, NRV is both necessary and sufficient for the truth of MSG. The polarity of the *dare* claim then sets the value of NRV, allowing us to conclude whether or not MSG was realized.

On the other hand, while *dare* in (3.52c) also resolves NRV, Proposal 3.50 predicts that it will not be acceptable in this case. This is because two relevant conditions for COM are unresolved in the discourse context: we do not know the values of either BRK or LST. In other words, NRV in this case is necessary, but not sufficient for the implicative complement, and *dare* cannot be felicitously used. The story is more or less the same for (3.52d). NRV is again causally necessary but not causally sufficient for the implicative complement SPY, because its causal ancestors BRK, LST and COM are all undetermined in the discourse context.

We can also use the fictitious Dreyfus dynamics to illustrate how *manage* works as a non-specific or semantically-bleached implicative. Intuitively, all of (3.53a)-(3.53d) are felicitous.

(3.53) a. Dreyfus managed to send a message to the Germans. → NRV = 1

b. Dreyfus did not manage to send a message to the Germans. → NRV = 0

c. Dreyfus managed to make contact with the Germans.
→ NRV = MSG = LST = 1, BRK = 0

d. Dreyfus managed to spy for the Germans.
→ NRV = MSG = LST = COM = 1, BRK = 0

What accounts for the contrast between (3.52c)-(3.52d) and (3.53c)-(3.53d)? The current account predicts that, while *dare* requires that the only unresolved causal ancestor for its complement is connected in some way with Dreyfus's courage, *manage* – due to its lack of lexical specificity – simply requires that the set of unresolved causal ancestors for its complement can represent a causally necessary and sufficient condition. This view is supported by the fact that each statement in (3.53) licenses a particular set of inferences about the values of various relevant propositions in the Dreyfus situation. Should any of these conditions turn out not to be true, *manage* will no longer be appropriate (and might also be false).

For completeness, we consider finally a scenario nearer to the truth of the Dreyfus affair. Suppose Dreyfus is innocent, and in particular has no intention to spy for the Germans, though he is known for his unmatched courage in all situations. In this context, with a background situation that fixes INT = 0 and NRV = 1, each of (3.52a)-(3.52d) is infelicitous, since NRV is not sufficient in context for any of MSG, COM, or SPY. Notably, each of (3.53a)-(3.53b) also becomes infelicitous in the absence of Dreyfus's intent to spy, because if the background fixes that INT = 0 there is no condition or set of conditions which can possibly represent a sufficient situation for MSG, COM, or SPY.

3.6.2 More evidence for the prerequisite account

Proposal 3.50 meets the desiderata of Facts (A)-(C), and captures the differences between one- and two-way implicatives while assigning them identical at-issue content. I next present some empirical evidence that supports this proposal over the catalyst account from Baglini and Francez.

For a one-way implicative I, the prerequisite account makes two claims. First, a positive assertion $I(S, A)$ states that $H(S)$ obtains. Second, the truth of $H(S)$ is not enough to derive the actualization of $A(S)$. (3.54) illustrates this. In this case, it is not contradictory to follow the positive implicative claim with the negation of its complement, and we see that therre is no positive entailment from $I(S, A)$ to $A(S)$. Nevertheless, (3.54) conveys that the requisite strength was available.

(3.54) Hän **jakso-i** tappelema-an, mutta päätt-i sitä
he.NOM have.strength-PST.3SG fight-INF, but decide-PST.3SG he.PART
vastaan.
against.ILL
'He had the strength to fight, but he decided not to.'

Baglini and Francez do not make predictions about this case, since the catalyst proposal simply does not cover one-way implicatives.

Since both prerequisite and catalyst proposals derive the dual entailment pattern of two-way implicatives, the most promising ground for adjudication between the two accounts is represented by the not-at-issue content. Proposal 3.50 in particular predicts infelicity from two-way implicative utterances in contexts where causal factors for $A(S)$ independent of the named attribute are known to be in question (thus invalidating the sufficiency presupposition). This does not follow from Baglini and Francez's proposal, since the catalyst situation is not taken to be causally sufficient for $A(S)$.

