A Semantic Account of Distributional Constraints on Temporal *in*-Adverbials

by

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Submitted to the Department of Linguistics and Philosophy in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 2023

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ABSTRACT

Temporal in-adverbials (TIAs) are a class of English expressions that can be exemplified with *in three days*. They are remarkable in that, depending on the syntactic position they occupy, TIAs are subject to very different distributional constraints. In some configurations, their licensing is conditioned by the lexical aspect of verbal predicates. In others, these expressions are negative polarity items. Though both varieties of TIAs have been discussed extensively in the semantics literature (Gajewski, 2005, 2007; Hoeksema, 2006; Iatridou and Zeijlstra, 2017, 2021; Krifka, 1989, 1998), no attempt has been made to understand the relationship between the two. I offer a unified semantic analysis of TIAs, which derives from semantic principles their eclectic distributional constraints.

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Acknowledgments

Although mine is the name listed on the cover, so many of the ideas within are owed to others. In no particular order, I wish to give credit where credit is due. I have doubtless failed to include a great many people who are owed their thanks here; for this I apologize.

Let me begin by thanking the members of my committee. Kai von Fintel has kept me honest throughout the writing of this dissertation. He was always quick to shine light on those details I worked so hard to obscure. The pages of comments he gave me were worth their weight in gold. My meetings with Danny Fox were some of the most challenging discussions I have participated in. In the course of these discussions, the inklings I brought were forged into sharp insights. Martin Hackl provided me with the freedom to fully explore the scope of my proposals. His were always the first ears (and often the only ones) to hear some of the deeper motivations behind this work. Last, but not least, is Sabine Iatridou. It is through my many discussions with her that were planted the very earliest seeds of this work. Her faith in me throughout the years, when I so often lacked it in myself, was instrumental to the completion of this work. Thank you so much to the four of you!

A special debt of gratitude is owed to Edward Flemming, Norvin Richards, and Roger Schwarzschild, who formed my generals committee. In this function, they bore witness to the earliest version of this work. Their questions and comments laid the foundations for this dissertation.

I must also thank my earliest mentors, Bernhard Schwarz and Luis Alonso-Ovalle. Both of them took me under their wings and showed me the ropes. I will never forget the generosity I received from them.

I wish to mention the many friendships I was lucky enough to form throughout my years at MIT. For good times, I want to thank Daniel Asherov, Tanya Bondarenko, Colin Davis, Patrick Elliott, Enrico Flor, Filipe Hisao Kobayashi, Chiara Masnovo, Patrick Niedzielski, Christopher Yang, and Stanislao Zompì. I also want to thank Jennifer, who made enjoyable what were to be two unbearable last months. Finally, I want to give special thanks to Yourdanis Sedarous for a friendship near and dear to my heart. Thank you, Yourdanis, for always lending me your ears.

This section would not be complete if I did not express my gratitude towards my parents. Even in the face of my most ungrateful moments, they showed me great patience. They are to thank for many of my few qualities, and to blame for few of my many flaws. Merci pour tout papa et maman, je pourrai jamais vous rendre la dette que je vous dois!

Finally, I would like to thank you, dear reader, for picking up this work. I ask only of you that you be patient with it, and hope you will find that its few qualities redeem its many flaws.

Contents

Chapter 1

Two Adverbials, One Meaning

1.1 Introduction

The focus of this work is on the distribution of *temporal in-adverbials* (TIAs). Within this class of English expressions, I concentrate my efforts on those of the form "in ν μ", where ν μ is a measure phrase composed of a numeral ν and a measure word μ (e.g. *in three days*). To set the stage for the theoretical discussions to follow, I begin by calling attention to two distinct uses of TIAs. The sentences in (1) exemplify the first of these, which I refer to as **eventuality measuring TIAs** (E-TIAs).

(1) a. Mary wrote up a chapter in three days.
  b. *Mary was sick in three days.

E-TIAs specify the duration of eventualities.[1] The sentence in (1-a) can be loosely paraphrased as asserting the existence of a three day long eventuality of Mary writing up a chapter.[2] A particularity of E-TIAs is that their grammaticality, at least in the perfective aspect, depends on the temporal constitution of the predicate they combine with, i.e. whether a predicate is **telic** or **atelic**.

[1] *Eventuality* serves as an umbrella terms for events, states, or any sort of object in the extension of a verbal predicate (Bach, 1986).

[2] We'll see in §1.3 that (1-a)'s meaning is better described as asserting that there was an eventuality of Mary writing up a chapter that lasted three days *or less*.

The contrast between (1-a) and (1-b) illustrates that while E-TIAs are licensed in a sentence where the VP denotes a telic predicate (e.g. *wrote up a chapter*), they cannot appear when the predicate it denotes is atelic (e.g. *was sick*).[3]

In (2), I exemplify the use of TIAs I call **gap measuring TIAs** (G-TIAs).

(2) a. *Mary has been sick in three days.
 b. Mary hasn't been sick in three days.

In (2-b), *in three days* doesn't tell us anything about the duration of a sickness eventuality. Rather, the adverbial is best understood as specifying the duration of the gap between the time of utterance and the last time Mary was sick.[4,5] The contrast between (2-a) and (2-b) reveals that while G-TIAs are ungrammatical in simple positive sentences, negation will license them. They can thus be considered **negative polarity items** (NPIs).

At first glance, the data in (1) and (2) invite treating E- and G-TIAs as fundamentally different linguistics expressions. The two come apart not only in terms of what they contribute to the meaning of a sentence, but also in terms of the constraints that govern their respective distributions. Unlike a G-TIA, the E-TIA in (1-a) is perfectly happy without negation. Similarly, unlike an E-TIA the G-TIA in (2-b) is grammatical in spite of the VP denoting an atelic predicate. Given these facts, it should come as no surprise that the literature has seen no attempt at a unified semantics of the two (Gajewski, 2005, 2007; Hoeksema, 2006; Iatridou & Zeijlstra, 2017, 2021; Krifka, 1989).

The whole of this work has as its primary purpose to argue in favor of a

[3]Telic and atelic predicates differ in terms of whether or not eventualities in their extensions must culminate in a change of state. On the one hand, Mary writing up a chapter implies a change to a state where a chapter is finished. On the other, an eventuality of Mary being sick doesn't imply a change of state; if Mary was sick yesterday, that sickness could still go on today.

[4]As we'll see in §1.3, there isn't a requirement that there actually be a sickness eventuality at the start of the gap.

[5]We can't treat the G-TIA in (2-b) as an E-TIA measuring an eventuality of not being sick. On the one hand, the predicate of such eventualities is arguably stative. This E-TIA would thus exceptionally be combining with an atelic predicate. On the other, E-TIAs and G-TIAs come apart in that the boundaries of the intervals the latter measure are always given. While (2-b) asserts when the gap being measured starts and ends, the start and end of the interval measured in (1-a) aren't specified.

unified semantic treatment of E- and G-TIAs. As I hope to show, this will offer insight into the semantic factors responsible for both the interaction of E-TIAs with the temporal constitution of predicates, as well as the polarity sensitivity of G-TIAs. In this chapter, I take the first steps towards a unified semantics for TIAs. I argue that a fundamental difference between E- and G-TIAs is their syntactic locus. I show that, once we understand the semantics of the different environments where each class of adverbial appears, we can offer a very simple meaning for *in* that correctly derives the meanings of both the E-TIA in (1-a), and the G-TIA in (2-b).

In §1.2, I present arguments for distinguishing E- and G-TIAs in terms of their syntactic environments: an E-TIA modifies a VP, whereas a G-TIA is in a position in proximity of the perfect. In §1.3, I flesh out the details of a unified compositional semantics of the two. §1.4 concludes with the challenges ahead.

1.2 The Syntactic Loci of TIAs

1.2.1 E-TIAs, G-TIAs, and the Perfect

In this section, I highlight the importance of the perfect in the licensing G-TIAs. Let's make this point by first highlighting the fact that polarity and E-TIAs don't interact. Take first the sentence in (3-a) and its negative counterpart in (3-b).

(3) a. Mary wrote up a chapter in three days.
b. Mary didn't write up a chapter in three days(, but in two).

In §1.1, we discussed how the E-TIA in (3-a) is acceptable with the telic predicate *wrote up a chapter*. While perhaps slightly odd out of the blue context, the TIA in (3-a)'s negation is perfectly grammatical. Any trace of oddness can be removed by the addition of *but in two*, which makes it clear that the adverbial is being interpreted as an E-TIA. Indeed, with or without this addition, the sentence in (3-b) can only be interpreted as saying that the duration of Mary's writing eventuality didn't last three days. There is no G-TIA reading, which would say that the gap between the time of utterance and Mary's last writing eventuality lasted three days. Polarity thus has no effect on the grammaticality of E-TIAs with telic predicates.

We can similarly show that polarity doesn't impact the acceptability of E-TIAs with atelic predicates. The sentence in (4-b) is as ungrammatical as its negatum in (4-a), and no improvement whatsoever comes from adding *but in two* to it.

(4) a. *Mary was sick in three days.
    b. *Mary wasn't sick in three days(, but in two).

Now, observe that the sentences in (4) and (5) differ only insofar as the former are in the simple past, while the latter are in the present perfect. This small difference is enough to change whether polarity affects the grammaticality of the sentences: unlike with the sentences in (4), polarity does affect the the grammaticality of the sentences in (5).

(5) a. *Mary has been sick in three days.
    b. Mary hasn't been sick in three days.

Whereas (5-a) is ungrammatical, the TIA is acceptable with negation in (5-b), and this in spite of the fact that the verbal predicate is atelic. However, the adverbial in (5-b) can only be interpreted as a G-TIA: while the sentence can mean that there is a three days gap between the moment of utterance and the last eventuality of Mary being sick, it's meaning cannot be that Mary wasn't sick for a period of three days. The crucial factor in distinguishing between the unacceptability of the TIA in (4-b) and its acceptability in (5-b) is the fact that the latter is in the perfect. [6]

[6] While the two sentences also differ in terms of their tense, the former being the past and the latter the present, changing the tense of (5-a) and (5-b) to the past, as in (6), has no impact on our acceptability judgments.

(6) a. *Mary had been sick in three days.
    b. Mary hadn't been sick in three days.

We introduced this chapter by pointing out some distributional restrictions on E- and G-TIAs. We saw that, unlike G-TIAs, E-TIAs cannot combine with atelic predicates. We also saw that, unlike E-TIAs, G-TIAs are polarity sensitive items. We can add to the distributional restrictions on G-TIAs the fact that, unlike E-TIAs, they cannot appear without the perfect. As will soon become clear, it is essential that we understand the semantic role played by the perfect if we wish to understand the semantic differences between E- and G-TIAs (and by extension to propose a semantic unification of the two). Before moving on to the next section, where we will begin discussing the perfect, I want to highlight a methodological point by looking at the sentence in (7). Observe that it doesn't contain an atelic predicate, isn't a simple positive sentence, and is in the perfect.

(7) Mary hasn't written up a chapter in three days.

Since the verbal predicate of the sentence isn't atelic, we should expect it to license E-TIAs. Since the sentence contains a negation and is in the perfect, it should license G-TIAs. We thus expect the sentence to be ambiguous between the reading in (8-a), where *in three days* is an E-TIA, and the one in (8-b), where it is a G-TIA. This is indeed what we observe.

(8) a. It hasn't taken Mary three days to write up a chapter.
b. Mary hasn't written up any chapters within the last three days.

Since this sort of ambiguity exists with TIAs, I will avoid ambiguous sentences unless they help underscore a theoretical point. Thus, whenever I wish to discuss the properties of E-TIAs, I will normally use examples that aren't in the perfect. Whenever it is the properties of G-TIAs that I wish to discuss, the VPs in my examples will normally denote atelic predicates.

1.2.2 The Perfect Time Span

Understanding the difference in the meanings of E- and G-TIAs requires understanding the semantics of the perfect. Following much literature on the subject, I take the perfect to introduce an interval to which the situation time (i.e. the time of the matrix eventuality) is related (Heny, 1982; Iatridou et al., 2003; McCoard, 1978; Richards, 1982). Different authors give this interval different names; I adopt Iatridou et al.'s terminology and refer to it as the **perfect time span** (PTS).[7] Different elements of a sentence fix the PTS's left-boundary (LB) and right-boundary (RB). Let's review what has been said about the perfect by first looking at the example of the present perfect sentence in (9).

(9) Mary has been sick exactly three times since her birth.

In loose terms, (9)'s meaning can be described as asserting that Mary was sick exactly three times between her birth and the moment of the sentence's utterence.[8] With what was just said about the perfect, we can rephrase it as asserting that the PTS, whose LB is her birth and whose RB is the moment of utterance, includes exactly three eventualities of Mary being sick. Figure 1.1 depicts a scenario that verifies (9). Here, each counted period of sickness is marked by a square containing the letter *e*, for *eventuality*.

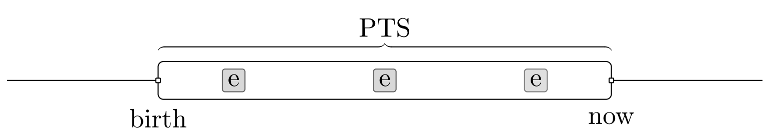

Figure 1.1: Scenario verifying (9)

Heny, Iatridou et al., and Richards all take the role of tense in the perfect to be that of fixing the RB of the PTS. Its LB can be fixed explicitly by an adverbial, or implicitly by the context (Iatridou et al., 2003). In (9), its LB is thus set by the adverbial *since her birth*, while its RB is set by the present

[7]As we will discuss later, it is better to think of the perfect as quantifying over a class of candidates PTSs than as referencing a specific interval.

[8]It is far from obvious by what mechanism *exactly three times* is counting instances of Mary being sick. As already mentioned, a given sickness eventuality can itself be made up of shorter instances of sickness. To avoid overcounting, Kai von Fintel (p.c.) suggests counting something like maximal disjoint intervals of sickness. See von Fintel (2005) for further discussion of this problem.

tense. Compare now (9)'s meaning with that of its past and future perfect counterparts. Consider first the past perfect sentence in (10).

(10) (At her graduation,) Mary had been sick exactly three times since her birth.

Like (9), the sentence in (10) states that Mary was sick exactly three times in the PTS. However, (9) and (10) differ in terms of the RB of their respective PTSs. The former says that Mary was sick three times between her birth and the moment of utterance. The latter tells us that Mary was sick three times between her birth and some point before the moment of utterance. While the present tense fixes the PTS's RB at the moment of utterance, the past tense does so at some time preceding it. What exactly this past time is can be made explicit with the addition of a frame adverbial like *at her graduation*. Notice here that (10) presupposes that Mary has already graduated by the time of utterance. The scenario depicted in Figure 1.2 verifies the past perfect sentence in (10), but not the present perfect one in (9).

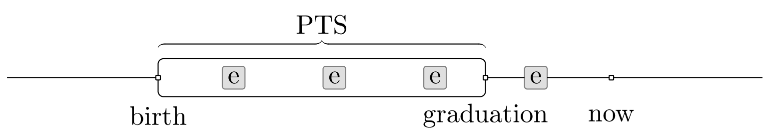

Figure 1.2: Scenario verifying (10)

Finally consider the future perfect counterpart of (9) and (10), in (11).

(11) (At her hooding,) Mary will have been sick exactly three times since her birth.

The only difference between this sentence and the others is again the PTS's RB. Here, the three instances of sickness are contained between Mary's birth and some time after the moment of utterance. As in the case of the past perfect, a frame adverbials like *at her hooding* can explicitly set the PTS's RB. Similar to how the frame adverbial in (10) led to the presupposition that Mary's graduation already took place, the one in (11) triggers the presupposition that her hooding has yet to take place. Figure 1.3 depicts a scenario that verifies (11), but where (9) and (10) are both false.

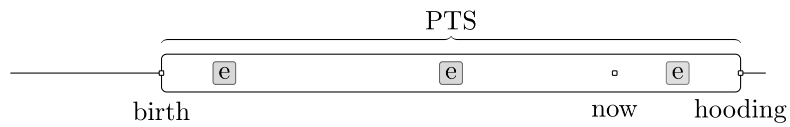

Figure 1.3: Scenario verifying (11)

The perfect in (9)-(11) never specifies when in the PTS the three periods of sickness occurred. While in Figure 1.3 some occur before the moment of utterance and others after it, the sentence in (11) would be true irrespective of whether all three occurred before or after the moment of utterance.

Let's finally note that in the absence of an adverbial explicitly setting the PTS's LB, such as *since her birth*, it will be fixed by the context (Iatridou et al., 2003). In (12), for example, it could be Mary's birth, the start of the academic year, or perhaps the start of the semester; whichever it is depends on what is salient in the context.

(12) Mary has been sick exactly three times.

1.2.3 Eventuality-level and Perfect-level Adverbials

The distinction between E- and G-TIAs can be understood in terms of the distinction between what are called **eventuality-level adverbials** and **perfect-level adverbials**. The terms *eventuality-level* and *perfect-level* reflect two points of divergence between these classes. Firstly, they reflect the kinds of intervals each class tells us about: eventuality-level adverbials tell us about the durations of eventualities, perfect-level adverbials tell us about the PTS. Secondly, as indicated by the use of the word *level*, the terminology reflects that the two differ in terms of their syntactic locus.I assume the clausal spine in (13).[9]

(13) Tense > Perfect > Aspect > VP

[9] I defer to §1.3 any discussion of aspect.

Since VPs are typically taken to denote predicates of eventualities, eventuality-level adverbials are naturally assumed to adjoin to them. The syntactic locus of perfect-level adverbials, on the other hand, is assumed to be in proximity of the perfect. However, following closely the analysis of perfect-level adverbials in von Fintel & Iatridou (2019) analysis, I won't be assuming that they modify the perfect directly.

Because the perfect outscopes the VP in (13), we expect perfect-level adverbials to scope higher than their eventuality-level counterparts. We can, in fact, use a number of syntactic tests to show this. Let's begin by looking at *for*-adverbials, which are thought to be able to take on either role (Vlach, 1993; Iatridou et al., 2003). Consider the sentence in (14), and its two available readings in (14-a) and (14-b).

(14) Mary has been sick for three days.

- a. At some point, Mary was sick for a period of three days.
- b. Mary was sick throughout the last three days.

There is a question as to whether or not the readings in (14-a) and (14-b) reflect a true ambiguity: if Mary was sick throughout the last three days, this entails that she was sick for three days at some point in the past. We could think that the only interpretation available to the sentence is (14-a), whereas (14-b) is nothing more than its limiting case. Dowty (1979) famously showed that *for*-adverbials can give rise to the reading in (14-b) independently of (14-a). He observed that fronting the adverbial, as in (15), disambiguates the sentence: only the reading in (14-b) remains here.

(15) For three days, Mary has been sick.

- a. #At some point, Mary was sick for three days.
- b. Mary was sick throughout the last three days.

To be sure, this argument doesn't show that (14) itself is ambiguous; it could still be that a sentence-final *for*-adverbial only really has the reading in (14-a). To show that there sentence is a *bona fide* ambiguity in the sentence, we can simply embed it in an entailment reversing environment, e.g. the restrictor of a universal quantifier. If (15) only had the reading in (15-a), (16) should also only have the reading in (16-a). Observe, however, that the sentence is judged true in scenarios where (16-b) is true but not (16-a). Since (16-a) strictly entails (16-b), this is only possible if (16-b) is an independently available reading. This confirms that (15) must indeed have both readings.

(16) Every student who has been sick for three days must rest.

a. Every student who at some point was sick for a period of three days must rest.

b. Every student who was sick throughout the last three days must rest.

We can make sense of the ambiguity in (14) in terms of the eventuality- and perfect-level distinction. On the reading in (14-a), the sentence says that within the PTS, whose LB is contextually determined and whose RB is the moment of utterance, there was a three day long eventuality of Mary being sick. The *for*-adverbial thus contributes a measure for the sickness eventuality, supporting the idea that it is an eventuality-level adverbial. Figure 1.4 depicts a prototypical scenario verying the sentence on this reading.

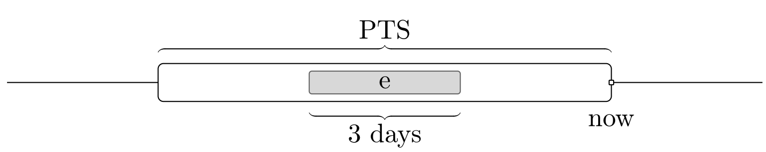

Figure 1.4: Scenario verifying an eventuality-level reading of (14)

Let's now turn to the reading in (15-b). Iatridou, Anagnostopoulou, & Izvorski (IAI ; 2003) argue that the lack of ambiguity in (15) is the result of a general principle determining the syntactic locus of sentence-initial adverbials. They argue that when an expression that is normally able to serve as either an eventuality- or a perfect-level adverbials is sentence-initial, only the higher of the two syntactic positions is available to it (i.e. the perfect-level position). If this is right, the unavailability of an eventuality-level reading in (15) results from *for three days*'s ability to be a perfect-level adverbial. We can lend support to this claim if we observe that, in the absence of the perfect, a sentence-initial *for*-adverbial has an eventuality-level interpretation. Take the example of the sentence in (17-a). Since the sentence isn't in the perfect, *for three days* cannot be a perfect-level adverbial. If we make *for three days* sentence initial here, IAI's constraint won't block its eventuality-level reading. We indeed observe that, unlike in (15), the *for*-adverbial in (17-b) clearly has the eventuality-level interpretation.

(17) a. Mary was sick for three days.
b. For three days, Mary was sick.

Like other expressions in this position, IAI take perfect-level *for*-adverbials to set the PTS's LB. On this interpretation, *for three days* fixes the LB of (14)'s PTS at three days prior to its RB. We can restate this readings as saying that throughout the PTS, which lasted three days counting back from the moment of utterance, Mary was sick. A scenario verifying this reading of the sentence is depicted in Figure 1.5.