On Proposal 3.50, then, we expect infelicity to result from using a two-way implicative in contexts where the dynamics is explicitly constructed so that, in addition to $H(S)$, $A(S)$ has other unresolved causal ancestors. This prediction is supported by the following examples, using *bother* and the two-way Finnish implicatives *ehtiä* ('have the time') and *kehdata* ('be unashamed').

(3.55) *Context.* Bill is apathetic about parties. He's known to be a networker, though, and will often convince himself to show up if he thinks there will be someone there who would be useful to make a connection with. Mary planned a party for some friends and neighbors, and invited the newly-elected members of city council. She

invited Bill last week and he said he would think about whether he wanted to meet the councillors. When she told him the date of the party, however, he said he might be away on a business trip and so he wasn't sure if he'd be able to attend in any case. They didn't get a chance to talk again before the party, so she never found out what he decided or if he had to go out of town. In the end, he didn't show up, and Mary says:

a. ?"Bill didn't bother to come to my party."

The context in (3.55) explicitly introduces a consideration unrelated to apathy which might prevent Bill from attending the party, and which is unresolved in context. Being in town is clearly a necessary condition for his attendence. There is some variation in judgement with respect to the felicity of (3.55a) in this context; however, where it was felt to be acceptable, my informants interpreted Mary's comment as a 'meta'-comment on Bill's general attitude, or his failure to properly RSVP, rather than as an accurate description of the situation at hand. In general, however, since the reasons for Bill's absence remained unknown, Mary's use of *bother* was felt to be marked. This markedness is even more obvious with the addition of a *because*-clause which attempts to pin down the connection between *bother* and the specific target of Bill's (potential) apathy:

(3.56) Mary: #"Bill didn't bother to come to my party because he decided the councillors weren't worth his time."

Judgements are sharper for *ehtiä* ('have the time')and *kehdata* ('be unashamed') in similarly-constructed contexts:

(3.57) *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 caught sight of 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.*

The context in (3.57) explicitly suspends a necessary and time-independent condition for shooting the bear – namely, whether or not the hunter had any bullets remaining. This results in the infelicity of (3.57a): one informant explained this by saying she could not use *ehtiä* ('have the time') because "if he didn't have any bullets, he could not have shot the bear." She identified the same problem for a negative *ehtiä* assertion in the same context, even if the intention of the speaker was to convey that the bear was not shot.

My informants also judged the use of *kehdata* (roughly, 'act without shame') to be inappropriate in the context provided in (3.58). As in (3.57), the context establishes an unresolved condition which might have independently prevented the actualization of the implicative complement: namely, the consultant might not have had the version of the survey which included the offending questions.

(3.58) *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.*

The judgements reported for (3.55)-(3.58) support the predictions of the prerequisite account. In both cases, two-way verbs are infelicitous when a causally necessary condition independent of the condition specified by the implicative is explicitly left unresolved in the discourse context. This contrasts with contexts where other factors are not made salient. In a neutral context – for instance, one where the background contains only the information that the hunter in (3.58) was reaching for food and not holding his gun when he spotted the bear – (3.58a) will not only be felicitous, but will also allow us to infer that the only potential obstruction to the complement's realization was time. Given the positive resolution of the time condition, we infer that the hunter shot the bear. Taken together with the evidence

from (3.55)-(3.58), this suggests that an account of implicatives which includes a causal sufficiency precondition is on the right track.

3.6.3 Additional remarks

Circumscription, presupposition, and implicature

In Proposal 3.50, 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 $H(S)$ 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.

The second presupposition in Proposal 3.50, (3.50-iii), is formulated in a particular way: causal sufficiency is established by closing off the possibility that any necessary conditions other than $H(S)$ are left unresolved or open in context. This is a 'what you see is what you get' presupposition – or, to be more precise, a presupposition that 'what you see is all there is' (WYSIATI; Kahneman 2011). Essentially, we take it for granted that the causally necessary condition that has been brought to our attention (highlighted by the implicative verb, via the causal necessity presupposition) represents the only relevant condition on which the determination of the implicative complement hinges.

This kind of reasoning – from the highlighting of a single condition to conclusion that alternative conditions of the same type are not contextually relevant – is a very natural sort of pragmatic reasoning. I want to suggest that it is precisely the WYSIATI inference, drawn at the pragmatic level in the case of one-way implicatives, which accounts for the observed tendency for positive assertions of one-way verbs to defeasibly implicate their complements. These implicatures are spelled out for *jaksaa* ('have the strength') and *mahtua* ('be small enough') in (3.47)-(3.48).

(3.47) a. Hän **jakso-i** noust-a.
he.NOM have.strength-PST.3SG rise.INF
'He had the strength to rise.' ⇝ *He rose.*

(3.48) a. Hän **mahtu-i** kulke-ma-an ove-sta.
he.NOM fit-PST.3SG go-INF-ILL door-ELA
'He was small enough to go through the door.'

$\rightsquigarrow$ *He went through the door.*

Bolstering this hypothesis, Karttunen (2012) draws a parallel between these implicatures and the well-known pragmatic phenomenon of **conditional perfection** (Geis and Zwicky, 1971). In cases of conditional perfection, a statement of the form *if P, (then) Q* is interpreted biconditionally, as *Q if and only if P*. (3.59) is an example of conditional perfection.

(3.59) You will get an A on the test if you study Chapter 5 carefully.

a. *Implicates:* You will not get an A on the test if you do not study Chapter 5 carefully.

b. *'Perfected' interpretation:* You will get an A on the test if and only if you study Chapter 5 carefully.

The two phenomena – conditional perfection and the complement implicatures of verbs like *jaksaa* ('have the strength') and *mahtua* ('be small enough') – both involve WYSIATI inferences. In each case, the listener infers from the highlighting of a single condition (P or $H(S)$) that it is in fact the *only* contextually-relevant condition for the relevant conclusion (Q or $A(S)$). In cases of conditional perfection, we infer necessity (3.59a, above) from asserted sufficiency. For implicative implicatures, we infer causal sufficiency from presupposed causal necessity. Since the necessity-sufficiency direction is reversed in the implicative case, we might call these implicatures instances of **antiperfection**. Perfection and antiperfection are not fundamentally different, however: both implicatures are licensed by the speaker's mention of a single condition.

We may even go one step farther in classifying implicative 'antiperfection' inferences by comparing them to the implicatures of causative verbs. In Lauer and Nadathur (2018, 2019), we analyze periphrastic causatives like *cause* and *make* in terms of causal dependency relations, focusing on the claim that *make* (as in "Gurung made the children dance") asserts that the bringing-about relationship between a cause and its effect is one of causal sufficiency.

Empirically, however, there are many uses of *make* that seem to license inferences about (causal) necessity:

(3.60) *Context:* the speaker is on trial for participating in the blocking of a coal train in Spokane, Washington. The action was undertaken in an effort to protest and/or curtail global warming.

a. ?Climate change made me do it.

$\rightsquigarrow$ *I would not have done it, were it not for climate change.*

Lauer and Nadathur 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 3.60) a necessary as well as a sufficient condition. The analogy with conditional perfection, in (3.59), is immediate.

Since implicative 'antiperfection' also involves reasoning about the structure of a causal dynamics, we can describe the complement implicatures in (3.47)-(3.48) as instances of **causal antiperfection**. Causal antiperfection might also be expected to arise in the interpretation of necessity causatives (if such causatives exist; some treatments of English *cause* suggest that it predicates only necessity, but there is no consensus on the meaning of this verb). 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 *circumscription*:

> "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.*" McCarthy (1980, p.27, emphasis in original)

In the semantic/pragmatic literature, McCarthy's circumscription is 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 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.[20]

We have seen that two-way implicatives are infelicitous when a condition independent of $H(S)$ 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 $A(S)$ other than $H(S)$ 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 3.50 as a circumscriptive one thus establishes a natural continuity between one- and two-way predicates.