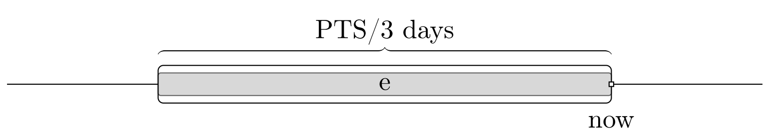

Figure 1.5: Scenario verifying a perfect-level reading of (14)

Just like we modeled the ambiguity of (14) in terms of the scope of *for three days*, we can make sense of the E- and G-TIA readings of (18) in terms of the scope of *in three days*.

(18) Mary hasn't written up a chapter in three days.
a. It hasn't taken Mary three days to write up a chapter. (E-TIA)
b. Mary hasn't written up any chapters within the last three days. (G-TIA)

As an E-TIA, it is intuitive to think of *in three days* as an eventuality-level adverbial. On the reading in (18-a), the TIA tells us about the durations of eventualities of Mary being sick: it say that no such eventuality is included in the PTS lasted three days. A scenario like the one depicted in Figure 1.6, where e is now a four day long eventuality of Mary writing up a chapter, would verify this reading.

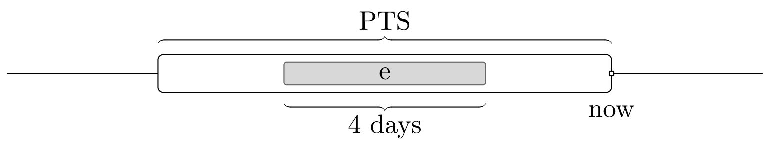

Figure 1.6: Scenario verifying (18) on an eventuality-level reading

Filipe Hisao Kobayashi (p.c.) suggests to me a test that further supports attaching this reading to the eventuality-level position. In the second part of (19), the VP is fronted with the TIA. Observe that here, it lacks the G-TIA reading.

(19) Mary has successfully accomplished many feats recently, but write up a chapter in three days she hasn't.

a. It didn't take Mary three days to write up a chapter. (E-TIA)

b. #Mary didn't write up any chapters in the last three days. (G-TIA)

Extracting the TIA with the VP ensures that it is one of its subsconstituents. The unavailability of a G-TIA reading in (19) is explained by the fact that *in three days* can only be an eventuality-level adverbial here.

Iatridou & Zeijlstra (2017) and Iatridou & Zeijlstra (2021) are, to my knowledge, the first to highlight the fact that G-TIAs are perfect-level adverbials. Like all such adverbials, their role is also to set the PTS's LB. Hence, on the reading of (18) where *in three days* is a G-TIA, it sets the LB of the PTS at three days prior to its RB, i.e. the moment of utterance. The sentence is best paraphrased as saying that, within this PTS, there were no eventualities of Mary writing up a chapter. A scenario like the one depicted in Figure 1.7, where the last eventuality of Mary being sick abuts the PTS, verifies this reading. The sentence would, of course, also be true in scenarios where the sickness ended earlier than three days prior to the moment of utterance.

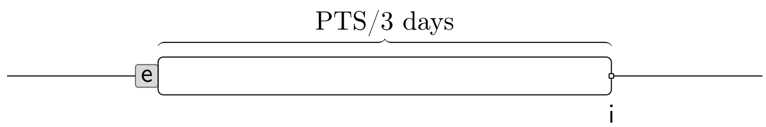

Figure 1.7: Scenario verifying a perfect-level reading of (18)

Given the constraint on the interpretation of sentence-initial adverbials presented in IAI, we predict that fronting just the TIA in (18) will block its having an E-TIA reading. This is exactly what we observe in (20), which lends further support to viewing G-TIAs as perfect-level adverbials.

(20) In three days, Mary hasn't written up a chapter.

a. #It didn't take Mary three days to write up a chapter. (E-TIA)

b. Mary didn't write up any chapters in the last three days. (G-TIA)

I want to propose a final test that we can use to probe the syntactic difference between E- and G-TIAs. This test comes from stacking two TIAs, as in (21-a) and (21-b).

(21) a. Mary hasn't written up a chapter in three days in two weeks.

b. #Mary hasn't written up a chapter in two weeks in three days.

In both sentences, the adverbial closest to the VP must be an E-TIA, whereas the one furthest away must be a G-TIA. This can explain the contrast in the felicity of (21-a) and (21-b). The former says that in the PTS, whose RB is the moment of utterance and whose LB is two weeks before that, Mary didn't write any chapter in three days. This is a perfectly sensible meaning. On the other hand, (21-b) says that within the PTS, whose RB is the moment of utterance and whose LB is three days before that, Mary didn't write any chapters in two weeks. The sentence's oddness comes from its being a tautology: a two week long eventuality cannot be included in a three day long interval. The correspondence between the interpretation of a TIA and its proximity to the VP strengthens the point that there is a fundamental syntactic difference between E- and G-TIAs.

1.3 A Unified Semantics for TIAs

1.3.1 Technical Background

Following Link (1983), I assume that the members of the domain of entities $\mathcal{D}_e$ include both singularities like Mary (m), Sue (s), and John (j), as well as all the pluralities obtained from summing up these entities with the operation $\oplus_e$.[10] $\mathcal{D}_e$ is closed under the $\oplus_e$ operation, and the parthood relation $\sqsubseteq_e$ on D_e (which is defined in terms of $\oplus_e$) is a complete join-semilattice with its bottom element removed.[11]

In addition to assuming a domain for entities, my semantics relies on there being a domain of eventualities $\mathcal{D}_v$, a domain of moments $\mathcal{D}_m$, a domain of intervals of time $\mathcal{D}_i$, a domain of degrees $\mathcal{D}_d$, a domain of possible worlds $\mathcal{D}_s$, and a domain of truth-values $\mathcal{D}_t$. I assume a bivalent semantics, where $\mathcal{D}_t = \{\mathcal{T}, \mathcal{F}\}$.

Like Krifka (1989), I assume that $\mathcal{D}_v$ is closed under the operation $\oplus_v$, which is formally analogous to $\oplus_e$. Similarly, D_v is partially ordered by $\sqsubseteq_v$, which stands in the same relation to $\oplus_v$ as $\sqsubseteq_e$ does to $\oplus_e$.

The elements of $\mathcal{D}_m$ are totally ordered by the relation of temporal precedence $\preceq_m$, and by its strict counterpart $\prec_m$. The members of D_i can be thought of as convex sets of moments.[12] We can define a partial order $\preceq_i$ on

[10]The operation $\oplus_e$ is assumed to be idempotent ($x \oplus_e x = x$), commutative ($x \oplus_e y = y \oplus_e x$), and associative ($(x \oplus_e y) \oplus_e z = x \oplus_e (y \oplus_e z)$).

[11]$x \sqsubseteq_e y$ iff $\exists z[x \oplus_e z = y]$.

[12]$\forall t \in \mathcal{D}_i \forall m^1, m^2, m^3 \in \mathcal{D}_m[(m^1 \in t \wedge m^3 \in t \wedge m^1 \prec_m m^2 \prec_m m^3) \rightarrow m^2 \in t]$.

intervals, whereby $t^1 \preceq_i t^2$ iff each of t^1's moments precedes each of t^2's.[13] We also have the strict counterpart $\prec_i$ of $\preceq_i$, whereby $t^1 \prec t^2$ iff each of t^1's moments strictly precedes each of t^2's.[14]

To keep things easy, I take $\mathcal{D}_d$'s members to just be the positive rational numbers, $\mathbb{Q}^+$. The identification of degrees with numbers should not be seen as a serious theoretical commitment, but instead as a notational convenience. I assume that the members of $\mathcal{D}_d$ stand in relation to one another in terms of the dense total $\leq_d$, and its strict counterpart $<_d$.

In addition to the basic types e, v, i, d, s, and t, we can define derived types through a recursive procedure (I don't assume that there are any expressions of type m, nor any expressions of a type derived from m). For any two types σ and τ, we have the type $(\sigma\tau)$. As a notational convention, parentheses will be dropped as much as possible around types, which are right-associative. The type of quantificational determiners $((et)((et)t))$, for example, will be rendered as simply $(et)(et)t$. This is the type of functions that take in an argument of type et, and output a function that takes inputs of type et and outputs something of type t. For every derived type $\sigma\tau$, $\mathcal{D}_{\sigma\tau}$ is the domain of functions of that type.

The interpretation function $[\![\cdot]\!]^{w,u,g}$, which maps linguistic expressions to their extensions, is parameterized by a world of evaluation w, a time of evaluation u, and an assignment function g. For the purposes of this work, we can assume that when we interpret a sentence, u is always assigned to the (degenerate) interval that contains just the sentence's moment of utterance. I assume the assignment function g to be a surjection from indices to the member of the union of the domains of each type. As a convention, parameters will be dropped from $[\![\cdot]\!]^{w,u,g}$ whenever they are inconsequential to the interpretation of a linguistic expression. The intensions of linguistic expressions are obtained by abstracting over the world variable on the interpretation function: for any expression $\mathbf{X}$, its intension is $\lambda w.[\![\mathbf{X}]\!]^{w,u,g}$. To minimize clutter, we can say that $[\![\mathbf{X}]\!]^{u,g}_{¢} = \lambda w.[\![\mathbf{X}]\!]^{w,u,g}$. I assume that composition proceeds via the rules

[13] $t^1 \preceq_i t^2$ iff $\forall m^1 \in t^1 \forall m^2 \in t^2 [m^1 \preceq_m m^2]$.

[14] $t^1 \prec_i t^2$ iff $\forall m^1 \in t^1 \forall m^2 \in t^2 [m^1 \prec_m m^2]$

of functional application (FA), (generalized) predicate modification (PM), and predicate abstraction (PA) from Heim & Kratzer (1998), and via intensional functional application (IFA) from von Fintel & Heim (2011).[15] In Chapter 3, I will also be defining the function $\{\!|\cdot|\!\}^{u,g}$, which maps a linguistic expression to the intensions of its formal alternatives.

I will switch freely between function-talk and set-talk when discussing objects of type σt. I may thus describe $\lambda\alpha_\sigma.\phi$, where ϕ is a statement, as either the smallest function that outputs $\mathcal{T}$ given β iff $\phi[\alpha \mapsto \beta]$ holds, or as the set of every β such that $\phi[\alpha \mapsto \beta]$ holds. As a final convention, I will write "$[\lambda\alpha_\sigma.\phi](\beta) = \phi[\alpha \mapsto \beta]$" as shorthand for "$[\lambda\alpha_\sigma.\phi](\beta) = \mathcal{T}$ iff $\phi[\alpha \mapsto \beta]$".

1.3.2 Eventualities, intervals, and maps

In §1.2, I characterized the semantic difference between E- and G-TIAs as follows: E-TIAs measure the duration of eventualities, while G-TIAs set the LB of the PTS. We can take our first step toward a unified semantics for TIAs by recognizing that both kinds are just measuring out intervals. Indeed, note first that it is only in a loose sense that we say that an E-TIA measures the duration of an eventuality. Only time intervals have duration, and what an E-TIA measures is the **runtime** of an eventuality, i.e. the interval that corresponds to when in time it took place. Observe next that, since the RB of the PTS is always given by the tense, saying that the G-TIA *in three days* fixes the PTS's LB at three days before its RB is tantamount to saying that it measures out the PTS as being three days long.

[15]The rules of composition are defined below.

$$\begin{array}{lll}
\text{FA:} & [\![\mathbf{X}\ \mathbf{Y}]\!]^{w,u,g} := [\![\mathbf{X}]\!]^{w,u,g}([\![\mathbf{Y}]\!]^{w,u,g}) & \text{if } [\![\mathbf{X}]\!]^{w,u,g} :: \sigma\tau \text{ and } [\![\mathbf{Y}]\!]^{w,u,g} :: \sigma \\
 & [\![\mathbf{X}\ \mathbf{Y}]\!]^{w,u,g} := [\![\mathbf{Y}]\!]^{w,u,g}([\![\mathbf{X}]\!]^{w,u,g}) & \text{if } [\![\mathbf{X}]\!]^{w,u,g} :: \tau \text{ and } [\![\mathbf{Y}]\!]^{w,u,g} :: \sigma\tau \\
\text{PM:} & [\![\mathbf{X}\ \mathbf{Y}]\!]^{w,u,g} := \lambda\alpha_\sigma.[\![\mathbf{X}]\!]^{w,u,g}(\alpha) \wedge [\![\mathbf{Y}]\!]^{w,u,g}(\alpha) & \\
 & & \text{if } [\![\mathbf{X}]\!]^{w,u,g} :: \sigma t \text{ and } [\![\mathbf{Y}]\!]^{w,u,g} :: \sigma t \\
\text{PA:} & [\![i\ \mathbf{X}]\!]^{w,u,g} := \lambda\alpha_\sigma.[\![\mathbf{X}]\!]^{w,u,g[i\mapsto\alpha]} & \text{if } g(i) :: \sigma \\
\text{IFA:} & [\![\mathbf{X}\ \mathbf{Y}]\!]^{w,u,g} := [\![\mathbf{X}]\!]^{w,u,g}([\![\mathbf{Y}]\!]^{u,g}_{¢}) & \text{if } [\![\mathbf{X}]\!]^{w,u,g} :: (s\sigma)\tau \text{ and } [\![\mathbf{Y}]\!]^{w,u,g} :: \sigma \\
 & [\![\mathbf{X}\ \mathbf{Y}]\!]^{w,u,g} := [\![\mathbf{Y}]\!]^{w,u,g}([\![\mathbf{X}]\!]^{u,g}_{¢}) & \text{if } [\![\mathbf{X}]\!]^{w,u,g} :: \sigma \text{ and } [\![\mathbf{Y}]\!]^{w,u,g} :: (s\sigma)\tau
\end{array}$$

Though both kinds of TIAs measure intervals, a complication arises from the fact that, while G-TIAs measure out the PTS directly, the VPs modified by E-TIAs don't have direct access to the runtimes of eventualities. This raises two problems for a unified semantics of TIAs. On the one hand, because VPs denote sets of eventualities, E-TIAs need to know that they must look at the *runtimes* of those eventualities. On the other, since the PTS is already an interval, G-TIAs must know to simply measure the PTS *itself*.

To solve this problem, I introduce what Champollion (2017) calls **map functions**: these are functions that take elements from one domain and map them onto those of another. I will be assuming that the extension of *in* is a function that always takes a map function as its first argument. In the case of E-TIAs, the argument map is always τ_w, the runtime (or temporal trace) function. This function maps any eventuality to its runtime. With this map, E-TIAs will know to measure the runtimes of the eventualities in the VP they modify. In the case of G-TIAs, I simply assume the map function to be the identity function id, which maps any object onto itself. As we'll see, what this does is more or less to tell a G-TIA that it must measure the PTS directly. I will implement the assumption that the extension of *in* takes a map function as its first argument by having its sister be a covert expression denoting a map. In the context of an E-TIA, the covert expression RUNTIME. In the context of a G-TIA, it is ID.

(22) a. $[\![\text{RUNTIME}]\!]^w := \tau_w$
b. $[\![\text{ID}]\!] := \mathsf{id}$

It's worth noting that there is independent evidence in favor of TIAs needing a mechanism to map elements from one domain onto those of another. This becomes evident when we look at examples like (23).

(23) We haven't seen a gas station in thirty miles.

While *miles* measures out elements from the spatial domain, *in thirty miles* behaves here like your run of the mill G-TIA. As (24-a) and (24-b) show, it both requires the perfect and negation in order to be licensed.

(24) a. *We didn't see a gas station in thirty miles.
b. *We have seen a gas station in thirty miles.

Furthermore, the meaning we intuit for (23) is one where *in three days* is giving us the LB of the PTS. It asserts that between the time of evaluation and the time at which we were thirty miles away from where we are now, we have seen no gas stations. Map functions offer a simple way to derive this meaning: the thirty miles are mapped to the time it took to cross them, and it is this time that corresponds to the duration of the PTS.

1.3.3 The Monotonicity of E-TIAs

Before fleshing out a compositional analysis of the meaning of E-TIAs, we first need to be clear on what that meaning is. It is important to realize that the basic meaning of *in three days* is not the same as that of *in exactly three days*. If it were, the sequence in (25-a) would be contradictory.

(25) a. Mary wrote up a chapter in three days. What's more, she wrote it in two.
b. Mary wrote up a chapter in three days. #What's more, she wrote it in four.

The consistency of the sequence in (25-a) demonstrates that the extension of *wrote up a chapter in three days* can include two day long eventualities. It has been assumed since at least Dowty (1979) that the literal meaning of *in three days* is best paraphrased as *in three days or less.* Though we might infer from the first part of (25-a) that Mary's chapter writing took no less than three days, this is best though of as being a scalar implicature. This basic semantics for E-TIAs offers us an explanation for why the sequence in (25-a) is felictous, but not its counterpart in (25-b).

If we think of *what's more* as introducing the precisification of a prior statement, the material following it should add information into the discourse. If *in three days* really means *in three days or less*, and *in two days* really means *in two days or less*, then it follows that the second part of (25-a) strictly entails the first. As such, the statement following *what's more* succeeds in its goal of being informative. However, if *in four days* really means *in four days or less*, then it is the first part of (25-b) that entails the second. As such, the material following *what's more* is completely redundant, and so fails to achieve its purpose.

We can draw a comparison between the interactions of *in three days* with the material following *what's more* in (25), and the interaction of *most* with similar material in (26).

(26) a. Mary met with many students. What's more, she met with all of them.
b. Mary met with many students. #What's more, she met with some of them.

Though we normally infer from the first part of (26-a) that Mary did not meet all students, its consistency with the second part shows this to be an implicature. We can once again contrast the acceptability of the sequence in (26-a) with the infelicity of (26-b)'s second part. The material following *what's more* in (26-a) strictly entails the material preceding it, and is thus informative. However, the material following *what's more* in (26-b) is strictly entailed by the material preceding it, which explains its oddness. The behavior of *in three days* in (25) is thus parallel to that of scalar items like *many* in (26-b).

We get quite clear evidence for the basic meaning of *in three days* being *in three days or less* when we embed it in entailment reversing environments, such as the restrictor of a universal quantifier. Whereas a sentence containing *in two days* should entail its counterpart with *in three days* when unembedded, we should see this entailment reversed in the examples in (27).

(27) a. Every student who wrote up a chapter in three days passed.
b. Every student who wrote up a chapter in two days passed.

It is indeed clear that on the most salient readings of the two sentences, (27-a) strictly entails (27-b). The former clearly states that every student who wrote up a chapter in *three days or less* passed, which entails that every student who wrote up a chapter in *two days or less* did too.

It's worth noting that (27-a) can be interpreted as saying that every student who wrote a chapter in *exactly three days* passed. A similar interpretation is also available for (27-b). On these readings, the sentences are logically independent from one another. We shouldn't conclude from this that E-TIAs are ambiguous. Here too, TIAs behave just like other scalar items: while on one reading (28-a) entails (28-b), there is a reading of the first sentence where the domain of *every* is restricted to students who wrote some but not all of their chpaters. There is a similar reading available for the second. On these readings, the two sentences are also logically independent. We will return to how to explain these sorts of readings in Chapter 3.

(28) a. Every student who wrote some of his chapters passed.
b. Every student who wrote all of his chapters passed.

1.3.4 Composing E-TIAs

Now that we have an understanding of what the basic meaning of E-TIAs is, we need to arrive at it compositionally. To this end, I will here loosely follow Dowty's (1979) semantics for E-TIAs. Consider once more the sentence in (29).

(29) Mary wrote up a chapter in three days.

We described the sentence as asserting the existence of an eventuality of Mary writing up a chapter whose runtime lasted three days or less. Dowty offers an equivalent way of stating this in terms of an inclusion relation between two intervals: the runtime of an eventuality of Mary writing up a chapter is included in a three day long interval. With this reformulation in mind, let's assume for (29) the LF in Figure 1.8.

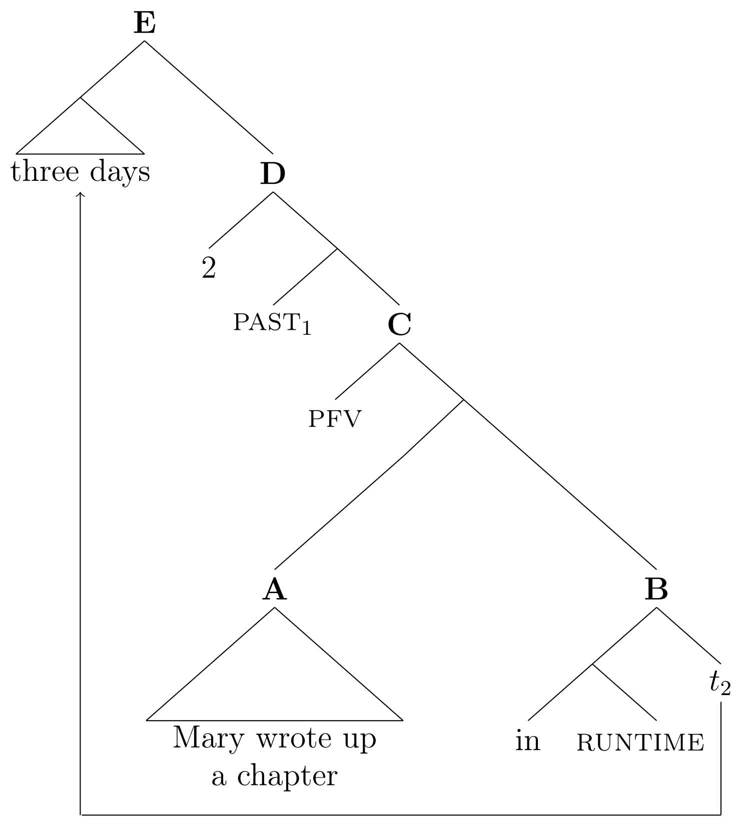

Figure 1.8: LF for (29)

I won't give a compositional analysis of the VP *Mary wrote up a chapter*, which is labeled **A**.[16] I simply treat it as denoting (the characteristic function of) the set of eventualities of Mary writing up a chapter in w. This is the extension of the metalanguage predicate mwc_w.

(30) $[\![\mathbf{A}]\!]^w \coloneqq \mathsf{mwc}_w$

This constituent is then modified by the E-TIA, which is headed by *in*. I propose a polymorphic denotation to *in*, which allows TIAs to combine with objects of different types.