On this view, two-way implicatives can be seen to have lexicalized antiperfection inferences, resulting in two-way entailments. One-way implicatives do not lexicalize antiperfection, but it easily arises in the pragmatic dimension, in case no alternative causal conditions for the implicative complement are made salient. If alternative conditions are in fact salient, one-way verbs simply fail to implicate complement actualization. This 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, 2015, 2016). 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.

[20]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 the 'grammatical' operation *exh* (Fox, 2007; Chierchia et al., 2012). Herburger (2015) offers an analysis in the latter style.

Polarity-reversing implicatives

One more group of predicates deserves attention: polarity-reversing implicatives like *fail* and *laiminlyödä* ('neglect'). As examples (3.61) and (3.62), show, positive assertions of two-way polarity reversing implicatives entail the negation of their complements; negative assertions entail complement actualization.

(3.61) a. Juri **failed** to open the door. ⊢ *Juri did not open the door.*

b. Juri did not **fail** to open the door. ⊢ *Juri opened the door.*

(3.62) a. Hän **laiminlö-i** korjat-a virhee-n.
he.NOM neglect-PST.3SG repair-INF error-GEN/ACC
'He neglected to correct the error.' ⊢ *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.' ⊢ *He corrected the error.*

There are two fairly easy ways in which we might extend Proposal 3.50 to polarity-reversing implicatives. Either option involves a minor change to the presuppositional content associated with polarity-preserving implicatives. The first possibility would be to background the highlighted condition $H(S)$ as causally necessary in context for $\neg A(S)$; this derives the negative entailments in (3.61b) and (3.62b) immediately, and the positive entailments in (3.61a) and (3.62a) secondarily as a result of circumscribing $H(S)$ as the only causally necessary condition in question. Alternatively, we might instead background the failure of $H(S)$ as causally necessary for $A(S)$. If we choose this route, we get the positive entailments directly, and the negative entailments as a result of the second, circumscriptive presupposition. From the two-way data in (3.61) and (3.62) alone, it is not clear which route is to be preferred.

One-way polarity-reversing implicatives resolve the matter. *Hesitate* and its Finnish equivalent *epäröidä* preserve entailment under a negative matrix assertion, but, like polarity-preserving one-way implicatives, do not entail in the positive case.

(3.63) a. Amira **hesitated** to drink a beer. ⊬ *Amira drank a beer.*

b. Amira did not **hesitate** to drink a beer. ⊢ *Amira drank a beer.*

(3.64) 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.'

⊬ *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.'

⊢ *Juno took part in the race.*

Since the positive entailments (from $H(S)$ 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 $H(S)$ to be causally necessary for the failure of the implicative complement. Then, as in the polarity-preserving cases, two-way polarity-reversers can be seen to have lexicalized the circumscriptive reasoning that leads to a causal sufficiency relationship, 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.

(3.65) Juri **hesitated** to ask for help.

a. *Implicative implicature:* Juri didn't ask for help (because of her hesitance).

b. *Factive implicature:* Juri asked for help (after some time had passed).

(3.66) 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.'[21]

a. *Implicative implicature:* Leo did not show me the picture (due to shyness).

b. *Factive implicature:* Leo showed me the picture (with reluctance).

The availability of both types of inferences shown in (3.65)-(3.66) 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 recent results described in Karttunen (2014) (see also Tonhauser et al. 2015), which indicate a certain fluidity in the use of implicative- or factive-type inferencing for phrasal constructions like *be lucky to* (which have traditionally been treated as factive). I leave an investigation of these connections for future work.

3.7 Conclusions and outlook for actuality inferences

Motivated by Bhatt's (1999) observations linking actualized interpretations of ability ascriptions with the interpretation of *managed to* claims, this chapter focused on an analysis of implicative verbs, ultimately proposing a new account of implicative lexical semantics. Where Bhatt's original account of actuality inferences aims to derive the semantic parallels from an underlying equivalence in the lexical representations of *manage* and a predicate ABLE (representing both ability modals and *be able*), I argued that the parallels actually arise at an analytical level. In other words, the lexical semantic properties that derive the complement entailments of *manage* (and other two-way implicative verbs) are the same properties that derive actuality entailments, but in the latter case arise in the composition of ability and (perfective) aspect.

To pursue this idea, we first needed to know how implicative entailments are themselves derived, and to establish what semantic features constitute the property of *implicativity*.

[21] In Finnish, case marking within the embedded proposition seems to correlate with which implicature is preferred. In (3.66), partitive marking on *kuva* ('picture'), seems to privilege a factive inference, while the genitive/accusative marker privileges an implicative inference.

The account of implicative verbs developed in this chapter allows us to identify three key components in the production of the characteristic two-way entailment pattern. First, as anticipated by Karttunen (1971), implicatives presuppose the existence of a necessary and sufficient condition for the realization of their complements. Some verbs, such as *dare* and *bother*, place constraints on the nature of the condition, while others do not – notably, *manage*, its Finnish counterpart *onnistua*, and by extension the French implicative *réussir* ('manage', 'succeed'). Secondly, building on an insight from Baglini and Francez (2016), I argued that the relations of necessity and sufficiency involved in implicative semantics are causal in nature. Necessity and sufficiency of any sort are modal notions, insofar as they deal with relations of consistency and consequence in inferential systems – as we saw in Section 3.3, for instance, causal necessity and causal sufficiency involve reasoning about normal causal developments, or different ways in which a course of events might unfold in the world. Thus, the second condition for implicative behaviour amounts to the requirement that the modality involved is causal in flavour. Finally, against Karttunen and Peters (1979), I proposed that implicatives do not trivially assert their complement propositions, but instead establish whether or not the causal condition was met as their at-issue contribution. Thus, as originally suggested by Karttunen, an implicative statement has as its 'central' proposition the claim that a necessary and sufficient condition was satisfied. The implicative entailments follow as causal consequences in the joint contribution of presupposed and asserted content.

Table 3.2 summarizes these findings; as before, S is the individual argument to an implicative, $A(S)$ the complement proposition, and $H(S)$ stands for the causal condition. I let c be the background situation provided by the utterance context. If actuality entailments are, as hypothesized, derived in the implicative pattern, then each of the components in Table 3.2 must appear in the combination of ability and aspect. The next task, then, is to locate them.

As a starting point, let us take another look at the inferences associated with *be able*. Under positive matrix polarity, the situation is familiar: past-tense uses of *was able* may implicate their complements, but they do not entail them. We have not yet considered what happens under negative matrix polarity, however. As (3.67b) shows, negative *was*

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

Table 3.2: The semantic components of polarity-preserving two-way implicativity

able statements entail the negation of their complements. *Be able*, then, has the inferential profile of a one-way polarity-preserving implicative.

(3.67) a. Eman was able to go to the party ... $\rightsquigarrow$*Eman came to the party.*
✓... but she decided to stay at home.

b. Eman was not able to go to the party ... $\vdash$ *Eman did not go to the party.*
... but she went in the end.

On the basis of this inference pattern, Karttunen (1971, 2012) classifies *be able* as a one-way implicative.[22] Adopting this idea now leads to the analysis in (3.68).

(3.68) ***Be able* as a one-way implicative.** (Proposal, to be revised)
For an agent S, and a one-place predicate A, the claim that S *is able to* A:

i. *Presupposes:* The existence of a predicate H such that $H(S)$ is causally necessary for $A(S)$ in the utterance context. $H(S) \blacktriangleleft_c A(S)$

ii. *Asserts:* $H(S)$

[22]Karttunen (p.c.) also classifies Finnish *pystya* ('be able'), which we saw in Section 3.5.2 as a one-way implicative; Flint (1980) describes this verb as one of "possibility," and places it in a taxonomy which includes both modal verbs and one- and two-way implicatives.