(31) $[\![\text{in}]\!] \coloneqq \lambda M_{\sigma i} \lambda t_i \lambda \alpha_\sigma .\ M(\alpha) \subseteq t$

[16]I am assuming VP-internal subjects (Koopman & Sportiche, 1991; Speas, 1986; Woolford, 1991; i.a.).

The first argument of this function is a map M, which takes an object of any type σ and maps it onto an interval. It then outputs a relation between an interval t and an object α of type σ: the relation is true of t and α whenever $M(\alpha)$, the interval onto which M maps α, is included in t. The domain of this map determines the kind of TIA we end up with. In the case at hand, *in* combines with RUNTIME, which maps eventualities to their runtimes. This thus gives us an E-TIA.

Departing from Dowty, I treat the constituent *three days* as denoting a generalized quantifier ranging over intervals, i.e. an object of type $(it)t$. To avoid a type mismatch, this constituent undergoes quantifier raising to the highest position in the tree. This leaves behind the trace t_2 of type i. The consituent *in* RUNTIME t_2, which I have labelled as **B**, therefore denotes the set of eventualities (whose runtimes are) included in $g(2)$, the interval onto which g maps 2.

(32) $[\![\mathbf{B}]\!]^{w,g} = \lambda e_v.\tau_w(e) \subseteq g(2)$

Both the constituents **A** and **B** denote functions of type vt. They combine via PM, which gives us the set of mwc_w eventualities that are included in $g(2)$. Let's refer to this part of the LF as the **sentence-radical**, which is everything below the aspectual material.

(33) $[\![\mathbf{A}\ \mathbf{B}]\!]^{w,g} = \lambda e_v.\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq g(2)$

Tense and aspect relate eventualities in the sentence-radical to the time of evaluation u. In the case at hand, the aspect is the perfective (not to be confused with the perfect), while the tense is the past. The perfective is represented by the aspectual operator PFV, whose meaning is given in (34).

(34) $[\![\text{PFV}]\!]^{w} \coloneqq \lambda V_{vt}\lambda t_i.\ \exists e[V(e) \wedge \tau_w(e) \subseteq t]$

We can think of this operator as serving as semantic glue between the sentence-radical and tense: it takes a set of eventualities V and outputs the set of all intervals which include a member of V. The combination of PFV and **A B**, labelled as **C**, denotes the set of intervals which include an $\textsf{mwc}_w$ eventuality which is also included in $g(2)$.

(35) $[\![\mathbf{C}]\!]^{w,g} = \lambda t_i.\exists e[\textsf{mwc}_w(e) \wedge \tau_w(e) \subseteq g(2) \wedge \tau_w(e) \subseteq t]$

We now have a function with an argument slot for an interval, which tense can saturate. In the tree, the past tense is represented by $\textsc{past}_1$. Following Partee (1973) I assume this expression to function like a pronoun: it carries the index 1 and denotes the interval that g assigns to it. Importantly, it is also interpreted relative to the time of evaluation u: it is defined only if $g(1)$ precedes u. Nothing in my analysis hinges on assuming a referential analysis for tense, and a quantificational analysis would work the same way.

(36) a. $[\![\textsc{past}_i]\!]^{u,g}$ is defined only if $g(i) \prec_i u$.
b. When defined, $[\![\textsc{past}_i]\!]^{u,g} = g(i)$.

The extension we obtain from combining $\textsc{past}_1$ with **C** is defined only if $g(1)$ (strictly) precedes u. When defined, it is $\mathcal{T}$ iff there exists an $\textsf{mwc}_w$ eventuality included both in $g(1)$ and $g(2)$. The movement of *three days* results in the index 2 combining with **C**. Via PA, we can abstract over this index and obtain for **D** the predicate of intervals in (37).

(37) $$[\![\mathbf{D}]\!]^{w,u,g} = \lambda t_i : g(1) \prec_i u.\exists e[\textsf{mwc}_w(e) \wedge \tau_w(e) \subseteq t \wedge \tau_w(e) \subseteq g(1)]$$
$$= \lambda t_i : g(1) \prec_i u.\exists e[\textsf{mwc}_{1,w}(e) \wedge \tau_w(e) \subseteq t]$$

The definedness condition of $\textsc{past}_1$ projects, such that the function denoted by **D** is defined only if $g(1)$ precedes u. When defined, its output is $\mathcal{T}$ iff some $\textsf{mwc}_w$ eventuality is included both in $g(1)$ and t. To make things easier to read, $\textsf{mwc}_{1,w}$ will be shorthand for the predicate of $\textsf{mwc}_w$ eventualities that are included in $g(1)$.

Now we arrive at the meaning of *three days*, which I have already said is of type $(it)t$. Compositionally, I take *three* to simply output the degree 3, while *days* denotes a function that takes a degree n and outputs the set of intervals with an n day long member. The measure function $\textsf{days}$ is a total function from intervals to degrees that correspond to their duration in days.

(38) a. $[\![\text{three}]\!] := 3$
b. $[\![\text{days}]\!] := \lambda n_d \lambda I_{it}.\exists t[\mathsf{days}(t) = n \wedge I(t)]$
c. $[\![\text{three days}]\!] = \lambda I_{it}.\exists t[\mathsf{days}(t) = 3 \wedge I(t)]$

What *three days* denotes is thus an existential generalized quantifier restricted to three day long intervals. We get the final meaning of the LF by combining the meanings of *three days* and **D**.

(39) a. $[\![\mathbf{E}]\!]^{w,u,g}$ is defined only if $g(1) \prec u$.
b. When defined, $[\![\mathbf{E}]\!]^{w,u,g} = \exists t[\mathsf{days}(t) = 3 \wedge \exists e[\mathsf{mwc}_{1,w}(e) \wedge \tau_w(e) \subseteq t]]$
$= \exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

This is defined only if $g(1)$ precedes u, and, when defined, is $\mathcal{T}$ iff some $\mathsf{mwc}_{1,w}$ eventuality is included in a three day long eventuality. This is equivalent to saying that there exists an $\mathsf{mwc}_{1,w}$ eventuality whose runtime lasted three days or less, which is precisely the basic meaning we argued for. We have thus achieved our first goal of compositionally arriving at the meaning of (29).

1.3.5 Composing G-TIAs

The sentence in (40-a) asserts that in the interval whose RB is the moment of utterance and whose LB is the moment three days before that, there were no eventualities of Mary being sick.

(40) a. Mary hasn't been sick in three days.
b. ... In fact, she ceased to be sick four days ago.
c. ... In fact she was never sick at all.

Though the sentence strongly implies that Mary was sick and that her sickness ended three days ago, this inference is a scalar implicature (Iatridou & Zeijlstra, 2017, 2021). The felicity of (40-b), as a follow-up to (40-a), shows that it is consistent with the sickness having ended more than three days ago.

In fact, (40-c)'s felicity shows that it is consistent with Mary never having been sick.

In this section, I will show that the Dowty-inspired semantics assumed for E-TIAs naturally extends to G-TIAs, and derives the desired meaning. I assume for (40-a) the LF in Figure 1.9.

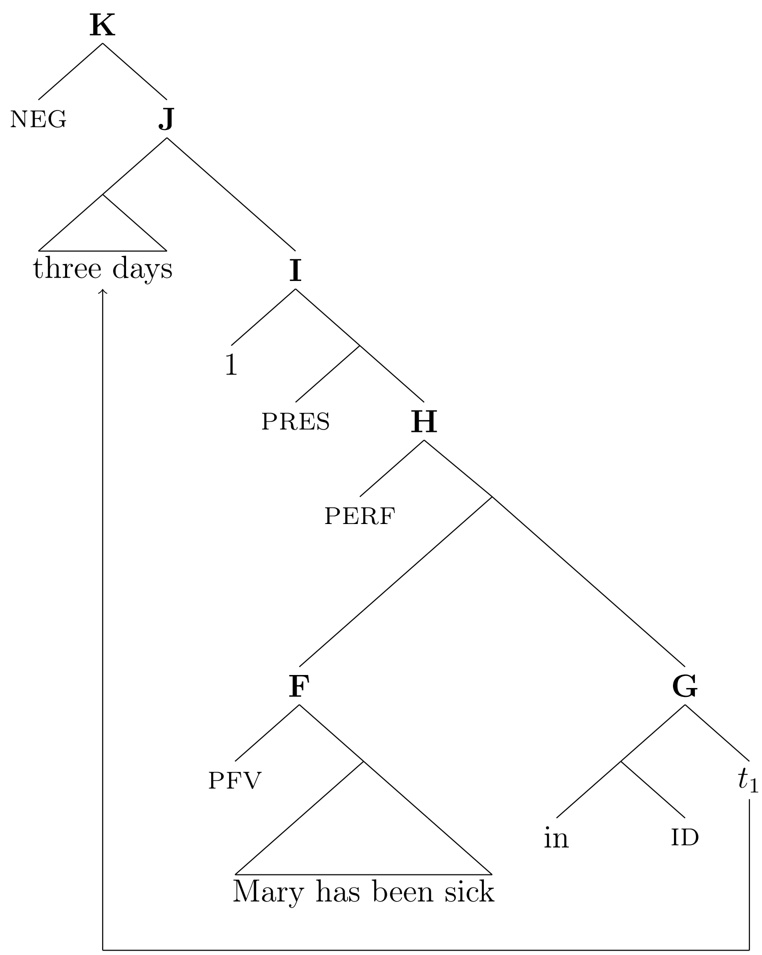

Figure 1.9: LF for (40-a)

As with E-TIAs, *three days* undergoes quantifier raising. Note two important differences between the E-TIA in Figure 1.8 and the G-TIA in Figure 1.9. The first is that it doesn't modify a VP. Rather, in keeping with assumptions made in von Fintel & Iatridou (2019), perfect-level adverbials modify the constituent headed by the aspectual head. The extension of the constituent it modifies, labeled as **F**, is given in (41).

(41) $[\![\mathbf{F}]\!]^w = \lambda t_i.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t]$

The predicate mbs denotes the set of eventualities of Mary being sick, which PFV's sister denotes. **F** is thus interpreted as the set of intervals that include an mbs eventuality.

The second difference between the TIAs is that their map functions are different. Rather than RUNTIME, we here have ID. The TIA thus denotes the set of intervals t such that $\mathsf{id}(t)$ (i.e. t itself) is included in the interval $g(1)$.

(42) $[\![\mathbf{G}]\!]^g = \lambda t_i.\mathsf{id}(t) \subseteq g(1)$
$= \lambda t_i.t \subseteq g(1)$

The extensions of nodes **F** and **G** are both functions of type *it*, and compose via PM. This gives us the set of interval that include an mbs eventuality and are included in $g(1)$.

(43) $[\![\mathbf{F}\ \mathbf{G}]\!]^{w,g} = \lambda t_i.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t \subseteq g(1)]$

Rather than having **F G** combine with tense directly, we have the operator PERF intervening between the two. Although I have talked as if there is such a thing as *the* PTS of a sentence, we'll see that we don't actually need (or want) to have PERF referencing a specific interval. The meaning I give it now, which I will slightly revise in Chapter 2, treats the perfect as an existential quantifier over intervals (von Fintel & Iatridou, 2019).

(44) $[\![\text{PERF}]\!] = \lambda I_{it}\lambda t_i^1.\exists t^2[\mathsf{rb}(t^1, t^2) \wedge I(t^2)]$ (*To be revised*)

The relation $\mathsf{rb}(t^1, t^2)$ should be read as "t^1 right-bounds t^2". I take this to mean that the LB of t^1 is the RB of t^2.[17] PERF thus takes in a set of intervals

[17]We can think of the LB of some interval t as the latest moment that precedes every moment in t, and its RB as the earliest moment that is preceded by every moment in t. We can formalize the two concepts as $\mathsf{min}^{\preceq_i}$ and $\mathsf{max}^{\preceq_i}$ below.

(45) a. $\mathsf{min}^{\preceq_i}(t) := \iota m^1[\{m^2 \mid \{m^2\} \preceq_i t\} \preceq_i \{m^1\} \preceq_i t]$

I, and outputs the set of intervals which right-bound a member of I.

PERF combines with **F G**, which returns the set of intervals that right-bound some t that includes an mbs eventuality and are included in $g(1)$.

(47) $$[\![\mathbf{H}]\!]^{w,g} = \lambda t^1_i.\exists t^2[\mathsf{rb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t^2 \subseteq g(1)]]$$

The present tense (represented by PRES) is what saturates the predicate in (47). As with the past tense, the present is given a referential treatment: it denotes the time of evaluation.

(48) $$[\![\text{PRES}]\!]^u := u$$

The extension we get from combining PRES and **H** is $\mathcal{T}$ iff some mbs eventuality is included in an interval that is both right-bounded by u and included in $g(1)$. The index left behind by the movement of *three days* allows us to bind t_1, resulting in the predicate in (49).

(49) $$[\![\mathbf{I}]\!]^{w,u} = \lambda t^1_i.\exists t^2[\mathsf{rb}(u, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t^2 \subseteq t^1]]$$

This is the set of every interval t^1 which contain some t^2 right-bounded by u, which itself contains some mbs eventuality. When we combine this with the extension of *three days*, we obtain what's given in (50).

(50) $$\begin{aligned}[\![\mathbf{J}]\!]^{w,u} &= \exists t^1[\mathsf{days}(t^1) = 3 \wedge \exists t^2[\mathsf{rb}(u, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t^2 \subseteq t^1]]] \\ &= \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]\end{aligned}$$

The output of this combination is $\mathcal{T}$ iff two conditions hold. Firstly, some mbs_w eventuality e must be included in some interval t^2 that is right-bounded by u. Secondly, t^2 must itself be included in a three day long interval t^3. We can simplify the representation of this meaning by introducing handy notation: the

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b. $\mathsf{max}^{\preceq_i}(t) := \iota m^1[t \preceq_i \{m^1\} \preceq_i \{m^2 \mid t \preceq_i \{m^2\}\}]$

We can then define what it means for t^1 to right-bound t^2, and by extension for t^1 to left-bound t^2, in terms of these two concepts.

(46) a. $\mathsf{rb}(t^1, t^2)$ iff $\mathsf{min}^{\preceq_i}(t^1) = \mathsf{max}^{\preceq_1}(t^2)$
b. $\mathsf{lb}(t^1, t^2)$ iff $\mathsf{rb}(t^2, t^1)$

function $\mathsf{pts}_{\mu}(n, t^1)$ takes in a measure phrase μ, a degree n, and an interval t^1, and outputs an interval t^2 that is right-bounded by t^1 and for who $\mu(t^2) = n$.[18] The interval $\mathsf{pts}_{\mathsf{days}}(3, u)$ is thus the PTS whose RB is the moment of utterance and whose LB is the moment three days before that.

To say that some mbs_w eventuality is included in some t^2 that is both right-bounded by u and included in a three day long interval t^3 is, in fact, equivalent to just saying that some mbs_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(3, u)$. We can show that the equivalence holds by showing that both statements entail each other.

On the one hand, observe that if t^2 is right-bounded by u and included in a three day long interval, its own duration lasts at most three days. It thus follows that $t^2 \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)$, which is right-bounded by u and last three days. We can conclude by the transitivity of inclusion that if $\tau_w(e) \subseteq t^2$ for some e, then $\tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)$.

On the other hand, observe that $\mathsf{pts}_{\mathsf{days}}(3, u)$ is both right-bounded by u and included in a three days long interval (i.e. itself). If $\tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)$ for some e, then it follows that $\tau_w(e)$ is included in some t^2 right-bounded by u and included in a three days long interval.

The final meaning of the whole LF is obtained by negating **J**'s extension. This gives us $\mathcal{T}$ iff there were no mbs_w eventualities included in $\mathsf{pts}_{\mathsf{days}}(3, u)$. This is precisely the meaning we want for (40-a).

(51) $[\![\mathbf{K}]\!]^{w,u} = \neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]$

Notice that we derive this meaning while at the same time treating PERF as an existential quantifier over interval. This has clear advantages over assuming that the perfect refers to some PTS directly. If the perfect referred to a specific interval, it would create problems for sentences like (52-a) and (52-b).

(52) a. Mary hasn't been sick in at least three days.
b. Mary hasn't been sick in more than three days.

[18] $\mathsf{pts}_{\mu}(n, t^1) := \iota t^2[\mathsf{rb}(t^1, t^2) \wedge \mu(\{m \mid \mathsf{min}^{\preceq_i}(t^2) \preceq_m m \preceq_m \mathsf{max}^{\preceq_i}(t^2)\}) = n]$

Sentence (52-a) asserts there were no mbs_w eventualities in some interval right-bounded by u that lasted at least three days. Similarly, (52-b) denies there being any such eventuality in some interval right-bounded by u lasting more than three days. In both sentences, the perfect seems to be quantifying over a class of candidate PTSs rather than be referencing a specific PTS. We can nevertheless use the term PTS in a derived sense for sentences like (40-a): in spite of PERF's meaning being quantificational, the truth-conditions of the sentence depend on whether or not an mbs_w eventuality is contained in $\mathsf{pts}_{\mathsf{days}}(3, u)$. In this sense, we can still think of $\mathsf{pts}_{\mathsf{days}}(3, u)$ as the PTS of this sentence.

1.4 Concluding Remarks

In this chapter, I argued that E- and G-TIAs differ in terms of their syntactic scope: E-TIAs are eventuality-level adverbials, while G-TIAs are perfect-level adverbials. However, I showed that with a single meaning for *in* that is underspecified as to the type of its relata, we can with the right map functions arrive at meanings of both E- and G-TIAs.

While this chapter is successful in providing a unified semantics for TIAs, there remains an important question: what accounts for the different distributional restrictions on E- and G-TIAs? We saw that while E-TIAs reject combining with atelic predicates, G-TIAs are NPIs. In Chapter 2, I will show that both restrictions can be understood as the result of a single requirement on the measure phrase of TIAs.

Chapter 2

Maximal Informativity and Temporal *in*-Adverbials

2.1 Introduction

In this chapter, I propose a single explanation for why E-TIAs reject combining with atelic predicates and G-TIAs are NPIs. Central to this explanation is the notion of **maximal informativity** (Beck & Rullmann, 1999; von Fintel et al., 2014). More specifically, we will see that we can predict whether or not a TIA is acceptable based on whether or not the numeral in its measure phrase can be maximally informative.

Though a technical notion, we can summarize maximal informativity in informal terms: *three* is maximally informative in a sentence **S** if (i) **S** is true and (ii) were we to substitute for *three* some numeral $\boldsymbol{\nu}$ and get a true sentence **S′**, then **S** would entail **S′**.

While the licensing of E-TIAs has previously been analyzed in terms of whether or not their numerals can be maximally informative (Krifka, 1989,Krifka, 1998), I extend this idea to G-TIAs. I show that in order for such an account to be successful, a new semantics for the perfect is required: the domain of quantification of the perfect must be restricted to open intervals.

The layout of this Chapter is as follows. In §2.2, I show how maximal informativity interacts with lexical aspect and E-TIAs, and propose a constraint to predict the licensing of TIAs. In §2.3, I show the difficulties this constraint faces in accounting for the polarity sensitivity of G-TIAs, and show that they can be overcome if we assume the perfect to quantify over open intervals only. In §2.4, I provide two independent arguments in favor of treating the perfect as a quantifier restricted to open intervals. In §2.5, I compare my proposal to previous accounts of the polarity sensitivity of G-TIAs. In §2.6, I provide arguments in favor of a quantificational analysis of the perfect that rely on the maximal informativity constraint imposed on TIAs. Finally, §2.7 concludes.

2.2 Maximal Informativity and E-TIAs

2.2.1 Maximal Informativity and Scalarity

In this section, I lay down the foundations upon which I will develop an explanation for the distributional restrictions of E- and G-TIAs. Underpinning this foundation is the notion of **maximal informativity**, which is best understood when compared to standard maximality (Beck & Rullmann, 1999; von Fintel et al., 2014). Standard maximality is defined in purely extensional terms: a degree n is maximal within a set of degrees N iff it is the greatest degree in that set. In contrast, maximal informativity is defined in intensional terms. For a given property $\mathcal{X}$, α is maximally informative in $\mathcal{X}$ if two conditions are met. Firstly, the property must hold of α in the world of evaluation. Secondly, for any β of which $\mathcal{X}$ also holds, $\mathcal{X}$ holding of α entails its holding of β. I encode maximal informativity into the meaning of $\mathsf{max}^{\Rightarrow}_{w}$ below.[1]

(1) $\mathsf{max}^{\Rightarrow}_{w}(\mathcal{X}_{s\sigma t}) := \iota\alpha_{\sigma}[\mathcal{X}(w,\alpha) \wedge \forall\beta_{\sigma}[\mathcal{X}(w,\beta) \rightarrow (\lambda v.\mathcal{X}(v,\alpha) \Rightarrow \lambda v.\mathcal{X}(v,\beta))]]$

Although the definition for $\mathsf{max}^{\Rightarrow}_{w}$ is polymorphic, we will for now be restricting our attention to how it interacts with properties of degrees. Specifically, I want to draw attention to how it interacts with their scalarity. Some properties of degrees are such that their being true of a degree n implies their being true

[1] $p_{st} \Rightarrow q_{st}$ iff $\forall w_s[p(w) \rightarrow q(w)]$

of every smaller degree m. We will say that such properties of degrees are **downward scalar**.

(2) **Downward Scalarity**:
A property of degrees $\mathcal{N}_{sdt}$ is downward scalar iff
$\forall n, m[m < n \rightarrow (\lambda w.\mathcal{N}(w, n) \Rightarrow \lambda w.\mathcal{N}(w, m))]$

Other properties are such that if they are true of n, this implies that they are true of every greater degree m. Such properties are **upward scalar**.

(3) **Upward Scalarity:**
A property of degrees $\mathcal{N}_{sdt}$ is upward scalar iff
$\forall n, m[n < m \rightarrow (\lambda w.\mathcal{N}(w, n) \Rightarrow \lambda w.\mathcal{N}(w, m))]$

The scalarity of properties of degrees affects whether the maximally informative degree in a property is the greatest or the smallest of which it holds. To illustrate this point, let's consider the properties in (4-a) and (4-b).