(3.46) a. Hän **pysty-i** tappelema-an.
he.NOM able-PST.3SG fight-INF
'He was able to fight.' $\not\vdash (\rightsquigarrow)$ *He fought.*

b. Hän e-i **pysty-nyt** tappelema-an.
he.NOM NEG-3SG able-SG.PP fight-INF
'He was not able to fight.' $\vdash$ *He did not fight.*

This seems promising. While we maintain the spirit of Bhatt's proposal, we improve on his predictions by treating *be able* as a one-way implicative rather than equating it with the two-way implicative *manage*. The similarities between *be able* and *manage* follow from their shared implicative structure, but the key contrast – that *be able* does not entail its complement under positive matrix polarity, while *manage* does – now follows from the difference between one- and two-way implicatives: namely, that two-way implicatives presuppose both the causal necessity and the causal sufficiency of some condition for their complements, one-way verbs presuppose only causal necessity.

If we pursue this line of analysis further, by taking on Bhatt's idea that *be able* and ability modals like *pouvoir* and *saknaa* are all realizations of a single predicate, ABLE, we also predict the observed contrast between *pouvoir* ('can', 'be able') and *réussir* ('manage', 'succeed') under imperfective marking. The imperfective ability claim in (3.69a) is compatible with Jean's never having escaped; the implicative claim in (3.69b) is not.

(3.69) a. *Jean **pouvait** s'enfuir, mais il ne s'est jamais enfui.*
'Jean could-PFV escape, but he never escaped.'

b. *Jean **réussissait** à s'enfuir, #mais il ne s'est jamais enfui.*
'Jean managed-IMPF to escape, #but he never escaped.'

We run into trouble at this point, however. Bhatt's account assigned ABLE an underlyingly complement-entailing semantics, thus requiring an additional explanation for the acceptability of (3.69a). If ABLE has the semantics in (3.68), we have what amounts to the opposite problem. We predict the acceptability of (3.69a), but we still have not explained what produces the actuality entailment when the ability modal appears with perfective marking.

(3.70) *Jean a pu s'enfuir, #mais il ne s'est jamais enfui.*
'Jean could-PFV escape, but he never escaped.'

To go from the one-way implicative meaning to the complement-entailing interpretation

in (3.70), we need to add the one component from Table 3.2 which (3.68) omits: the presupposition of causal sufficiency. But the only difference between (3.69a) and (3.70) is the aspectual contrast. Thus, if we are to make an implicative account of ABLE work, it seems as if we need the perfective to somehow introduce causal sufficiency. Given what we know about the semantics of perfective aspect (see Section 2.1.3), it is difficult to see how this might come about.

Nevertheless, there is reason to believe that the implicative approach to ABLE is on the right track. To see why, we take a step back out and consider the overall aims of the investigation. One of the goals established by the framing questions in Chapter 1 was to develop a semantic treatment of *be able* and ability modals – ABLE, following Bhatt – which connects the three meanings of (pure) ability, actuality, and possibility.

It is fairly straightforward to locate a possibility meaning in (3.68): under positive matrix polarity, the assertion that a causally necessary condition $H(S)$ for $A(S)$ was met leaves the truth of $A(S)$ open, and thus making the truth of $A(S)$ a possible (but not guaranteed) causal development. Although the one-way implicative analysis does not yet allows us to explain actuality entailments, it does supply a straightforward account of the weaker actuality implicatures associated with *be able*. As we saw in Sections 3.5.2 and 3.6.3, positive assertions of one-way implicatives are predicted to license defeasible 'antiperfection' inferences to the realization of their complements.