(4) a. $\lambda w_s \lambda n_d : n \in \mathbb{Z}^+ . \exists x[\mathsf{chapters}_w(x) \wedge \mathsf{wrote}_w(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]$
b. $\lambda w_s \lambda n_d : n \in \mathbb{Z}^+ . \neg\exists x[\mathsf{chapters}_w(x) \wedge \mathsf{wrote}_w(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]$

The first property is that of the amount of chapters that Mary wrote, whereas the second is that of the amount of chapters that she didn't write. To keep things simple, these properties are only defined for degrees that are part of the positive integers $\mathbb{Z}^+ = \{1, 2, 3, \ldots\}$. The metalanguage function amount takes entities and calculates the number of singularities that form them.

Suppose that in our world of evaluation, Mary wrote exactly three chapters. In Figure 2.1, I've represented the entailments between every propositions "$\lambda w.\exists x[\mathsf{chapters}_w(x) \wedge \mathsf{wrote}_w(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]$", where $n \in \mathcal{D}_d$. We see that Mary having written n chapters strictly entails her having written $n - 1$ chapters; the property in (4-a) is thus (strictly) downward scalar. In Figure 2.2, I represent the entailments between the proposition "$\lambda w.\neg\exists x[\mathsf{chapters}_w(x) \wedge \mathsf{wrote}_w(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]$", for $n \in \mathcal{D}_d$. Here, Mary not having written n chapters strictly entails her not having written $n + 1$: the property in (4-b) is therefore (strictly) upward scalar.

$$\begin{array}{r} \ldots, \\ \mathsf{amount} = 6, \\ \mathsf{amount} = 5, \\ \mathsf{amount} = 4, \\ \mathsf{amount} = 3, \\ \mathsf{amount} = 2, \\ \mathsf{amount} = 1 \end{array} \Big\Downarrow$$

Figure 2.1: Entailments in (4-a).

$$\begin{array}{r} \ldots, \\ \mathsf{amount} \neq 6, \\ \mathsf{amount} \neq 5, \\ \mathsf{amount} \neq 4, \\ \mathsf{amount} \neq 3, \\ \mathsf{amount} \neq 2, \\ \mathsf{amount} \neq 1 \end{array} \Big\Uparrow$$

Figure 2.2: Entailments in (4-b).

In both figures, the shaded area corresponds to those propositions that are are true in the world of evaluation. Observe that for the downward scalar property in (4-a), its maximally informative element is the greatest number of chapters that Mary wrote, i.e. 3. For the upward scalar property, however, it is the smallest number of chapters that she didn't write, i.e. 4.

(5) a. $\mathsf{max}^{\Rightarrow}_{w}(\lambda v_s \lambda n_d : n \in \mathbb{Z}^+ . \exists x[\mathsf{wrote}_v(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]) = 3$

b. $\mathsf{max}^{\Rightarrow}_{w}(\lambda v_s \lambda n_d : n \in \mathbb{Z}^+ . \neg\exists x[\mathsf{wrote}_v(\mathsf{m}, x) \wedge \mathsf{amount}(x) = n]) = 4$

What we learn is thus the following: the maximally informative element in a strictly downward scalar property of degrees is the greatest element of which it holds, while that of a strictly upward scalar property is the smallest of which it holds. For the remainder of this chapter, I will show how the interaction of maximal informativity with scalarity is key to understanding the distributional restrictions on E- and G-TIAs.

2.2.2 The Algebraic Properties of Telic and Atelic Predicates

We can bring to light the relationship between E-TIAs, maximal informativity, and the temporal constitution of verbal predicates after we've examined the algebraic properties of telic and atelic predicates. Let's begin by looking at the sentence in (6), whose VP denotes a telic predicate.

(6) Mary wrote up a chapter from Monday to Wednesday.

a. $\not\Rightarrow$ Mary wrote up a chapter from Monday to Tuesday.

b. $\not\Rightarrow$ Mary wrote up a chapter from Tuesday to Wednesday.

The sentence entails neither the sentence in (6-a) nor the one in (6-b). Intuitively, this is because any eventuality of Mary writing up a chapter involves both the start and culmination of a writing process. As such, (6) asserts that Mary began writing a chapter on Monday and completed it on Wednesday. This does not entail (6-a), which asserts that Mary completed a chapter on Tuesday, nor does it entail (6-b), which asserts that she began writing a chapter on Tuesday.

Following Krifka (1989) and Krifka (1998), we can assume that the property of eventualities of Mary writing up a chapter at $g(1)$ (i.e. $\lambda w_s \lambda e_v.\mathsf{mwc}_{1,w}(e)$) has the higher-order property of **quantized reference**. This means that no two distinct eventualities of which the property holds are ever part of one another.[2]

(7) **Property of Quantized Reference:**
A property of eventualities $\mathcal{V}_{svt}$ has the property of quantized reference iff $\forall w, e^1, e^2[(\mathcal{V}(w, e^1) \wedge \mathcal{V}(w, e^2) \wedge e^1 \sqsubseteq_v e^2) \rightarrow e^1 = e^2]$

In contrast to the pattern of entailment we see in (6), the sentence in (8), where the VP denotes a telic predicate, entails both (8-a) and (8-b).

(8) Mary was sick from Monday to Wednesday.

a. $\Rightarrow$ Mary was sick from Monday to Tuesday.

b. $\Rightarrow$ Mary was sick from Tuesday to Wednesday.

Like we had clear intuitions for why the entailments didn't go through in (6), we have a sense for why they do in (8). A state of Mary being sick is the cumulation of shorter such eventualities: whenever Mary is sick at some time

[2]It is important to distinguish temporal inclusion from parthood in the domain of eventualities. Though the runtimes of two simultaneous eventualities will include one another, the two eventualities might not be part of one another.

interval, it holds that she is sick at each of its subintervals. This is higher-order property is referred to as the **subinterval property** (Bennett & Partee, 1972).[3]

(10) **Subinterval Property:**
A property of eventualities $\mathcal{V}_{svt}$ has the subinterval property iff
$\forall w, e^1, t[(\mathcal{V}(w, e^1) \wedge t \subseteq \tau_w(e^1)) \rightarrow \exists e^2[\mathcal{V}(w, e^2) \wedge t = \tau_w(e^2)]]$

With these preliminaries in place, we can now turn to how maximal informativity connects with the interaction of E-TIAs and temporal constitution. Krifka (1989), and subsequently Krifka (1998), are to my knowledge the first works to use maximal informativity to account for the unacceptability of E-TIAs with atelic predicates. As we are about to see, unlike with telic predicates, the value denoted by a TIA's numeral can never be maximally informative in combination with atelic predicates.

We will be comparing how maximal informativity interacts with the TIAs in (11) and with (12). As we saw in Chapter 1, the LF for the first is the one given in (11-a), whose extension is $\mathcal{T}$ iff (11-b) is true. If we were to substitute for *Mary wrote up a chapter* the VP *Mary was sick*, as in (12), we would get an LF whose extension is $\mathcal{T}$ iff (11-b) is true. Here, $\mathsf{mbs}_{1,w}$ is shorthand for the predicate of eventualities of Mary being sick at $g(1)$ in w.

(11) Mary wrote up a chapter in three days.

a. [three days] 2 PAST$_1$ PFV [Mary wrote up a chapter] [in RUNTIME] t_2

b. $\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

(12) *Mary was sick in three days.

[3] The formulation I present for the subinterval property is an event-semantics adaptation of Bennett & Partee's original formualtion. This allows us to define a stronger property still: for any interval corresponding to the runtime of an mbs eventuality, its every subinterval is the runtime of such an eventuality *that is also part of the first one*. This is formalized in (9). The weaker property in (10) is sufficient for our purposes.

(9) $\forall w, e^1, t[(\mathcal{V}(w, e^1) \wedge t \subseteq \tau_w(e_1)) \rightarrow \exists e^2[\mathcal{V}(e^2, w) \wedge e^2 \sqsubseteq_e e^1 \wedge t = \tau_w(e^2)]]$

a. [three days] 2 $\textsc{past}_1$ $\textsc{pfv}$ [Mary was sick] [in $\textsc{runtime}$] t_2

b. $\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

To compare whether or not the value of the numeral can be maximally informative in (11) and (12), we need to derive from each sentence a property of degrees. We can do this by manipulating their respective LF: in each of them, we can substitute for *three* a pronoun pro_i assigned to a degree, and adjoin the index i to the whole structure.

(13) a. 3 [pro_3 days] 2 $\textsc{past}_1$ $\textsc{pfv}$ [Mary wrote up a chapter] [in $\textsc{runtime}$] t_2

b. 3 [pro_3 days] 2 $\textsc{past}_1$ $\textsc{pfv}$ [Mary was sick] [in $\textsc{runtime}$] t_2

The intension of (13-a), given in (14-a), is the property of degrees n such that some $\mathsf{mwc}_{1,w}$ eventuality lasted n days or less. Similarly, the intension of (13-b), which is shown in (14-b), is the property of degrees n such that an $\mathsf{mbs}_{1,w}$ eventuality lasted n days or less.

(14) a. $\lambda w_s \lambda n_d.\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$

b. $\lambda w_s \lambda n_d.\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$

Because of the algebraic properties of the verbal predicates in (13-a) and (13-b), the two properties differ in terms of scalarity. The property in (13-a) is upward scalar: if Mary wrote a chapter in three days or less, she wrote it in four days or less. However, because $\mathsf{mwc}_{1,c}$ has quantized reference, it doesn't follow from her writing a chapter in three days that she wrote one in a shorter period of time. Mary writing up a chapter in four days or less would be true if she wrote exactly one chapter, and wrote it in no less than four days. The property is therefore strictly upward scalar.

While (14-b) too is upward scalar, it is also downward scalar. If we have an $\mathsf{mbs}_{1,w}$ eventuality lasting three days or less, it follows that we have such an eventuality lasting four days or less. However, because this predicate has the subinterval property, the converse is also true. Any $\mathsf{mbs}_{1,w}$ eventuality that lasts four days or less has a part of its runtime that lasts three days or less;

this part is the runtime of an $\mathsf{mbs}_{1,w}$ eventuality.

Having shown that the scalarities of the two properties differ, we already anticipate that they won't behave the same way with maximal informativity. Suppose that in the world of evaluation, Mary wrote exactly one chapter in exactly three days, and she was sick for exactly three days. In Figure 2.3, I represent the entailments between every propositions "$\lambda w.\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$" where $n \in \mathcal{D}_d$, and highlight those that include the world of evaluation. In Figure 2.4, I similarly depict entailments between the propositions of the form "$\lambda n.\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$", with the same sort of highlighting.

$$\begin{array}{r} \ldots, \\ \mathsf{mwc}_{1,w} \leq 4, \\ \ldots, \\ \mathsf{mwc}_{1,w} \leq 3, \\ \ldots, \\ \mathsf{mwc}_{1,w} \leq 2, \\ \ldots, \end{array} \Uparrow \qquad\qquad \begin{array}{r} \ldots, \\ \mathsf{mbs}_{1,w} \leq 4, \\ \ldots, \\ \mathsf{mbs}_{1,w} \leq 3, \\ \ldots, \\ \mathsf{mbs}_{1,w} \leq 2, \\ \ldots, \end{array} \Updownarrow$$

Figure 2.3: Entailments with telicity. Figure 2.4: Entailments with atelicity.

We can tell from these that while 3 is maximally informative in (14-a), it isn't in (14-b). In fact, since the propositions in Figure 2.4 all entail one another, no maximally informative degree is defined for (14-b).

(15) a. $\mathsf{max}^{\Rightarrow}_{w}(\lambda v_s \lambda n_d.\exists e[\mathsf{mwc}_{1,v}(e) \wedge \mathsf{days}(\tau_v(e)) \leq_d n]) = 3$
b. $\mathsf{max}^{\Rightarrow}_{w}(\lambda v_s \lambda n_d.\exists e[\mathsf{mbs}_{1,v}(e) \wedge \mathsf{days}(\tau_v(e)) \leq_d n])$ is undefined.

We can actually show that measuring any $\mathsf{mbs}_{1,w}$ eventuality as lasting three days or less is equivalent to just asserting that there was an $\mathsf{mbs}_{1,w}$ eventuality. To begin, note that the reasoning in (16) is straightforward given conjunction elimination.

(16) $\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$
$\therefore$ $\exists e[\mathsf{mbs}_{1,w}(e)]$

Observe, furthermore, that the reasoning in (17) is also valid. If there exists some $\mathsf{mbs}_{1,w}$ eventuality e, and if any part of e's runtime is itself the runtime of an $\mathsf{mbs}_{1,w}$ eventuality, then there is a part of e's runtime that lasts three days or less and is the runtime of an $\mathsf{mbs}_{1,w}$ eventuality.

(17) $\exists e[\mathsf{mbs}_{1,w}(e)]$
$\forall e^1, t[(\mathsf{mbs}_{1,w}(e^1) \wedge t \subseteq \tau_w(e^1)) \rightarrow \exists e^2[\mathsf{mbs}_{1,w}(e^2) \wedge t = \tau_w(e^2)]]$
$\therefore \quad \exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

These two pieces of reasoning are valid no matter the numeral in the TIA. This means that the property in (14-b) is actually equivalent to (18). When we give it a world argument w, we get a constant function from any degree d to $\mathcal{T}$ iff Mary was sick at $g(1)$ in w. The degree argument itself contributes nothing to the output of this function.

(18) $\lambda w_s \lambda n_d.\exists e[\mathsf{mbs}_{1,w}(e)]$

It is based on the difference between how telic and atelic predicates interact with TIAs that Krifka accounts for their unacceptability with the latter. For him, pragmatic principles are at the root of why the impossibility of defining a maximally informative member in (15-b) is a problem. To begin, he assumes that there is a competition between (12) and alternatives where we have substituted another numeral for *three*. The goal of this competition is to lead speakers to use the sentence whose numeral is most informative. However, we just saw that all these alternatives are equally informative. In fact, the TIA is entirely redundant with atelic predicates. Since we can't find a maximally informative numeral, a second pragmatic principle requiring us to avoid unnecessarily complex sentences rules out their combination with atelic predicates. This is on the grounds that they can be dispensed with entirely.

In support of his proposal, Krifka shows that it predicts that atelic predicates can, in some instances, combine with E-TIAs. It is well known that the eventualities in the extension of many atelic predicates last too long for the predicate to have the subinterval property. A common illustration of this fact involves the predicate *waltzed*. Not every moment of waltzing measures out a waltz; there appears to be a required minimum number of steps before we are willing to call any sequence of movements a waltz. The predicate of waltzing eventualities could be described as having the subinterval property down to a point, viz. the sizes of minimal waltzing eventualities. This is known as the **minimal parts problem** for atelic predicates (Doetjes, 2015; Taylor, 1977; Dowty, 1979; J. Zwarts, 2013).

Krifka observes that the acceptability of an E-TIA with an atelic predicate is improved when its measure phrase could count as the duration of a minimal eventuality in the predicate's extension. While (20-a) is unacceptable, (20-b) seems fine if we imagine the couple taking 2.3 seconds to do the three steps characteristic of a waltz.[4]

(20) a. *The couple waltzed in 23 seconds.
     b. The couple waltzed in 2.3 seconds.

Krifka takes such examples to show that the acceptability of a TIA is always tied to whether or not its numeral can be maximally informative. Since they are somewhat marginal, I will be ignoring such cases and concentrate on atelic predicates that do have the subinterval property. I propose to distill the essence of Krifka's analysis by postulating the Maximal Informativity Constraint (MIC) in (21). This states that a TIA is only acceptable if it is possible for the numeral in its measure phrase to be maximally informative.

[4]Kai von Fintel (p.c.) points out that (20-a) is acceptable if the predicate *waltzed* is understood to denote eventualities of going through a full dance. This raises the question of whether (20-b)'s acceptability doesn't come from having coerced the predicate into denoting the set of eventualities of dancing a minimal waltz. I don't see a way of teasing both proposals apart. However, I don't see the theoretical appeal of this alternative. Consider stative predicates like *was sick*, whose minimal parts are punctual and thus lack any duration. As (19) shows, E-TIAs are bad with statives no matter how small the value of their numerals.

(19) a. *Mary was sick in 23 seconds.
     b. *Mary was sick in 0.23 seconds.

We have to conclude that we can only coerce predicates that have measurable minimal parts in their extension. But if this is the case, why even assume that the predicate is coerced in (20-b)? On Krifka's view, we already expect the sentence to be good without coercion, just like we expect (19-b) to be bad.

This successfully accounts for the difference in the acceptability of the E-TIAs in (11) and (12).

(21) **Maximal Informativity Constraint:**
A TIA "in ν μ" is acceptable in an LF $\mathbf{X}$ only if for some index i and some world w, $\mathsf{max}^{\Rightarrow}_{w}(\llbracket i\ \mathbf{X}[\nu \mapsto pro_i]\rrbracket^{u,g}_{¢}) = \llbracket \nu \rrbracket$.

The MIC raises questions about the exact relation between maximal informativity and the licensing of TIAs. If the licensing of TIAs is tied to whether or not their numerals can be maximally informative, why are maximal informativity inferences optional with them? The example in (22), which we already saw in Chapter 1, shows that *in three days* is good when the maximally informative number of days in which Mary wrote her chapter is less than three.

(22) Mary wrote up a chapter in three days. What's more, she wrote it in two.

In Chapter 3, I undertake the task of deriving the MIC from more general principles. In so doing, I will discuss the optionality of maximal informativity inferences. For the purposes of this Chapter, however, this more ambitious aim can be set aside. In the coming sections, I will show how maximal informativity interacts with G-TIAs, and use this as initial motivation for a new semantics for the perfect.

2.3 Maximal Informativity and G-TIAs

2.3.1 A Problem for the MIC and G-TIAs

In this section, I show that on the current semantics for the perfect, the MIC fails to account for the polarity sensitivity of G-TIAs. We can begin by considering the sentence in (23), where the G-TIA is unacceptable because it isn't in the scope of a negation. We have for it the LF in (23-a), whose extension is $\mathcal{T}$ iff (23-b) holds. If we abstract over the numeral in (23), we can obtain the property of degrees in (23-c).

(23) *Mary has been sick in three days.

a. [three days] 1 PRES PERF [PFV Mary has been sick] [in ID] t_1

b. $\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3,u)]$

c. $\lambda w \lambda n.\ \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(n,u)]$

The property of degrees in (23-c) is strictly upward scalar. If an mbs_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(3,u)$, it is also included in $\mathsf{pts}_{\mathsf{days}}(4,u)$. However, it may well be that some such eventuality is included in $\mathsf{pts}_{\mathsf{days}}(4,u)$, but not $\mathsf{pts}_{\mathsf{days}}(3,u)$, e.g. if Mary was sick in the last four days but not the last three. We can, in fact, come up with a scenario where 3 is maximally informative in this property. Consider the scenario depicted in Figure 2.5.

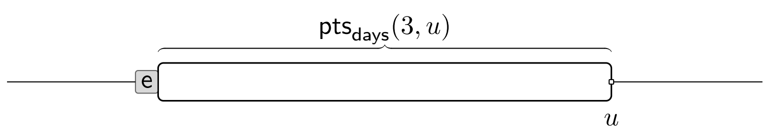

Figure 2.5: Scenario verifying (23-b).

Since (23-c) is upward scalar, its maximally informative member will be the smallest degree n such that some mbs_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(n,u)$. In Figure 2.5, we have the RB of an mbs_w eventuality abutting the LB of $\mathsf{pts}_{\mathsf{days}}(3,u)$. Because of the subinterval property, the interval consisting just of the eventuality's RB is itself the runtime of a (punctual) mbs_w eventuality. What this means is that in this scenario, $\mathsf{pts}_{\mathsf{days}}(3,u)$ does in fact contain an mbs_w eventuality, albeit a momentary one. Moreover, for any $n <_d 3$, there are no mbs_w eventualities included in $\mathsf{pts}_{\mathsf{days}}(n,u)$. In Figure 2.6, I both represent the entailment between propositions of the form "$\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(n,u)]$", and highlight which of these are true in the scenario at hand.

$$
\begin{array}{r}
\ldots, \\
\subseteq \mathsf{pts}(4, u), \\
\ldots, \\
\subseteq \mathsf{pts}(3, u), \\
\ldots, \\
\subseteq \mathsf{pts}(2, u), \\
\ldots,
\end{array}
\Big\Uparrow
$$

Figure 2.6: Entailments with G-TIAs.

We see that there is indeed a smallest degree n such that an mbs_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(n, u)$, viz. 3. What this means is that this is the maximally informative element in (23-c). In other words, the MIC does not predict the unacceptability of (23).

(24) $\mathsf{max}^{\Rightarrow}_{w}(\lambda v \lambda n. \exists e[\mathsf{mbs}_v(e) \wedge \tau_v(e) \subseteq \mathsf{pts}_{\mathsf{days}}(n, u)]) = 3$

I want to stress the point that we don't obtain this results because mbs_w has the subinterval property. The MIC also fails to rule out a reading of the sentence in (25) in which *in three days* is a G-TIA.

(25) Mary has written up a chapter in three days.

a. [three days] 1 PRES PERF [PFV Mary has written up] [in ID] t_1

b. $\exists e[\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]$

c. $\lambda w \lambda n.\ \exists e[\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(n, u)]$

Such a reading is obtained by assuming the LF in (25-a), which is $\mathcal{T}$ iff some mwc_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(3, u)$. Once again, the property of degrees in (25-c) is strictly upward scalar, so we are looking for the smallest n such that $\mathsf{pts}_{\mathsf{days}}(n, u)$ that contains a mwc_w eventuality. Consider now the scenario in Figure 2.7.

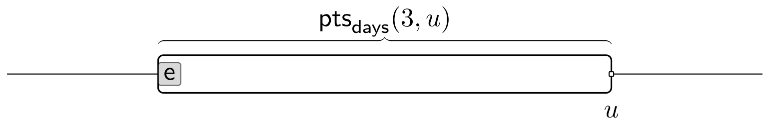

Figure 2.7: Scenario verifying (25-b).