What we are missing is a connection to the pure ability reading associated with both *be able* and ability modals. In Section 2.3 of Chapter 2, we saw that these readings demanded some notion of 'regularity' or 'reliability': in particular, we saw that pure ability interpretations of ability modals are not licensed by a single witness for the modal complement. I proposed to capture the reliability requirement by representing abilitative predicates as hypothetical guarantees. In Chapter 2, we left the precise content of the 'guarantee' component as an open question. Following the discussion of causal dependence relations in Section 3.3, we are now in a position to formalize this component in terms of causal sufficiency, making $H'(S)$ in (3.71) the event that ensures or makes $A(S)$ inevitable, given the actual (normal) course of events in the world.

(3.71) ***Can/be able* as a hypothetical guarantee.** (Proposal, to be revised)
For an agent S and a one-place predicate A, the claim that S *can/is able to* A is true just in case S has an available action, H', such that $H'(S)$ is causally sufficient for (guarantees) $A(S)$.

There is an intriguing structural similarity between the analysis of ABLE as a one-way implicative and the hypothetical guarantee proposal in (3.71). Both proposals make relevant an intermediary or intervening event which is causally involved in the realization of $A(S)$, and in which S is participant. These intervening conditions, however, cannot be quite the same. In (3.71), $H'(S)$ is causally sufficient for $A(S)$. A possibility meaning for $A(S)$ is preserved insofar as the realization of $H'(S)$ is not asserted, but only its availability (to S). On the implicative view in (3.68), however, the intervening condition $H(S)$ is causally necessary for $A(S)$. In this case, the realization of $H(S)$ *is* asserted. Moreover, it is the absence of a causal sufficiency relationship that preserves the possibility meaning for $A(S)$ in this case, and which crucially distinguishes ABLE from *manage/réussir* in examples like (3.69).

What emerges from this discussion is that the way forward on each of the two problems faced by the implicative analysis of ABLE, as it is stated in (3.68), seems to involve a causal sufficiency component. Causal sufficiency is needed, on the one hand, to move from positive assertions of ABLE which license only actuality implicatures to assertions which produce the full actuality entailment. On the other hand, it is needed – as per the hypothetical guarantee proposal – to capture the reliability or regularity requirement of pure ability readings. In other words, causal sufficiency – in some way that we have not yet explained – unifies the divergent actuality and ability meanings at the heart of the actuality inference puzzle! This finding is a compelling reason to continue the current line of investigation.

What we would like, to help us complete the picture, is some way of reconciling the two proposals (3.68) and (3.71), while preserving the positive features of both analyses. In particular, we would like this merged proposal to encode the causal sufficiency component required to capture the notion of reliability, but somehow leave it 'inactive' except in the

overt presence of perfective aspect. In order to see how this might work, we need some way to probe more deeply into the structure of ABLE, and in particular, into the nature and structure of the causal condition which figures in both the one-way implicative analysis and the hypothetical guarantee structure. It does not seem possible to do this directly with either ability predicates or implicative verbs.

It turns out, however, that there is a class of predicates which will allow us to look at the structure of ability and implicativity at a finer level of granularity. *Enough* and *too* predicates, like the ones marked in bold in (3.72), belong to a class of 'optional' or 'defeasible' implicatives:

(3.72) a. ?[John Boehner] **was smart enough** to leave once he saw the direction his party was going.

b. ?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.

Enough and *too* predicates are related to implicative verbs insofar as they "must sometimes be understood in an implicative, sometimes in a non-implicative sense" (Karttunen, 1971, p.354). As we will see in the next chapter, some of this variability is governed by aspect; the implicative behaviour of certain *enough/too* predicates shows the same sensitivity to aspect as the implicative inferences of ability modals. In addition, and crucially for our current purposes, these predicates are unlike either lexical implicatives or abilitative predicates in that they have an internal compositional structure. *Enough* and *too* are complex, produced in the composition of either *enough* or *too* with a gradable adjective. This complexity represents a point of access to their internal structure which will allow us to get 'under the hood' of their implicative behaviour in a way that is impossible with simple implicative and abilitative predicates. The next chapter therefore takes up the investigation of implicativity in *enough* and *too* constructions.