Here, we have an mwc_w eventuality whose LB is the same as the LB of $\mathsf{pts}_{\mathsf{days}}(3, u)$. Because the property of mwc_w has quantized reference, no proper part of this eventuality is also in the extension of this predicate. But what this means is that for any $n <_d 3$, $\mathsf{pts}_{\mathsf{days}}(n, u)$ only contains part of an mwc_w eventuality; none of these intervals thus contain any mwc_w eventualities. On the other hand, $\mathsf{pts}_{\mathsf{days}}(3, u)$ does. We here have 3 being maximally informative in (25-c), and thus don't rule out the undesirable reading of (25) with the MIC.

2.3.2 Deriving the Polarity Sensitivity of G-TIAs

We can overcome the difficulty in deriving the polarity sensitivity of G-TIAs with the MIC once we revise our semantics for the perfect. This revision relies on the difference between **open intervals** and **closed intervals**, which depends on whether or not the intervals include their LB and RB.

(26) a. A closed interval $[m^1, m^2]$ is the set $\{m^3 \mid m^1 \preceq_m m^3 \preceq_m m^2\}$
b. An open interval (m^1, m^2) is the set $\{m^3 \mid m^1 \prec_m m^3 \prec_m m^2\}$

Closed intervals, as defined in (26-a), are convex sets of moments that include both their LB and RB. Contrast this with how open intervals are defined in (26-b). An open interval is one which excludes both its LB and its RB.[5] I will show that the MIC derives the polarity sensitivity of G-TIAs if (i) the domain of quantification of the perfect is restricted to open intervals and (ii) the runtime function maps eventualities to closed intervals. The crucial intuition behind this idea is that whenever an open interval includes a closed intervals, so will a proposer subset of the open interval.

[5] We can also define left-open and right-open intervals: a left-open interval $(m^1, m^2]$ is the set $\{m^3 \mid m^1 \prec_m m^3 \preceq_n m^2\}$, and a right-open interval $[m_1, m_2)$ is the set $\{m^3 \mid m^1 \preceq_m m^3 \prec_m m^2\}$.

(27) $[\![\text{PERF}]\!] := \lambda I_{it}\lambda t^1_i.\ \exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(t^1, t^2) \wedge I(t^2)]$ (*Revised*)

The metalanguage function $\mathsf{pts}_\mu(n, t^1)$ defined a closed interval t^2 which is right-bounded by t^1 such that $\mu(t^2) = n$. The function $\mathsf{t}_\mu(n, t^1)$ gives us the counterpart of $\mathsf{pts}_\mu(n, t^1)$ which excludes its LB and RB (i.e. its open counterpart).[6] The sentence in (28) now has the meaning in (28-a).

(28) *Mary has been sick in three days.

a. $\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3, u)]$

b. $\lambda w\lambda n.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u)]$

Just as before, the property of degrees we obtain in (28-b) is strictly upward scalar. The maximally informative degree in (28-b) the smallest n such that $\mathsf{t}_{\mathsf{days}}(n, u)$ includes an mbs_w eventuality. We can show that, on current assumptions, this derives a contradiction. A scenario verifying (28-a) is given in Figure 2.8.

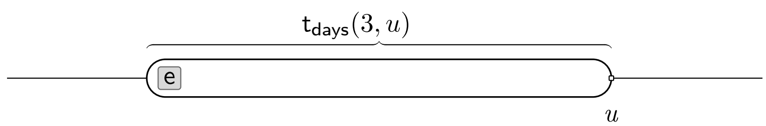

Figure 2.8: Scenario verifying (28-a)

An open interval (m^1, m^2) only includes a closed interval $[m^3, m^4]$ on the condition that $m^1 \prec_m m^3$ and $m^2 \prec_m m^4$. Since, by assumption, the PTS is open while the runtimes of eventualities are closed, $\mathsf{t}_{\mathsf{days}}(3, u)$ can only include an mbs_w eventuality e if the former's LB strictly precedes the latter's. Let's call the former's LB b^1, and the latter's b^2. Since intervals are convex sets of moment, it follows that there is in $\mathsf{t}_{\mathsf{days}}(3, u)$ some m such that $\mathsf{b}^1 \prec_m m \prec_m \mathsf{b}^2$.

In Chapter 1, I assumed that $\leq_d$ and $<_d$ form dense total orders on the domain of degrees $\mathcal{D}_d$. By assuming this, measure functions like days can map every interval to a degree. This has immediate consequences for our scenario. We already know that $\mathsf{days}([\mathsf{b}^1, u]) = 3$, but it must also be the case that

[6] $\mathsf{t}_\mu(n, t) := \mathsf{pts}_\mu(n, t) \setminus \{\mathsf{min}^{\preceq_i}(\mathsf{pts}_\mu(n, t)), \mathsf{max}^{\preceq_i}(\mathsf{pts}_\mu(n, t))\}$

$\mathsf{days}([m,u]) = n$ for some $n <_d 3$. Moreover, since $m \prec_m b^2$, it follows that $\mathsf{t}_{\mathsf{days}}(n,u)$ includes an mbs_w eventuality. We can conclude from all of this that, contrary to our assumption, 3 cannot be maximally informative in (28-b). The logic behind this example is that there is always a smaller open interval that includes the runtime of an mbs_w eventuality. As such, there can thus never be a maximally informative degree in (28-b) (cf. Fox & Hackl (2006) for similar interactions between density and maximal informativity).

(29) $\mathsf{max}^{\Rightarrow}_{w}(\lambda v \lambda n.\exists e[\mathsf{mbs}_v(e) \wedge \tau_v(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)])$ is undefined.

On the assumptions given here, the MIC does rule out the sentence in (28). In fact, G-TIAs are predicted to be unacceptable in simple positive sentences. We now need to make sure, however, that it doesn't block G-TIAs from appearing below negation, as in (30).

(30) Mary hasn't been sick in three days.
  a. $\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)]$
  b. $\lambda w \lambda n.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)]$

The property of degrees in (30-b) is strictly downward scalar. The greatest degree n such that $\mathsf{t}_{\mathsf{days}}(n,u)$ contains no mbs_w eventualities will be maximally informative in (30-b). As it turns out, there is no issue in defining such a degree. Consider the scenario depicted in Figure 2.9.

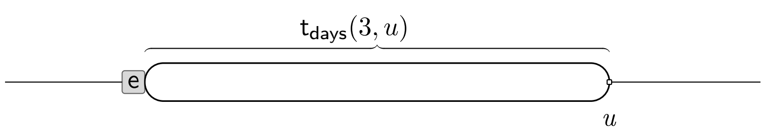

Figure 2.9: Scenario verifying (30-b)

Here, we have an mbs_w eventuality e that left-bounds the PTS. Because the PTS is an open interval, it excludes e's RB, and includes no mbs_w eventualities whatsoever. However, as soon as we move the LB of the PTS to the left, it will include part of e. Since the property of mbs_w eventualities has the subinterval property, this means that any larger PTS will include an mbs_w eventuality. In other words, for every $n >_d 3$, an mbs_w eventuality is included in $\mathsf{t}_{\mathsf{days}}(n,u)$. In Figure 2.10, I highlight which propositions of the form "$\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n)]$" are true in this scenario.

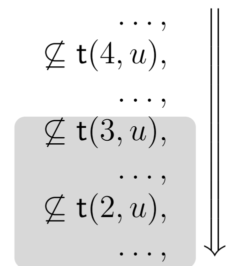

Figure 2.10: True members of

We see here that indeed, 3 is maximally informative in (30-b). It is the greatest degree n such that the interval $\mathsf{t}_{\mathsf{days}}(n,u)$ includes no mbs_w eventuality. As such, the MIC does not rule out the G-TIA in (30).

(31) $\mathsf{max}_w^{\Rightarrow}(\lambda v \lambda n.\neg\exists e[\mathsf{mbs}_v(e) \wedge \tau_v(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)]) = 3$

Once again, I want to stress that deriving this result does not depend in any way upon properties of eventualities having the subinterval property. We predict the sentence in (32) to also be acceptable on the reading in (32-a), where *in three days* is a G-TIA. Consider here the scenario in Figure 2.11.

(32) Mary hasn't written up a chapter in three days.

a. $\neg\exists e[\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)]$

b. $\lambda w \lambda n.\neg\exists e[\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)]$

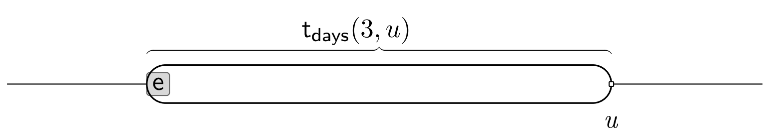

Figure 2.11: Scenario verifying (30-b)

What this shows is a scenario where the PTS shares its LB with that an

mwc_w eventuality e. The difference between the two, however, is that while the PTS excludes this moment, e's runtime includes it. What this implies then is that $\mathsf{t}_{\mathsf{days}}(3, u)$ does not include e. Moreover, since the property of mwc_w eventualities has quantized reference, no part of e included in $\mathsf{t}_{\mathsf{days}}(3, u)$ is itself an mwc_w eventuality. However, as soon as we move the LB of the PTS to the left, this new interval will include e's LB. Thus, for every $n >_n 3$, $\mathsf{t}_{\mathsf{days}}(n, u)$ includes some mwc_w eventuality. Once again, 3 is maximally informative in (32-b).

In this section, I began by showing that under prior assumptions, the MIC does not succeed in ruling out G-TIAs in simple positive sentences. I went on to show that, if we assume the PTS is always an open interval and that the runtime of eventualities are always closed intervals, we can derive the polarity sensitivity of G-TIAs. These assumptions seem, on the face of things, rather *ad hoc*. In §2.4, I provide two novel arguments that help motivate these assumptions.

2.4 The Perfect Quantifies over Open Interval

2.4.1 The Bounds of E-Perfects and U-Perfects

In this section, I advance the first of two arguments in support of the claim that intervals over which the perfect quantifies are open, and that those in the range of the runtime function are closed. Both arguments rely on the fact that many sentences are ambiguous between what are called an **existential perfect** (E-perfect) and a **universal perfect** (U-perfect) reading. For example, the sentence in (33) can receive the E-perfect interpretation in (33-a), or the U-perfect interpretation in (33-b). This is true of any sentence in the perfect whose main VP predicate is stative.

(33) Mary has been sick since Monday.

a. Mary was sick at some point between Monday and now. (E-perfect)

b. Mary was sick at every point between Monday and now. (U-perfect)

We may call into question whether or not the E- and U-perfect readings of (33) are representative of a *bona fide* ambiguity. After all, we could assume that (33) only carries an E-perfect reading, while the alleged U-perfect reading is simply its limiting case. Against this view, Mittwoch (1988) shows that the sentence's ambiguity is preserved under negation: (34) has the E-perfect reading in (34-a) and the U-perfect reading in (34-b). This latter reading would be true if, for example, Mary became ill on Tuesday.

(34) Mary hasn't been sick since Monday.

a. Mary wasn't sick at any point between Monday and now. (E-perfect)

b. Mary wasn't sick at every point between Monday and now. (U-perfect)

If (33) only had an E-perfect reading, so should its negation. The availability of the weaker U-perfect reading in (34-b) confirms that the E- and U-perfect distinction represents a true ambiguity.[7]

With these preliminaries in place, let's turn to the argument at the heart

[7] Michael White (p.c.) suggests to me a method for maintaining an unambiguous treatment of (33) while capturing the ambiguity of (34) in terms of the scope of the *since*-adverbial relative to negation. If I have understood the view correctly, the reading in (34-a) is obtained when the adverbial scopes below negation, where what is obtained is the negation of (33-a). By allowing it to outscope negation, we could get a reading that says that at some point between Monday and u, Mary was not sick. It is this configuration that gives us the reading in (34-b). This approach is difficult to maintain if we consider examples like (35).

(35) [No priest]$_i$ has been sick since his$_i$ ordination.

a. No priest was sick at any point between his ordination and now. (E-perfect)

b. No priest was sick at every point between his ordination and now. (U-perfect)

The *since*-advebial in this sentence is forced below the scope of the negative quantifier because it binds the pronoun *his*. In spite of this, the sentence carries both the E-perfect interpretation in (35-a) and the U-perfect interpretation in (35-b) of this section. It is rooted in another of Mittwoch's observations. She points out that whether or not Mary was sick on Monday bears differently on the truth-conditions of (33) on its E- and U-perfect readings. On its E-perfect reading, her being sick on Monday is irrelevant to the truth or falsity of the sentence. While the sentence is not falsified if she was sick on Monday, it is true only if she was sick at some point after Monday. On the other hand, its U-perfect reading can only be true if she was sick on Monday.

Before showing how open intervals help deal with Mittwoch's observation, let me first draw a parallel between the ambiguity of (33) and the difference between (36-a) and its counterpart in the progressive (36-b).

(36) a. Mary has written up a chapter since Monday.
b. Mary has been writing up a chapter since Monday.

In total analogy with (33)'s E-perfect reading, (36-a) says that at some point between Monday and now, Mary wrote up a chapter. As with the E-perfect, whether or not Mary was writing a chapter on Monday does not matter for the sentence's truth-conditions. It is true only if Mary wrote up a chapter after Monday. We can likewise make an analogy between (33)'s U-perfect reading and (36-b). Like a U-perfect, the sentence says that at every point between Monday and now, Mary has been in the process of writing up a chapter. Importantly, the sentence is only true if Mary was in the process of writing a chapter on Monday. If we follow Iatridou et al.'s (2003) analysis of the E- and U-perfect distinction, these analogies are no accident. The E- and U-perfect readings of (33) are the result of the same difference in grammatical aspect that distinguishes (36-a) and (36-b). While (36-a) and the E-perfect reading of (33) are in the perfective aspect, (36-b) and the U-perfect reading of (33) are in the **imperfective aspect**. The semantic contribution of the imperfective is encoded in the operator IMPV.

(37) $[\![\text{IMPV}]\!]^w := \lambda V_{vt}\lambda t_i.\ \exists e[V(e) \wedge t \subseteq \tau_w(e)]$

In Chapter 1, I treated the perfective as a function from a predicate of eventualities to the set of intervals that include one of its members. We can think of the imperfective as doing something very similar: it takes a predicate of eventualities and outputs the set of intervals included in one of its members. On Iatridou et al.'s assumptions, the difference between the E- and U-perfect interpretations of (33) are whether its LF is (38-a) or (38-b).

(38) a. PRES PERF [PFV Mary has been sick] since Monday
b. PRES PERF [IMPV Mary has been sick] since Monday

Let's begin by analyzing the meaning we derive from (38-a). Heny (1982) observes that *since*-adverbials are only ever acceptable with the perfect, which makes them perfect-level adverbials *par excellence*. I assume that *since Monday* denotes the set of intervals left-bounded by Monday.

(39) $[\![\text{since Monday}]\!] := \lambda t_i.\ \mathsf{lb}(\mathsf{monday}, t)$

Supposing the perfect were not restricted to open intervals, we would expect (38-a) to denote $\mathcal{T}$ iff some mbs_w eventuality is contained in some interval left-bounded by monday and right-bounded by u. If we take $\mathsf{pts\text{-}monday}$ to be the closed interval bounded this way, the sentence is equivalent to asserting that some mbs_w eventuality is included in $\mathsf{pts\text{-}monday}$.

(40) $\exists t[\mathsf{rb}(u, t) \wedge \mathsf{lb}(\mathsf{monday}, t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t]]$
$\equiv \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts\text{-}monday}]$

Whether or not (40) has the truth-conditions we want depends on what intervals in the formula we assume to be open or closed. Let's assume that in addition to $\mathsf{pts\text{-}monday}$, both the interval monday and the runtimes of eventualities are closed eventualities. On these assumptions, (40) does not have the right truth-conditions. We can show this by considering the scenario in Figure 2.12.

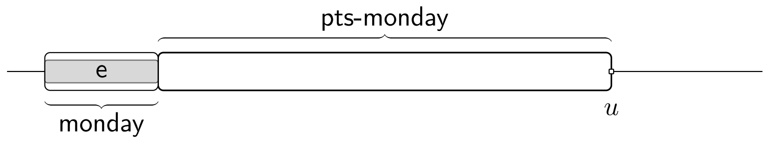

Figure 2.12: Scenario verifying (40)

This depicts a scenario where Mary was sick throughout Monday, but no later than that. We already discussed Mittwoch's observation that such a scenario will not verify (33) on its E-perfect reading: the reading is only verified provided Mary was sick after monday. Notice, however, that monday's RB is the same moment as $\mathsf{pts\text{-}monday}$'s LB. Because both are closed intervals, this moment is included in both monday and $\mathsf{pts\text{-}monday}$. If we assumed that the property of mbs eventualities has the subinterval property, then (40) is true in this scenario: $\mathsf{pts\text{-}monday}$ contains a single moment that is the runtime of an mbs_w eventuality, i.e. its LB.

We can avoid this undesirable result if we assume that the domain of quantification of the perfect is restricted to open intervals. On this assumption, the LF in (38-a) denotes $\mathcal{T}$ iff there exists an mbs_w eventuality included in the open interval lower-bounded by monday and right-bounded by u. Let's call this interval $\mathsf{ts\text{-}monda}$.

(41) $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \mathsf{lb}(\mathsf{monday},t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t]]$
$\equiv \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{ts\text{-}monda}]$

This immediately explains why Mary being sick on Monday has no bearing on the truth-conditions of the reading. Consider the scenario in Figure 2.13.

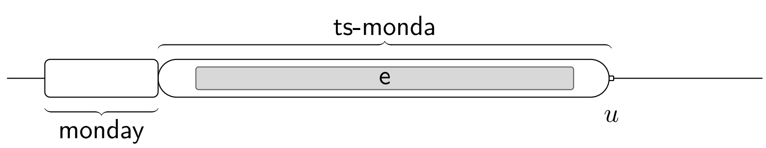

Figure 2.13: Scenario verifying (41)

Because the runtimes of eventualities are closed intervals, the LB of the $\mathsf{ts\text{-}monda}$ must be prior to that of the mbs_w eventuality it contains. The result of this is that any eventuality included in $\textsf{ts-monda}$ is always entirely disjoint from $\textsf{monday}$. This ensure that (41) is only ever verified if Mary was sick after Monday, although it is consistent with her being sick on Monday.

Let's now turn to (33)'s U-perfect reading. On the assumption that the perfect quantifies over just open intervals, the LF in (38-b) denotes $\mathcal{T}$ iff some $\textsf{mbs}_w$ eventuality includes the open interval $\textsf{ts-monda}$.

(42) $\exists t[\textsf{open}(t) \wedge \textsf{rb}(u,t) \wedge \textsf{lb}(\textsf{monday},t) \wedge \exists e[\textsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$
$\equiv \exists e[\textsf{mbs}_w(e) \wedge \textsf{ts-monda} \subseteq \tau_w(e)]$

This captures why (33)'s U-perfect implies that Mary was sick on Monday. Figure 2.14 depicts a scenario verifying this sentence. Since the runtime of the eventuality is closed while $\textsf{ts-monda}$ is open, the former can only include the latter if it includes its LB. This means that at least the final moment of $\textsf{monday}$ is included in this eventuality. In other words, this means that Mary was sick for part of that day.

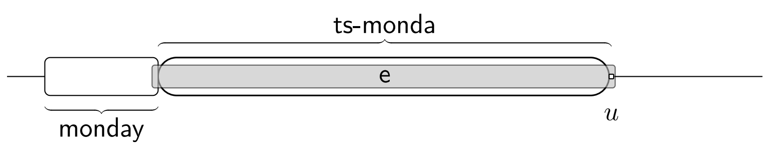

Figure 2.14: Scenario verifying (42)

My proposal has further consequences on whether or not Mary needs to be sick at the time of evaluation u for (33)'s truth-conditions. The prediction is that her being sick at u is irrelevant to the E-perfect's truth-conditions, but necessary for the U-perfect to be true. Indeed, any eventuality included in $\textsf{ts-monda}$ must exclude its RB, whereas any eventuality that includes $\textsf{ts-monda}$ must include it.

While it is clear that (33)'s U-perfect reading implies that Mary is still sick at the time of evaluation, it isn't straightforward to demonstrate that u is irrelevant to the E-perfect's truth-condition. What we would like to show is that in a scenario like Figure 2.15, where Mary's sickness begins at the time of evaluation, (33)'s U-perfect reading is false.

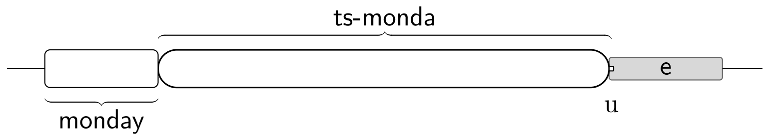

Figure 2.15: Scenario fasifying (41)

However, this scenario is too artifical to be taken seriously. There is just no realistic setting where we are evaluating the truth or falsity of (33) at the time of its utterance, while at the same time knowing that the time of evaluation corresponds to the very moment at which Mary begins to be sick.

A better argument in favor of this prediction comes from analyzing the truth-conditions of (36-a). Like (33)'s E-perfect reading, the sentence is in the perfective aspect. Its meaning is predicted to assert that an mwc_w eventuality is included in $\mathsf{ts\text{-}monda}$. An important difference between the predicates in (33) and (36-a) is that the former has the subinterval property, whereas the latter is quantized. A consequence of this is that while (33)'s E-perfect reading is true in the scenario in Figure 2.14, (36-a) isn't. Indeed, the subinterval property guarantees that if an mbs_w eventuality includes $\mathsf{ts\text{-}monda}$, then $\mathsf{ts\text{-}monda}$ will include such an eventuality. However, because mwc_w is quantized, $\mathsf{ts\text{-}monda}$ contains no such eventuality in the scenario.

What this means is that only a scenario like the one in Figure 2.13 can verify (36-a). This accords with our intuition that the sentence implies that at the moment of evaluation, Mary has already completed the chapter under discussion. This is in contrast to its imperfective counterpart in (36-b), which implies that she is still writing her chapter at the time of evalutaion. Both facts are predicted by my proposal. This concludes my first argument for treating the intervals over which the perfect quantifies as open.

2.4.2 *Since-when* Questions

In von Fintel & Iatridou (2019), the authors observe that *since*-when questions are unambiguously interpreted as U-perfects. The question in (43) can only be asking about the LB of an interval throughout which Mary was sick. It lacks any interpretation where we are asked for the LB of an interval in which Mary was sick at some point.

(43) Since when has Mary been sick?

a. #What is the LB of the PTS where Mary was sick at some point? (E-perfect)

b. What is the LB of the PTS where Mary was sick at every point? (U-perfect)

If we assume that the domain of quantification of the perfect includes closed intervals, this turns out to be a rather puzzling state of affair. It is a very common approach to the semantics of question that they be treated as denoting sets of propositions corresponding to their possible answers (Hamblin, 1973; Karttunen, 1977). Let's demonstrate how to arrive at this compositionally by assuming for (43)'s E-perfect reading the LF in (44-a), and for its U-perfect reading the LF in (44-b). To make discussing these easier, I have labeled them as **Q** and **R**, respectively.

(44) a. $[_{\mathbf{Q}}$ 4 when 1 [? p_4] PRES PERF [PFV Mary has been sick] since t_1]

b. $[_{\mathbf{R}}$ 4 when 1 [? p_4] PRES PERF [IMPV Mary has been sick] since t_1]

Let's begin by discussing the LF for the question's unavailable E-perfect reading. Observe three facts about **Q**. The first is the presence of the question-formation operator ?. As defined in (45-a), it denotes a relation of identity between propositions. The second is the fact that *when*, which according to (45-b) denotes an existential quantifier over intervals, moves to a position above the question-formation operator. Finally, observe that the sister of ? is bound by the leftmost index 4, which I will assume is assigned to a proposition.

(45) a. $[\![?]\!] := \lambda p_{st} \lambda q_{st}. p = q$

b. $[\![\text{when}]\!] := \lambda I_{it}. \exists t[I(t)]$

The LF in (44-a) denotes the function in (46-a), which takes a proposition and outputs $\mathcal{T}$ iff it is of the form "$\lambda w. \exists t^2[\mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq$

$t^2]]$", where t^1 is an interval. Another way to talk about this function is as the function characterizing the set of all such propositions, as in (46-b). We call the set of propositions characterized by a given question its **Hamblin set**.

(46) a. $\lambda p.\exists t^1[p = \lambda w.\exists t^2[\mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t^2]]]$
b. $\{\lambda w.\exists t^2[\mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t^2]] \mid t^1 \in \mathcal{D}_i\}$
c. $\{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(n, u)] \mid n \in \mathcal{D}_d\}$

The members of (46-b) are all the propositions where, for some t^1, consist of the worlds where Mary was sick at some point in the interval left-bounded by t^1 and right-bounded by u. Since each of these intervals has a measure in days, they can all be mapped to $\mathsf{pts}_{\mathsf{days}}(n, u)$ for some n. This set is thus equivalent to the set of propositions in (46-c), each of which consists of the set of worlds where, for some n, some mbs_w eventuality is included in $\mathsf{pts}_{\mathsf{days}}(n, u)$.

These are precisely the propositions corresponding to the intensions of sentences of the form "**Mary has been sick in n days*", on the assumption that the perfect allows closed intervals in its domain of quantification. In addition to this striking parallel, maximal informativity has been argued to figure prominently in the semantics of question. Following Dayal (1996), the LFs **Q** and **R** are both assumed to combine with the answerhood operator ANS, defined in (47).

(47) $$[\![\text{ANS}]\!]^w := \lambda \mathcal{Q}_{(st)t} : \exists p[\mathsf{max}^{\Rightarrow}_w(\lambda v_s \lambda q_{st}.v \in q \in \mathcal{Q}) = p] \\ .\iota p[\mathsf{max}^{\Rightarrow}_w(\lambda v_s \lambda q_{st}.v \in q \in \mathcal{Q}) = p]$$

We can think of this operator as picking out *the answer* to the question among those of the Hamblin set. However, this requires that we be able to identify among these possible answers one single element. It is here that maximal informativity comes into play: ANS is defined only for sets of propositions in which there is maximally informative true element, i.e. a proposition that is true and entails all other true propositions. When defined, it outputs the set's maximally informative true element.

We know already, from our discussion of G-TIAs in §2.3.1, that there is no issue in there being a maximally informative true element in (46-c). Recall the scenario we looked in this section, which I've repeated in Figure 2.16.

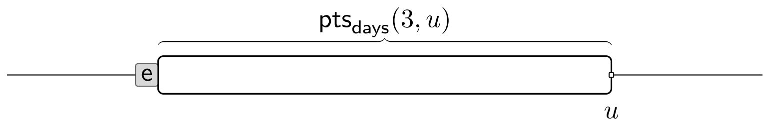

Figure 2.16: Possible answer for (46-c)

We saw that in a scenario like this one, where the RB of the mbs_w eventuality is also the LB of the PTS, 3 is the smallest degree such that $\mathsf{pts}_{\mathsf{days}}(n, u)$ contains an mbs_w eventuality. Another way to say this is that the proposition "$\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]$" is the maximally informative true element in (46-c).

(48) $[\![\text{ANS } \mathbf{Q}]\!]^{w,u,g} = \lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]$

There is no apparent reason why this reading of the question shouldn't be available. However, we do find an explanation for its unacceptability if we assume that the domain of quantification of the perfect is restricted to open intervals. On this view, the Hamblin set denoted by $\mathbf{Q}$ is (49).

(49) $\{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u)] \mid n \in \mathcal{D}_d\}$

We already saw that for any n, an mbs_w eventuality being included in $\mathsf{t}_{\mathsf{days}}(n, u)$ implies that it is included in a smaller PTS. What this means is that for any true proposition of the form "$\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u)]$", it is also the case that for some $m <_d n$, the proposition "$\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(m, u)]$" is also true. Any true element in (49) is thus strictly entailed by another of its true elements. As such, there can be no maximally informative true element in it. This means that, no matter the world of evaluation, $\mathbf{Q}$ is undefined in combination with ANS.

(50) $[\![\text{ANS } \mathbf{Q}]\!]^{w,u,g}$ is undefined

We can therefore understand the unacceptability of an E-perfect interpretation of (43) in terms of its never being defined. This lends further credibility to the view that the domain of quantification of the perfect is indeed restricted to open intervals. Happily, this view does not prevent the question from having the U-perfect interpretation in (43-b). The LF **R** denotes the function in (51-a), which characterizes the set of propositions of the form "$\lambda w.\exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]$", where t^1 is an interval.

(51) a. $\lambda p.\exists t^1[p = \lambda w.\exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]]$

b. $\{\lambda w.\exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(u, t^2) \wedge \mathsf{lb}(t^1, t^2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]] \mid t^1 \in \mathcal{D}_i\}$

c. $\{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \mathsf{t}_{\mathsf{days}}(n, u) \subseteq \tau_w(e)] \mid n \in \mathcal{D}_d\}$

This set consists of all the sets of worlds in which, for some t, the open interval left-bounded by t and right-bounded by u is included in an mbs_w eventuality. Each of these is equivalent to the set of worlds where, for some n, an mbs_w eventuality includes $\mathsf{t}_{\mathsf{days}}(n, u)$. The question thus characterizes the set in (51-c). There is no problem in finding in this set a maximally informative true element; consider Figure 2.17.

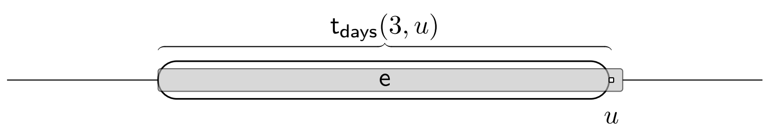

Figure 2.17: Possible Answer for (51-c)

In Figure 2.17, the mbs eventuality shares its LB with that of $\mathsf{t}_{\mathsf{days}}(3, u)$, while its RB is strictly preceded by u. The runtime of the eventuality being closed, it therefore includes the PTS. But for any $n > 3$, it doesn't include $\mathsf{t}_{\mathsf{days}}(n, u)$. The true answers for (51-c) are thus those shaded in Figure 2.18.

$\ldots,$
$\mathsf{t}_{\mathsf{days}}(4) \subseteq,$
$\ldots,$
$\mathsf{t}_{\mathsf{days}}(3) \subseteq,$
$\ldots,$
$\mathsf{t}_{\mathsf{days}}(2) \subseteq,$
$\ldots,$

Figure 2.18: True members of (51-c)

We see that we can indeed find a maximally informative true element in the set, viz. that proposition of the form "$\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \mathsf{t}_{\mathsf{days}}(3, u) \subseteq \tau_w(e)]$". There is thus every reason to expect the U-perfect to not be ruled out.

(52) $[\![\text{ANS } \mathbf{R}]\!]^{w,u,g} = \lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \mathsf{t}_{\mathsf{days}}(3, u) \subseteq \tau_w(e)]$

This concludes my second argument in favor for treating the perfect as a quantifier over open intervals. We see that restricting the domain of quantification of the perfect to open intervals is not simply an *ad hoc* way to derive the polarity sensitivty of G-TIAs in terms of the MIC. It actually does quick work of a number of empirical observations.

2.5 Prior Accounts of the Distribution of G-TIAs

2.5.1 A Note on Bare TIAs

In this section, I discuss two families of approaches designed to account for the poalrity sensitivity of G-TIAs. The first involves a reliance on formal licensing conditions (Hoeksema, 2006; Gajewski, 2005, 2007), while the second ties the acceptability of G-TIAs to whether they result in pathological scalar implicatures (Chierchia, 2013; Iatridou & Zeijlstra, 2017, 2021). As we will see, both views are difficult to reconcile with a unified semantics for TIAs.

Discussion of the polarity sensitivity of G-TIAs has restricted itself to the study of bare TIAs like *in days* or *in years*. Bare TIAs are analogous to those we have been looking at insofar as they too can be either E- or G-TIAs. Take first the examples in (53-a) and (53-b).

(53) a. Mary solved the problem in minutes.
b. *Mary was sick in minutes.

The adverbial in both sentences is an E-TIA. Not only does the TIA in (53-a) specify (albeit vaguely) the duration of a problem solving eventuality, but its counterpart in (53-b) displays the usual unacceptability of E-TIAs with atelic predicates. Contrast these sentences with those in (54-a) and (54-b).

(54) a. Mary hasn't been sick in years.
b. *Mary has been sick in years.

Here, we are clearly in the presence of G-TIAs. The TIA in (54-a) (vaguely) specifies the duration of the gap since Mary was last sick, and the TIA in its negatum is unacceptable.

Despite this similar distribution, bare TIAs exhibit properties that distinguish them from the TIAs discussed so far. As first noted by Hoeksema (2006), and as later discussed in detail in Iatridou & Zeijlstra (2017) and Iatridou & Zeijlstra (2021), the use of bare TIAs has rhetorical force; they serve to add emphasis onto how short or long an eventuality took. This is best illustrated if we compare the sentences in (53-a) and (54-a) to those in (55-a) and (55-b).

(55) a. #Mary solved the problem in years.
b. #Mary hasn't been sick in seconds.

The oddness of (55-a) and (55-b) highlights how part of a bare TIA's contribution involves adding emphasis to a statement. The E-TIA in (55-a) implies that a period of years is a strikingly short amount of time for Mary to have solved a problem in. The G-TIA in (55-b) implies that a period seconds is a remarkably long time for her to not have been sick in. The incongruity of these implications with common sense beliefs explains why neither sentence is felicitous.

I will not be discussing bare TIAs in this dissertation. Since, bare or not, G-TIAs show similar polarity sensitivity, I take it for granted that any account of the polarity sensitivity of bare G-TIAs should be measured by its ability to account for that of non-bare ones. As such, I will evaluate these proposals in terms of how they apply to TIAs that have numerals in their measure phrases.

2.5.2 Approach 1: Licensing Conditions

To my knowledge, the earliest discussion of the polarity sensitivity of G-TIAs are found in Hoeksema (2006), Gajewski (2005), and Gajewski (2007). The approach these authors use to account for their polarity sensitivity is rooted in Ladusaw's (1979) famous account of the distribution of expressions like *ever*. Consider the sentences in (56-a)-(56-b).

(56) a. *Mary has ever been sick.
  b. Mary hasn't ever been sick.
  c. Every student who has ever been sick has rested.
  d. *Every student has ever rested.
  e. No student who has ever been sick has rested.
  f. No student has ever rested.

Ladusaw observes that the environments in (56-a)-(56-f) where *ever* is acceptable share certain semantic characteristics. In all such cases, *ever* is in the scope a **downward entailing** (DE) operator. Following von Fintel (1999), I define what it means for a function to be DE in terms of a generalized notion of entailment.

(57) **Generalized Entailment:**
  a. $p \Rightarrow_t q$ iff $p \rightarrow q$
  b. $X \Rightarrow_{\sigma\tau} Y$ iff $\forall \alpha_\sigma [X(\alpha) \Rightarrow_\tau Y(\alpha)]$

The definition in (57) assumes the material condition as the base case for generalized entailment. Entailment can as such be defined for any functions of any type which, after some number of inputs, output a truth-value. With this definition in hand, we can define what it means for a function to be DE.

(58) **Downward Entailingness:**
$X_{\sigma\tau}$ is downward entailing iff
$\forall\alpha_\sigma, \beta_\sigma[(\alpha \Rightarrow_\sigma \beta) \rightarrow (X(\beta) \Rightarrow_\tau X(\alpha))]$

A function is DE when the relationship of entailment that exists between its outputs is the reverse of the one that exists between its inputs. In the spirit of Ladusaw, von Fintel proposes for NPIs like *ever* the licensing condition in (59).

(59) **Licensing Condition for NPIs:**
An NPI is acceptable in the scope of some expression **X** only if $[\![\mathbf{X}]\!]^{w,u,g}$ is DE.

We can convince ourselves that the expression *no student* is DE. The meaning of this quantificational determiner is given in (60). First, observe that (61-a) (strictly) entails (61-b). Anybody who rested and recovered is someone who rested.

(60) $[\![\text{no student}]\!]^w = \lambda P_{et}.\neg\exists x[\mathsf{student}_w(x) \wedge P(x)]$

(61) a. $\lambda x.\ \mathsf{rested}_w(x) \wedge \mathsf{recovered}_w(x)$
b. $\lambda x.\ \mathsf{rested}_w(x)$

After we apply (60) to both (61-a) and (61-b), we obtain the outputs in (62-a) and (62-b). Now, it is (62-b) that (strictly) entails (62-a): if no student rested, then no student both rested and recovered. The entailment between (61-a) and (61-b) has been reversed by *no student*.

(62) a. $\neg\exists x[\mathsf{student}_w(x) \wedge \mathsf{rested}_w(x) \wedge \mathsf{recovered}_w(x)]$
b. $\neg\exists x[\mathsf{student}_w(x) \wedge \mathsf{rested}_w(x)]$

The licensing condition in (59) accounts for why *ever* is licensed in (56-f). I leave it to the reader to verify that among the sentences in (56-a)-(56-f), the licensing condition predicts *ever* to be acceptable in all but (56-a) and (56-d).[8]

Hoeksema (2006) observes that the environments that license G-TIAs are a proper subset of those that license ever. On the approach under discussion, authors will propose a licensing condition for G-TIAs that is stricter than (59). This condition is typically shaped by F. Zwarts's (1998) discussion of the formal properties of weak and strong NPI licensers, though a recent exception to this is to be found in Gajewski (2011). Whatever condition this approach ultimately settles on, it is fundamentally incompatible with the project of a unified treatment of E- and G-TIAs. Indeed, neither the G-TIA in (63-a) nor the E-TIA in (63-b) is in the scope of a DE operator, let alone an operator with stronger semantic properties. If E- and G-TIAs are to be thought of as one and the same kind of expression, any licensing condition built on the semantic properties licensers that rules out (63-a) must also rule out (63-b).

(63) a. *Mary has been sick in three days.
b. Mary wrote up a chapter in three days.

To the extent where one wants to maintain a unified treatment of TIAs, one cannot account for the polarity sensitivity of G-TIAs by relying on a licensing condition in the spirit of Ladusaw's.

2.5.3 Approach 2: Subintervals of the PTS

The second approach to the polarity sensitivity of G-TIAs finds exemplars in works such as Chierchia (2013), Iatridou & Zeijlstra (2017), and Iatridou & Zeijlstra (2021). It is itself rooted in a broader project that links NPI licensing to whether or not the meanings of sentences containing them can be succesfully strengthened (Kadmon & Landman, 1993; Krifka, 1995; Chierchia, 2006).

Among these proposals, I will be focusing on the one in Iatridou & Zeijlstra (2021), henceforth I&Z. Their paper draws heavily from Chierchia (2013), but stands out in that it offers a realistic treatment of G-TIAs as perfect-level

[8] If we assume that the quantificational determiners *every* and *no* presuppose their restrictors aren't empty, then they are not actually DE, but Strawson DE in the sense of von Fintel (1999).

adverbials. The semantic interpretations they offer for (64-a) and (65-a) are those in (64-b) and (65-b), the very same that I assume modulo the openness of teh PTS.

(64) a. *Mary has been sick in three days.
b. $\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3,u)]$

(65) a. Mary hasn't been sick in three days.
b. $\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3,u)]$

On the approach for which I&Z advocate, it is suggested that (64-b) and (65-b) must stand in a certain logical relation with elements of a set of alternatives. A distinguishing factor between my propsal and theirs is in the nature of these alternatives. For them, alternatives are defined in terms of the subintervals of the PTS. For instance, (66) is the set of alternatives to (64-b).

(66) $\{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t] \mid t \subseteq \mathsf{pts}_{\mathsf{days}}(3,u)\}$

Let's call (66) the set of PTS-alternatives to (64-a). For each subinterval t of $\mathsf{pts}_{\mathsf{days}}(3,u)$, there is an alternative in (66) asserting that t includes an mbs_w eventuality. I&Z's proposal can be stated as follows: a G-TIA always triggers the (obligatory) implicature that the proposition to which it contributes its meaning is the maximally informative true element in the set of PTS-alternatives to that proposition. In other words, (64-a) leads to the inference that (64-b) entails every true member of (66).

I&Z's observation is that in simple positive sentences like (64-a), the inference generated by G-TIAs always leads to a contradiction. For (64-b) to be maximally informative in (66), it must entail every true member of the set. Equivalently, this means that all but those members entailed by (64-b) must be false. With the exception of (64-b) itself, each member of (66) strictly entails (64-b).[9] For (64-b) to be the maximally informative member of (66), it must therefore be the case that every other member of the set is false. To

[9]For any subinterval of $\mathsf{pts}_{\mathsf{days}}(3,u)$, if it includes an mbs_w eventuality, then so does $\mathsf{pts}_{\mathsf{days}}(3,u)$. The converse doesn't hold: if $\mathsf{pts}_{\mathsf{days}}(3,u)$ includes an mbs_w eventuality, there is no guarantee that any particular subinterval of $\mathsf{pts}_{\mathsf{days}}(3,u)$ does.

grasp why this is contradictory, consider the scenario in Figure 2.19.

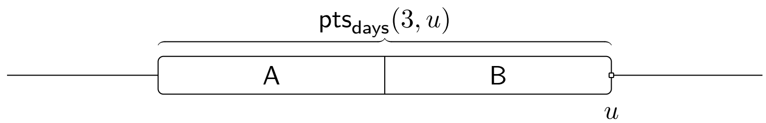

Figure 2.19: $\mathsf{pts}_{\mathsf{days}}(3, u)$ and some PTS-alternatives

In this scenario, I have depicted three intervals: $\mathsf{pts}_{\mathsf{days}}(3, u)$ and its subintervals A and B. Importantly, $\mathsf{pts}_{\mathsf{days}}(3, u)$ is the union of A and B. For (64-b) to the maximally informative member of (66), it must itself be true. This means that $\mathsf{pts}_{\mathsf{days}}(3, u)$ includes some mbs_w eventuality. This, in turn, implies that either A or B (or both) includes some such eventuality. However, because (64-b) must be maximally informative in (66), we know that neither A nor B can include any mbs_w eventuality. We have arrived at a contradiciton. I&Z thus take the unacceptability of the G-TIA in (64-a) to result from its leading to a contradiction.[10]

Let's now turn to (65-a), and show that it doesn't land us a contradiction. The PTS-alternatives of (65-b) are the members of (68).

(68) $\{\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t] \mid t \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)\}$

The members of this set are all strictly entailed by (65-a). If there are no mbs_w eventualities included in $\mathsf{pts}_{\mathsf{days}}(3, u)$, then it follows that none are included in any of its subintervals. So long as (65-a) is true, it is trivially the maximally

[10]Telic predicates are a problem for this conclusion. In (67-a), the atelic predicate *written up a chapter* has been substituted for *been sick*. The reading where *in three days* is a G-TIA is given in (67-b), and its alternatives are given in (67-c).

(67)
a. Mary has written a chapter in three days.
b. $\exists e[\mathsf{mwc}_w(e) \wedge \tau_w(e) \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)]$
c. $\{\exists e[\mathsf{mwc}_w(e) \wedge \tau(e) \subseteq_w t] \mid t \subseteq \mathsf{pts}_{\mathsf{days}}(3, u)\}$

Because the predicate is quantized, no contradiction comes from saying that (67-b) is the maximally informative member of (67-c). If the writing eventuality is coextensive with the PTS, then (67-b) is true while every other member of (67-c) is false. I&Z can evade this problem if they say that the relationship between the runtime of the matrix eventuality and the PTS is *proper* inclusion.

informative member of (68). I&Z are succesful in accounting for why G-TIAs are unacceptable in simple positive sentences like (64-a), but are licensed under the scope of negation. However, I take my proposal to fare better than theirs in two respects.

The first is that it isn't clear how they derive the alternatives of in (66) and (68). As I argued in Chapter 1, we don't want to say that the perfect actually references a definite interval; it is better to think of the perfect as a quantifier over intervals. If this is the case, then we don't really have such a thing as the PTS of the sentence upon which to base the PTS-alternatives in (66) and (68). In fact, I will provide further arguments in §2.6 in favor of a quantificational analysis of the perfect.

The second is that it is unclear where this proposal fits in a unified semantics for TIAs. The requirement that (64-a) and (65-a) be maximally informative relative to their PTS-alternatives must result from the presence of the G-TIAs themselves. Indeed, other perfect-level adverbials would show polarity sensitivity if this were a general requirement of sentences in the perfect. However, these alternatives can only be defined provided we have access to a PTS. If E- and G-TIAs are indeed the same kind of expression, then it is unclear what the alternatives are, let alone what their role is, in a sentence containing an E-TIA that lacks the perfect altogether.

2.6 G-TIAs and the U-perfect

In this section, I show that my analysis offers further support for a quantificational treatment of the perfect. Observe that, were we to assume that the perfect refrences the PTS, the sentence in (69) should be grammatical on the U-perfect reading in (69-a). On this semantics, the sentence asserts that Mary was sick throughout the PTS, which is $\mathsf{t}_{\mathsf{days}}(3, u)$.

(69) *Mary has been sick in three days.

a. $\exists e[\mathsf{mbs}_w(e) \wedge \mathsf{t}_{\mathsf{days}}(3, u) \subseteq \tau_w(e)]$

b. $\lambda w \lambda n.\exists e[\mathsf{mbs}_w(e) \wedge \mathsf{t}_{\mathsf{days}}(n, u) \subseteq \tau_w(e)]$

The property of degrees in (69-b) is strictly downward scalar. If $\mathsf{t_{days}}(3, u)$ is included in an mbs_w eventuality, then so is $\mathsf{t_{days}}(2, u)$. The converse does not, however, hold. We already saw an analogous case to (69-b) in §2.4.2, when we looked at *since*-when questions. There, we were able to show that there is no difficulty in finding a maximally informative degree for the set. In a scenario like the one in Figure 2.20, we have $\mathsf{t_{days}}(3, u)$ being included in an mbs_w eventuality which shares with it its LB. For every $n >_d 3$, $\mathsf{t_{days}}(n, u)$ isn't included in the eventuality.

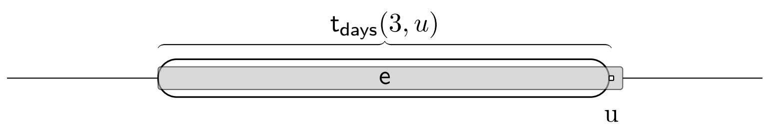

Figure 2.20: Scenario verifying (69)

In this scenario, the maximally informative degree in (69-b) is simply 3. This is highly problematic, as the sentence is of course ungrammatical. My proposal rules out this possibility. The crucial difference between this view and my own is that I treat the perfect as an existential quantifier. The result of this is that (69-a) is not what I predict (69) to mean on its U-perfect reading. The LF my analysis gives to the sentence is the one in Figure 2.21.

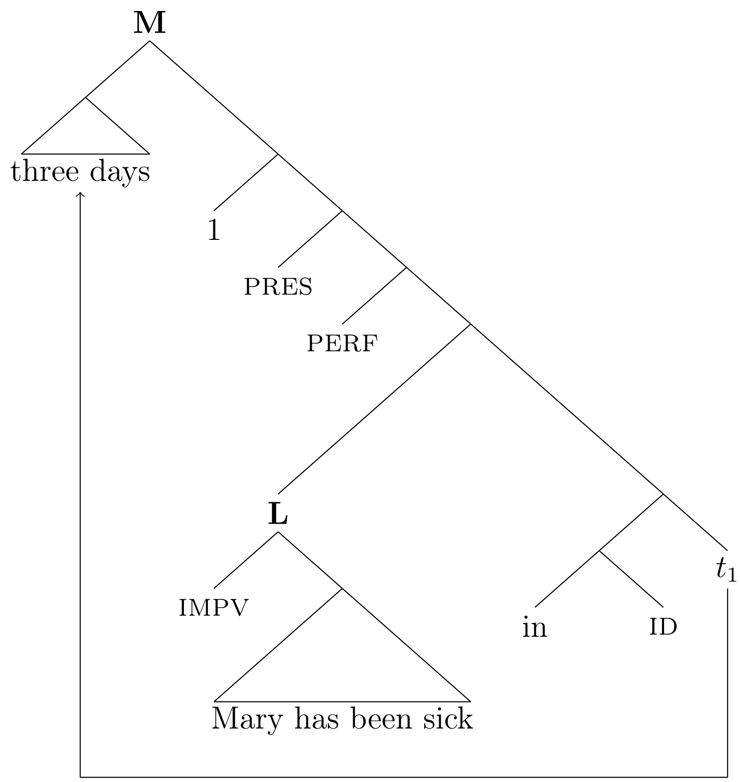

Figure 2.21: LF for (69) in the imperfective

In node **L**, we have the operator IMPV combining with the predicate of mbs eventualities. This gives us is the set of intervals included in such an eventuality.

(70) $[\![\mathbf{L}]\!]^w = \lambda t.\ \exists e[\mathsf{mbs}_w(e) \wedge t_w \subseteq \tau(e)]$

What is striking about this predicate is that it has the subinterval property. If an interval has the property of being included in an mbs_w eventuality, then so do all of its subintervals. Although we defined the subinterval property only for predicates of eventualities in §2.2.2, we can generalize it to all predicates using map functions. When we have predicates of eventualities, the subinterval property is defined in terms of τ_w, the temporal trace function.

(71) **Generalized Subinterval Property:**
For a given map $M_{\sigma t}$, a property $\mathcal{X}_{s\sigma t}$ has the Subinterval Property iff

$$\forall w_s, \alpha_\sigma, t_i[(\mathcal{X}(w,\alpha) \wedge t \subseteq M(w,\alpha)) \rightarrow \exists \beta_\sigma[\mathcal{X}(w,\beta) \wedge t = M(\beta)]]$$

When what we have are predicates of intervals, it is defined in terms of the identity function id. The subinterval property will, as with atelic predicates, make the semantic contribution of the TIA redundant. The meaning we obtain for **M** looks rather complicated: it says that exists is an mbs_w eventuality, and that included in its runtime is an open interval whose RB is u and which is istelf included in a three day long interval.

(72) $[\![\mathbf{M}]\!]^{w,u,g} = \exists t_1[\mathsf{days}(t_1) = 3 \wedge \exists t_2[\mathsf{open}(t_2) \wedge \mathsf{rb}(u,t) \wedge t_2 \subseteq t_1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t_2 \subseteq \tau_w(e)]]]$

In spite of appearance, this meaning is in fact equivalent to that of (73) on its U-perfect reading. Given the LF in (73-a), we get a meaning that simply states that some mbs eventuality contains an open interval whose RB is i.

(73) Mary has been sick.

a. PRES PERF IMPV [Mary has been sick]

b. $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

It is easy to show that (72) entails (73-b). The reasoning in (74) is valid on account of conjunction elimination.

(74) $\exists t_1[\mathsf{days}(t_1) = 3 \wedge \exists t_2[\mathsf{open}(t_2) \wedge \mathsf{rb}(u,t) \wedge t_2 \subseteq t_1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t_2 \subseteq \tau_w(e)]]]$

$\therefore$ $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

More importantly, we can show that the reasoning in (75) is also valid. This is because of the interaction of the existential meaning of the perfect with the meaning of *in* and the subinterval property.

(75) $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

$\forall t^1, t^2[(\exists e[\mathsf{mbs}_w(e) \wedge t^1 \subseteq \tau_w(e)] \wedge t^2 \subseteq t^1) \rightarrow \exists t^3[\exists e[\mathsf{mbs}_w(e) \wedge t^3 \subseteq \tau_w(e)] \wedge t^3 = t^2]]$

$\therefore$ $\exists t_1[\mathsf{days}(t_1) = 3 \wedge \exists t_2[\mathsf{open}(t_2) \wedge \mathsf{rb}(u,t) \wedge t_2 \subseteq t_1 \wedge$

$\exists e[\mathsf{mbs}_w(e) \wedge t_2 \subseteq \tau_w(e)]]]$

Suppose, as in (73), that an mbs_w eventuality contains *some* open interval t^1 whose RB is u. It is either the case that t^1 lasts more than three days, or that it lasts three days or less. If it lasts more than three days, then t^1 has a proper part t^2 which is a three day long open interval whose RB is also u. Since the predicate of intervals included in an mbs_w eventuality has the subinterval property, it follows that by virtue of being a proper part of t^1, t^2 is also included in some such eventuality. Since it lasts exactly three days, it also follows that t^2 is included in a three day long interval. Therefore, we can conclude that an mbs eventuality includes *some* open interval whose RB is u and which is included in a three day long interval. If, on the other hand, t^1 lasts three days or less, then it is already included in a three day long interval. Therefore, we can here too arrive at the same conclusion.

No matter the numeral we substitute for *three* in (69), it will always be the case that the meaning we derive for the U-perfect reading of the sentence is equivalent to (73-b). A consequence of this is that if we were to abstract over the numeral in the LF, we could obtain the property of degrees in (76).

(76) $\lambda w \lambda n.\ \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

For any input, this property outputs a constant function. It follows that there can be no maximally informative input for it. The MIC thus rules out (69) on a U-perfect reading, as the TIAs numeral cannot be maximally informative there.

(77) $\mathsf{max}^{\Rightarrow}_w(\lambda w \lambda n.\ \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]])$ is undefined.

In addition to the fact that (69) doesn't have a grammatical U-perfect reading, notice its negative counterpart in (78) only seems to have an E-perfect reading. The sentence can only mean that Mary wasn't sick at any point in the last three days. It doesn't have a weaker reading that says that Mary wasn't sick at every point in the last three days. My analysis predicts this because this latter statement is not the meaning predicted for the sentence on a U-perfect reading.

(78) Mary hasn't been sick in three days.

a. NEG [three days] λ_4 PRES PERF [IMPV [Mary has been sick]] [in ID] t_4

b. $\neg\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

The LF for (78) on a U-perfect reading should be (78-a). This should simply be interpreted as the negation of its negatum, as in (78-b). Here again, the TIA is semantically redundant. If we abstract over the numeral, we again obtain a constant function for which there is no maximally informative input.

(79) $\mathsf{max}^{\Rightarrow}_{w}(\lambda w \lambda n.\ \neg\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(u,t) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]])$ is undefined.

The interaction of G-TIAs with the imperfective aspect thus not only offers support for a quantificational analysis of the perfect, but actually provides additional support for a unified analysis of TIAs. We see here that once more, the MIC is at work blocking unattested readings of TIAs.

Throughought this work I have assumed a referential, as opposed to quantificational, analysis of tense. This raises the question of whether there is any reason to think tenses and the perfect differ in terms of definiteness. These questions invite looking at whether there may be expressions which, similar to G-TIAs, would allow us to tease apart a referential and quantificational analysis of tense. I leave this an open issue.

2.7 Concluding Remarks

This chapter followed up on Chapter 1's stated goal of carrying out a unified semantics for E- and G-TIAs. Here, I showed that a unified analysis of TIAs is capable of not only accounting for the interaction of lexical aspect with E-TIAs, but also the polarity sensitivity of G-TIAs. In both cases, the account relies on a requirement that it be possible for the numeral in a TIA to be maximally informative.

As I've already mentioned, the MIC raises some interesting questions. For example, if the licensing of TIAs is explicable in terms of maximal informativity, why are maximal informativity inferences optional with them? Such questions raise doubts about the depth of explanation offered by the MIC. To add to these doubts, I will point out in Chapter 3 that the MIC faces some undergeneration problems: it predicts that acceptable uses of TIAs should be blocked. There, I undertake a more ambitious project than was laid out in this chapter: I attempt to capture the distribuition of TIAs in terms of independently motivated constraints on numerals. In so doing, I hope to provide more insight into the linguistic mechanisms that underlie the distribution of E- and G-TIAs.

Chapter 3

Scalarity, Economy and Temporal *in*-Adverbials

3.1 Introduction

Chapter 2 saw the introduction of the MIC, repeated in (1), as a unified account of the distributional restrictions on E- and G-TIAs. It states that a TIA is only acceptable it is possible for the numeral in its measure phrase to be maximally informative.

(1) **Maximal Informativity Constraint:**
A TIA "in ν μ" is acceptable in an LF $\mathbf{X}$ only if for some index i and some world w, $\mathsf{max}_{w}^{\Rightarrow}(\llbracket i\ \mathbf{X}[\nu \mapsto pro_i]\rrbracket_{¢}^{u,g}) = \llbracket \nu \rrbracket$.

In this Chapter, I show that MIC is too strong. The observation behind this claim is that while (2-a) is acceptable, its interrogative counterpart in (2-b) is not.

(2) a. Mary didn't write this chapter in three days.
b. *In how many days did Mary not write this chapter?

Following prior work by Fox & Hackl (2006) on negative islands, I will argue that the unacceptability of the question in (2-b) is to be understood in terms of a failure of maximal informativity: there is never a maximally informative number of days n such that Mary didn't write the chapter in n days or less. If this is indeed the case, the MIC is predicted to rule out the sentence in (2-a).

I will argue that *in lieu* of the MIC, we should understand the distributional constraints on TIAs in terms of two independent principles. First, I show that the polarity sensitivity of G-TIAs in the perfective can be understood in terms of their giving rise to pathological scalar implicatures in simple positive sentences. I then argue, based on previous work by Buccola & Spector (2016), that numerals are independently ruled out when they are redundant. This explains the unacceptability of E-TIAs with atelic predicates, and of G-TIAs in the imperfective.

In §3.2, I demonstrate how the MIC overgenerates, and sketch out a solution in terms of syntactically covert operators. In §3.3, I cover the background on exhaustification operators, which are syntactically covert items responsible for generating scalar implicatures. In §3.4, I show how a requirement that TIAs be in the scope of an exhaustification operator can capture the polarity sensitivity of G-TIAs and overcome some of the empirical undercomings of the MIC. However, I show that it captures neither the unacceptability of E-TIAs with atelic predicates, nor that of G-TIAs in the imperfective. In §3.5, I show that these cases can be ruled out in terms of a principle of pragmatic economy. I finally conclude in §3.6.

3.2 The MIC is too Strong

The question in (3-a) bears all the hallmarks of a negative island, where a degree question in which a *wh*-phrase is extracted above negation leads to unacceptability (Beck & Rullmann, 1999; Fox & Hackl, 2006; Rullmann, 1995; von Stechow, 1984; Szabolcsi & Zwarts, 1993). Fox & Hackl (2006) tie the unacceptability of negative islands to a failure of maximal informativity: density makes it impossible for a maximally informative true answer to be defined in their Hamblin set. We can show this to be the case with (3-a), whose LF is **Q** in (3-b).

(3) a. *In how many days did Mary not write this chapter?

b. $[_{\mathbf{Q}}$ 4 [how many] 3 [p_4 ?] not [n_3 days] 2 PAST$_1$ PFV [Mary wrote this chapter] [in RUNTIME] t_2]

Similar to what we assumed to be the meaning for *when*, which we treated as a simple existential quantifier over intervals, we can think of *how many* as an existential quantifier over degrees.

(4) $[\![\text{how many}]\!] = \lambda D_{dt}.\exists n[D(n)]$

The extension of (3-b) is the function in (5-a), which characterizes the set of all propositions "$\lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$" for some $n \in \mathcal{D}_d$. Here, $\mathsf{mwt}_{1,w}$ is shorthand for the set of eventualities of Mary writing this chapter at $g(1)$ in w.

(5) a. $\lambda p_{st}.\neg\exists n[p = \lambda w.\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq n]]$

b. $\{\lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq n] \mid n \in \mathcal{D}_d\}$

The entailments between the different members of (5-b) are represented in Figure 3.1. If Mary didn't write this chapter in three days or less, this strictly implies that she didn't do so in two days or less.

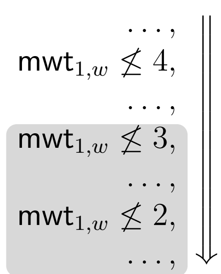

Figure 3.1: True members of (5-b)

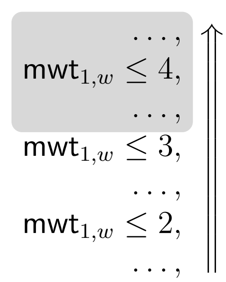

Figure 3.2: True members of (6)

We can show that the (5-b) cannot have a maximally informative true element. Suppose that the shaded area in Figure 3.1 highlights its true members; here, the maximally informative true element of the set would be the proposition "$\lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$". What this means is that, while there is no $\mathsf{mwt}_{1,w}$ eventuality whose runtime lasted three days or less, there is for every $n >_d 3$ some such eventuality lasting n days or less.

This raises an immediate question: in how many days did Mary write this chapter? The Hamblin set for this question is given in (6), and the entailments between its members are represented in Figure 3.2. We see from the shaded area that there is no maximally informative true member in this set: for every n such that "$\lambda w.\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$" includes the world of evaluation, there is some $m <_d n$ such that "$\lambda w.\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d m]$" does too.

(6) $\{\lambda w.\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n] \mid n \in \mathcal{D}_d\}$

We see that for there to be a maximally informative number of days in which Mary didn't write up her chapter, there can be no definite measure of how long it took her to write it. Since, by assumption, the measure function days is defined for every interval, this means that a maximally informative true element in (5-b) implies a contradiction. In other words, the extension of ANS is never defined for (5-b), which accounts for (3-a)'s unacceptability.

(7) $[\![\text{ANS } \mathbf{Q}]\!]^{w,u,g}$ is never defined.

But consider now the sentence in (8-a). Its LF is **A**, whose extension is $\mathcal{T}$ iff there are no $\mathsf{mwt}_{1,w}$ eventualities lasting three days or less.

(8) a. Mary didn't write this chapter in three days.
b. [$_{\mathbf{A}}$ not [three days] 2 PAST$_1$ PFV [Mary wrote this chapter] [in RUNTIME] t_2]
c. $\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

We can derive from **A** the property of degrees in (9), which is strictly downward scalar. For the same reason that there can be no maximally informative true element in (5-b), there is never a maximally informative degree in (9). Since the extension of *three* can never be maximally informative in (9), the MIC incorrectly predicts the sentence to be unacceptable.

(9) $\lambda w \lambda n.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$

(10) $\mathsf{max}^{\Rightarrow}_{w}(\lambda w \lambda n.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n])$ is undefined.

The issue with the MIC can be thought of as resulting from a lack of flexibility as to where it can be satisfied. As currently defined, the constraint requires us to check whether a TIA is licensed in an LF in terms of whether its numeral can be maximally informative in a property derived from the LF as a whole. If we had the option of checking whether or not it is satisfied at different points in an LF, we could predict the acceptability of (3-a). For example, we know that 3 can be maximally informative in (11-b), which is defined in terms of just the material below negation in **A**. What we need is a version of the MIC that isn't required to apply to LFs globally, but can instead apply locally in some of its subconstituents.

(11) a. [three days] 2 PAST$_1$ PFV [Mary wrote this chapter] [in RUNTIME] t_2

b. $\lambda w \lambda n.\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n]$

We could implement this in analogy with the answerhood operator ANS in questions: just like the maximal informativity requirement associated with questions is the result of a covert syntactic operator, so could this local MIC. A crucial difference between the two operators, however, is the type of the constitutents they combine with. Because ANS checks whether a set of propositions has a maximally informative true element, the type of its sister is $(st)t$. The operator from which we derive the MIC combines with LFs whose intensions are propositions. As such, the sisters of this operator will always be of type t. This difference between operators allows us to explain why the question in (3-a) is unacceptable, while its declarative counterpart in (8-a) is acceptable. In the LF in (3-b), only the highest constituent denotes something of type $(st)t$, thus ANS has no choice but to apply globally. On the other hand, there are two constituents of type t that contain the numeral in (8-b). We thus have the option of scoping this operator either above negation, as in (12-a), or below it, as in (12-b).

(12) a. OP not [three days] 2 PAST$_1$ PFV [Mary wrote this chapter] [in RUNTIME] t_2
b. not OP [three days] 2 PAST$_1$ PFV [Mary wrote this chapter] [in RUNTIME] t_2

We predict that while (12-a) is an unacceptable parse for (8-a), the parse in (12-b) should be fine. The question is now how to define the operator responsible for this local MIC. In §3.4, I will propose to identify this operator with exhaustification, a covert operatior assumed to be behind scalar implicatures (Chierchia, 2006; Fox, 2007; Landman, 1998). Such an identification finds initial motivation in the fact that, as we saw in Chapters 1 and 2, the maximal informativity inference tied to a TIA's numeral is at best a scalar implicature. This is supported by the consistency of (13-a) and (13-b).

(13) a. Mary wrote up a chapter in three days. What's more, she did so in two!
b. Mary hasn't been sick in three days. What's more, she hasn't been in four!

The MIC can thus be reformulated as follows: a TIA is only licensed in an LF if it is possible to draw from it the scalar implicature that its numeral is maximally informative. In §3.3, I present the basics of exhaustification, and how it has already been suggested as a mechanism for licensing other polarity sensitive items.

3.3 Background

3.3.1 Exhaustification

In most contexts, we will interpret an utterance of (14) as conveying that Mary did not order both the fish and the chicken.

(14) Mary ordered the fish or the chicken.
⇝ Mary didn't order both the fish and the chicken.

This inference cannot be tied to the basic meaning of *or*. If it were, the discourse in (15) would be contradictory. Instead, we should think of it as a scalar implicature (SI).

(15) Mary ordered the fish or the chicken. What's more, she ordered both.

The basic meaning of natural language disjunction is often assumed to be equivalent to that of its logical counterpart. On its literal interpretation, the sentence in (14) is true iff Mary ordered either soup, salad, or soup and salad. The SI that Mary didn't order both is thought to be the result of (14) having a formal alternative defined in terms of conjunction. As is often done, I will be defining the formal alternatives of a sentence in terms of syntactic substitutions of material (Horn, 1972; Gazdar, 1979; Atlas & Levinson, 1981).[1] I implement this idea with the following recursive procedure: the alternatives of an LF's terminal nodes are all given by the lexicon, and the alternatives of larger syntactic constituents are defined in terms of the pointwise combinations of their own alternatives. By this process, which is defined formally in (16), we can define the alternatives of a whole LF in terms of those of its terminal nodes.

(16) **Formal Alternatives:**

(i) $\mathcal{A}\ell t(\mathbf{X})$ is given by the lexicon if $\mathbf{X}$ is a lexical item.

(ii) $\mathcal{A}\ell t(\mathbf{X}\ \mathbf{Y}) := \{\mathbf{Z}\ \mathbf{V} \mid \mathbf{Z} \in \mathcal{A}\ell t(\mathbf{X}) \text{ and } \mathbf{V} \in \mathcal{A}\ell t(\mathbf{Y})\}$.

For simplicity's sake, we can assume for (14) the LF in (17-a). I said that we want it to have as an alternative the LF in (17-b), where *and* has been substituted for *or*.

(17) a. $[_{\mathbf{A}_{\text{or}}}$ [Mary ordered the fish] or [Mary ordered the chicken]]

b. $[_{\mathbf{A}_{\text{and}}}$ [Mary ordered the fish] and [Mary ordered the chicken]]

As a first shot, we can assume for *or* the set of alternatives in (18-a), which

[1] The analysis is also compatible with the view proposed in Katzir (2007), according to which alternatives are defined both in terms of substitutions and deletions of lexical material.

consists of *or* itself as well as *and*. We can distinguish *or* from other elements in the sentence in terms of its being a scalar item. Whereas scalar items have alternatives other than themselves, the set of alternatives of a non-scalar item is just the singleton set containing it. If we assume that *or* is the only scalar item in $\mathbf{A}_{\text{or}}$, we end up with (18-b) as its set of alternatives.

(18) a. $\mathcal{A}\ell t(\text{or}) := \{\text{or}, \text{and}\}$ (*To be revised*)
b. $\mathcal{A}\ell t(\mathbf{A}_{\text{or}}) = \{\mathbf{A}_{\text{or}}, \mathbf{A}_{\text{and}}\}$

We can now think of the SI associated with (14) in terms of the optional negation of its conjunctive alternative $\mathbf{A}_{\text{and}}$. Assuming the fairly typical denotations for disjunction and conjunction in (19), the intensions of $\mathbf{A}_{\text{or}}$ and $\mathbf{A}_{\text{and}}$ roughly correspond to (20-a) and (20-b). Since the latter strictly entails the former, we can think that the SI is derived from negating the extension of $\mathbf{A}_{\text{or}}$'s sole semantically stronger alternative.

(19) a. $[\![\text{or}]\!] := \lambda p_t \lambda q_t . p \vee q$
b. $[\![\text{and}]\!] := \lambda p_t \lambda q_t . p \wedge q$

(20) a. $\lambda w.\mathsf{ordered}_w(\mathsf{m}, \mathsf{f}) \vee \mathsf{ordered}_w(\mathsf{m}, \mathsf{c})$
b. $\lambda w.\mathsf{ordered}_w(\mathsf{m}, \mathsf{f}) \wedge \mathsf{ordered}_w(\mathsf{m}, \mathsf{c})$

While the simplicity of this story carries with it a great deal of appeal, it cannot be fully correct. Observe that when we embed the disjunction below a universal modal, as in (21), we generally infer that Mary was allowed order just the fish, or just the chicken. On the semantics for disjunction we are assuming, this cannot be an entailment of the sentence, which is true if Mary is required to order just the fish, and when she is required to order just the chicken.

(21) Mary was required to order the fish or the chicken.
$\rightsquigarrow$Mary was allowed to order just the fish.
$\rightsquigarrow$Mary was allowed to order just the chicken.

If we assume that *or* only has itself and *and* as alternatives, we won't be able to derive these from (21). If the LF for (21) is $\mathbf{A}_{\Box\text{or}}$, and we assume that *or* is again the only scalar item, its only other alternative will be $\mathbf{B}_{\Box\text{and}}$.

(22) a. $[_{\mathbf{A}_{\Box\text{or}}}$ required [Mary ordered the fish] or [Mary ordered the chicken]]

b. $[_{\mathbf{B}_{\Box\text{and}}}$ required [Mary ordered the fish] and [Mary ordered the chicken]]

The intensions of both LFs are roughly those in (23-a) and (23-b). Since the latter strictly entails the former, we should expect that the only SI available to (21) is that Mary wasn't required to order both the fish and the chicken. This isn't what we intuit in (21), as it is consistent with Mary being required to order just the fish, or being required to order just the chicken.

(23) a. $\lambda w.\Box_v^w(\mathsf{ordered}_v(\mathsf{m},\mathsf{f}) \vee \mathsf{ordered}_v(\mathsf{m},\mathsf{c}))$

b. $\lambda w.\Box_v^w(\mathsf{ordered}_v(\mathsf{m},\mathsf{f}) \wedge \mathsf{ordered}_v(\mathsf{m},\mathsf{c}))$

We can derive the inferences we want by assuming that a disjunctive LF doesn't just have an alternative defined in terms of conjunction, but alternatives defined in terms of its disjuncts as well. A convenient way to do this is to follow Sauerland (2004) in assuming that the alternatives of *or* include not only *and*, but also the connectives *L* and *R*. As we can see from their definitions in (25), the former delivers the leftmost disjunct while the latter the rightmost one.

(24) $\mathcal{A}\ell t(\text{or}) := \{\text{or}, \text{and}, \text{L}, \text{R}\}$ (*Revised*)

(25) a. $[\![\text{L}]\!] := \lambda p_t \lambda q_t.q$

b. $[\![\text{R}]\!] := \lambda p_t \lambda q_t.p$

This gives us two additional alternatives to $\mathbf{A}_{\Box\text{or}}$, viz. $\mathbf{A}_{\Box\text{L}}$ and $\mathbf{A}_{\Box\text{R}}$. The extension of the first is true iff Mary was required to order the fish, while the second's extension is true iff Mary was required to order the chicken. Both of their respective intensions, given in (27-a) and (27-b), strictly entail that of $\mathbf{A}_{\Box\text{or}}$.

(26) a. [$_{\mathbf{A}_{\Box\mathrm{L}}}$ required [Mary ordered the fish] L
[Mary ordered the chicken]]

b. [$_{\mathbf{A}_{\Box\mathrm{R}}}$ required [Mary ordered the fish] R
[Mary ordered the chicken]]

(27) a. $\lambda w.\Box_v^w \mathsf{ordered}_v(\mathsf{m}, \mathsf{f})$

b. $\lambda w.\Box_v^w \mathsf{ordered}_v(\mathsf{m}, \mathsf{c})$

The set of $\mathbf{A}_{\Box\mathrm{or}}$'s alternatives is therefore (28). Every element in this set, save for $\mathbf{A}_{\Box\mathrm{or}}$ itself, is stronger than it.

(28) $\mathcal{A}\ell t(\mathbf{A}_{\Box\mathrm{or}}) = \{\mathbf{A}_{\Box\mathrm{or}}, \mathbf{A}_{\Box\mathrm{and}}, \mathbf{A}_{\Box\mathrm{L}}, \mathbf{A}_{\Box\mathrm{R}}\}$

If we assert the extension of $\mathbf{A}_{\Box\mathrm{or}}$ and negate all of its other alternatives, we end up saying the following: that Mary was required to order the fish or the chicken, but that it is neither the case that she was required to order the fish nor that she was required to order the chicken (and consequently also that she wasn't required to order both). It follows from this that Mary was allowed to order just the fish, and was allowed to order just the chicken. We thus derive the desired inferences once we assume that the alternatives to a disjunctive LF include its disjuncts.

We now have a problem, however. In addition to its conjunctive alternative, the sentence in (14) should have both (29-a) and (29-b) as alternatives, whose respective intensions are (30-a) and (30-b). The set of alternatives for this sentence is therefore expanded to those in (31).

(29) a. [$_{\mathbf{A}_{\mathrm{L}}}$ [Mary ordered the fish] L [Mary ordered the chicken]]

b. [$_{\mathbf{A}_{\mathrm{R}}}$ [Mary ordered the fish] R [Mary ordered the chicken]]

(30) a. $\lambda w.\mathsf{ordered}_w(\mathsf{m}, \mathsf{f})$

b. $\lambda w.\mathsf{ordered}_w(\mathsf{m}, \mathsf{c})$

(31) $\mathcal{A}\ell t(\mathbf{A}_{\mathrm{or}}) = \{\mathbf{A}_{\mathrm{or}}, \mathbf{A}_{\mathrm{and}}, \mathbf{A}_{\mathrm{L}}, \mathbf{A}_{\mathrm{R}}\}$

The intensions of every member of this set, save for that of $\mathbf{A}_{\text{or}}$ itself, strictly entail it. Consequently, if the sentence's SI is derived by negating the extensions of all the stronger alternatives, we expect this meaning to be that Mary ordered the fish or the chicken, but didn't order the fish and didn't order the chicken (and consequently also didn't order the fish and the chicken). But this is clearly contradictory.

We need a way to make sure that when we generate the SI of a sentence where disjunction is unembedded, we only negate its conjunctive alternative. When the disjunction is embedded below a universal modal, however, we negate all of its stronger alternatives. This is schematized in Figures 3.3 and 3.4, where arrows indicate the direction of (strict) entailment between formulas.

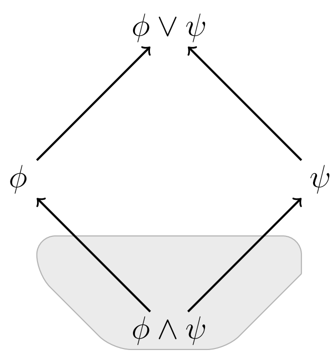

Figure 3.3: Alternatives in (31)

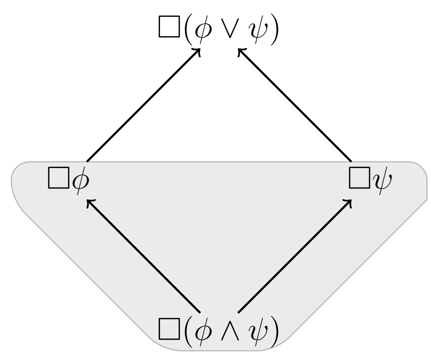

Figure 3.4: Alternatives in (28)

Following Sauerland (2004), Fox (2007) proposes an algorithm which does just this, defining what he calls the set of innocently excludable alternatives of a sentence. In a nutshell, the idea is to look at all the ways we can consistently negate as many alternatives as possible and not draw a contradiction, and find among these a kernel of alternatives that can always be negated. Before spelling out this algorithm, I will define the function $\{\!|\cdot|\!\}^{u,g}$, which is a function that takes an LF and outputs the set containing the intensions of all of its alternatives. This will make it easier to discuss the logical relations that exist between the intensions of a sentence and its alternatives.

(32) $\{\!|\mathbf{X}|\!\}^{u,g} := \{[\![\mathbf{Y}]\!]_{¢}^{u,g} \mid \mathbf{Y} \in \mathcal{A\ell t}(\mathbf{X})\}$

From hereon, I will be sloppy in my use of the term *alternative*. I may use it to refer to either syntactic expressions, or the propositions that they denote. The context of use will hopefully always make clear what I mean by the term. With this in mind, we can start defining innocent exclusion by first defining, for some proposition p and set of alternatives $\mathcal{Q}$, all the ways we can negate members of $\mathcal{Q}$ while remaining consistent with p.

(33) $\mathcal{C}on\mathcal{s}(p, \mathcal{Q}_1) :=$
$\{\mathcal{Q}_2 \mid \mathcal{Q}_2 \subseteq \mathcal{Q}_1 \text{ and } [\lambda w.p(w) \wedge \bigwedge_{q\in\mathcal{Q}_2} \neg q(w)] \not\Leftrightarrow [\lambda w.\mathcal{F}]\}$

We next want to hone in on those members of $\mathcal{C}on\mathcal{s}(p, \mathcal{Q})$ where negating every proposition gives us the strongest possible meaning. Since the more members of $\mathcal{Q}$ we negate, the stronger the meaning, this boils down to finding the elements of this set which contain the most propositions.

(34) $max\mathcal{C}on\mathcal{s}(p, \mathcal{Q}_1) :=$
$\{\mathcal{Q}_2 \mid \mathcal{Q}_2 \in \mathcal{C}on\mathcal{s}(p, \mathcal{Q}_1) \text{ and } \neg\exists\mathcal{Q}_3[\mathcal{Q}_3 \in \mathcal{C}on\mathcal{s}(p, \mathcal{Q}_1) \wedge Q_2 \subset \mathcal{Q}_3]\}$

We can already start to contrast how much we can negate when negation is unembedded versus when it is below a universal modal. Among the formulas ϕ, ψ, and $\phi\wedge\psi$, observe that at most two can be negated while being consistent with $\phi\vee\psi$. We can either negate both ϕ and $\phi\wedge\psi$, or ψ and $\phi\wedge\psi$. However, we arrive at a contradiction whenever we negate both ϕ and ψ. Hence, given an LF with an unembedded disjunction, we have two biggest sets of alternatives whose members can consistently be negated with its assertion. Notice that the alternatives in these sets only partially overlap, as they only share the conjunctive alternative.

(35) $max\mathcal{C}on\mathcal{s}([\![\mathbf{A}_{\text{or}}]\!]_{¢}^{u,g}, \{\!|\mathbf{A}_{\text{or}}|\!\}_{¢}^{u,g}) =$
$\{\{[\![\mathbf{A}_{\text{and}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\text{L}}]\!]_{¢}^{u,g}\}, \{[\![\mathbf{A}_{\text{and}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\text{R}}]\!]_{¢}^{u,g}\}\}$

Now consider what happens when we embed disjunction below a universal modal. We can negate all three of $\Box\phi$, $\Box\psi$, and $\Box(\phi \wedge \psi)$ while remaining consistent with $\Box(\phi \vee \psi)$. Thus, provided with an LF where a disjunction is embedded below a universal modal, we have one biggest set of alternatives whoses members can all be consistently negated, viz. the set containing every alternative but the disjunction itself.

(36) $\mathcal{maxCons}([\![\mathbf{A}_{\Box\text{or}}]\!]_{¢}^{u,g}, \{\![\mathbf{A}_{\Box\text{or}}]\!\}_{¢}^{u,g}) = \{\{[\![\mathbf{A}_{\Box\text{and}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\Box\text{L}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\Box\text{R}}]\!]_{¢}^{u,g}\}\}$

The innocently excludable alternatives of a given sentence are those which are in all the biggest sets of alternatives whose members can all be negated consistently with the sentence. Since they are members of every such set, we know that negating them all will never contradict our original sentence. They are, in this sense, those alternatives which we are always sure we can negate without producing a pathological meaning, hence their "innocent" excludability.

(37) $\mathcal{IE}(p, \mathcal{Q}) := \bigcap \mathcal{maxCons}(p, \mathcal{Q})$

We see that whenever disjunction is unembedded, only the conjunctive alternative is innocently excludable. However, whenever we embed disjunction below a universal modal, we add to the set of innocently excludable alternatives each of its disjuncts.

(38) a. $\mathcal{IE}([\![\mathbf{A}_{\text{or}}]\!]_{¢}^{u,g}, \{\![\mathbf{A}_{\text{or}}]\!\}^{u,g}) = \{[\![\mathbf{A}_{\text{and}}]\!]_{¢}^{u,g}\}$

b. $\mathcal{IE}([\![\mathbf{A}_{\Box\text{or}}]\!]_{¢}^{u,g}, \{\![\mathbf{A}_{\Box\text{or}}]\!\}^{u,g}) = \{[\![\mathbf{A}_{\Box\text{and}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\Box\text{L}}]\!]_{¢}^{u,g}, [\![\mathbf{A}_{\Box\text{R}}]\!]_{¢}^{u,g}\}$

We can therefore arrive at the right SIs for LFs with unembedded and embedded disjunction if we simply derive them by negating all their innocently excludable alternatives. Following Fox (2007), exhaustification will be the name of the operation which takes in a prejacent proposition p and a set of alternatives $\mathcal{Q}$, and asserts p while negating every innocently excludable member of $\mathcal{Q}$ (given p). This is defined in (39).

(39) $\mathcal{Exh}_{w}^{\mathcal{IE}}(p, \mathcal{Q}) := p(w) \wedge \bigwedge_{q \in \mathcal{IE}(p,\mathcal{Q})} \neg q(w)$

Deriving the correct SIs from the LFs $\mathbf{A}_{\text{or}}$ and $\mathbf{A}_{\Box\text{or}}$ is now simply a matter of feeding their intension and the set of intensions of their formal alternatives into the function $\mathcal{E}x\hbar^{\mathcal{IE}}$. As shown in (40) and (41), we get the desired result for both LFs.

(40) $\mathcal{E}x\hbar_w^{\mathcal{IE}}([\![\mathbf{A}_{\text{or}}]\!]_{¢}^{u,g}, \{\!|\mathbf{A}_{\text{or}}|\!\}^{u,g}) =$
$(\mathsf{ordered}_w(\mathsf{m},\mathsf{f}) \vee \mathsf{ordered}_w(\mathsf{m},\mathsf{c})) \wedge \neg(\mathsf{ordered}_w(\mathsf{m},\mathsf{f}) \wedge \mathsf{ordered}_w(\mathsf{m},\mathsf{c}))$

(41) $\mathcal{E}x\hbar_w^{\mathcal{IE}}([\![\mathbf{A}_{\Box\text{or}}]\!]_{¢}^{u,g}, \{\!|\mathbf{A}_{\Box\text{or}}|\!\}^{u,g}) =$
$\Box_v^w(\mathsf{ordered}_v(\mathsf{m},\mathsf{f}) \vee \mathsf{ordered}_v(\mathsf{m},\mathsf{c})) \wedge \neg\Box_v^w \mathsf{ordered}_v(\mathsf{m},\mathsf{f}) \wedge \neg\Box_v^w \mathsf{ordered}_v(\mathsf{m},\mathsf{c})$

Having gone through all of the trouble of defining exhaustification, we are now ready to return to the original point of this section. The goal was to highlight a parallel between an operator licensing TIAs which is capable of interacting scopally with other logical operators, and the fact that SIs have been argued to be the result of an operator that shows just these sorts of interactions. Let's delve into this point by first observing that the senquence in (42) is perfectly consistent.

(42) Everyone who ordered the fish or the chicken was charged \$10. But those who ordered both were charged \$20.

We can assume for the first part of (42) the LF in (43-a), whose interpretation is the one given in (43-b).

(43) a. [$_{\mathbf{A}_\forall}$ [everyone 1 [x_1 ordered the fish] or [x_1 ordered the chicken]] was charged \$10]

b. $\forall x[(\mathsf{ordered}_w(x,\mathsf{f}) \vee \mathsf{ordered}_w(x,\mathsf{c})) \rightarrow \mathsf{charged\text{-}ten}_w(x)]$

The problem with the sequence in (42) is that, in the restrictor of a universal quantifier, a disjunctive sentence entails its conjunctive counterpart. If everyone who ordered the fish or the chicken was charged \$10, it follows that everyone who ordered both was also charged \$10. Indeed, anybody who ordered both meals is someone who ordered either meal. The sequence in (42) should therefore be contradictory.

Intuitively, what we want to say is that we derive an SI such that (42)'s first part is interpreted as saying that everyone who ordered the fish or the chicken, but not both, was charged \$10. The issue, however, is that we cannot exhaustify this LF and obtain that meaning. The alternatives of the sentence are all defined by substituting for the disjunction either *and*, L, or R. However, as shown in Figure 3.5, all these alternatives are entailed by the disjunctive sentence.

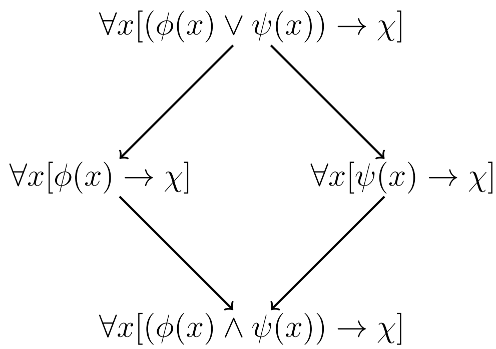

Figure 3.5: Alternatives of (43-a)

This means that the only subset of $\{\!|\mathbf{A}_\forall|\!\}^{u,g}$ such that every one of its members can be negated consistently with $[\![\mathbf{A}_\forall]\!]_{¢}^{u,g}$ is the empty set. The set of innocently excludable alternatives of $[\![\mathbf{A}_\forall]\!]_{¢}^{u,g}$ is thus empty.

(44) $\mathcal{IE}([\![\mathbf{A}_\forall]\!]_{¢}^{u,g}, \{\!|\mathbf{A}_\forall|\!\}^{u,g}) = \emptyset$

If we exhaustify $[\![\mathbf{A}_\forall]\!]_{¢}^{u,g}$ relative to $\{\!|\mathbf{A}_\forall|\!\}^{u,g}$, we end up asserting the former while negating every member of the empty set (i.e. negating nothing). Exhaustification is thus vacuous in this case, and does not deliver the implicature we want.

(45) $\mathcal{E}x\hbar_w^{\mathcal{IE}}([\![\mathbf{A}_\forall]\!]_{¢}^{u,g}, \{\!|\mathbf{A}_\forall|\!\}^{u,g}) = \forall x[(\mathsf{ordered}_w(x,\mathsf{f}) \vee \mathsf{ordered}_w(x,\mathsf{c})) \rightarrow \mathsf{charged\text{-}ten}_w(x)]$

The solution to this problem is to locate the source of exhaustification in the syntax, in the form of the operator EXH$^{\mathcal{IE}}$. The combination of this expression with an LF denotes its exhaustification relative to the set of its formal alternatives.

(46) $[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{X}]\!]^{w,u,g} := \mathcal{E}x\hbar_w^{\mathcal{IE}}([\![\mathbf{X}]\!]_{\text{¢}}^{u,g}, \{\!|\mathbf{X}|\!\}^{u,g})$

There are now two possible loci for an exhaustification operator in whose scope we find the disjunction. The first option is for it to apply globally to the LF, as in (47-a). As we just saw, exhaustification is vacuous in this position. The other option is to apply it local to the restrictor of *everyone*, as in (47-b).

(47) a. EXH$^{\mathcal{IE}}$ [everyone 1 [x_1 ordered the fish] or [x_1 ordered the chicken]] was charged \$10

b. [everyone 1 EXH$^{\mathcal{IE}}$ [x_1 ordered the fish] or [x_1 ordered the chicken]] was charged \$10

What this second option allows for is the strengthening of the disjunction before the universal quantifier has a chance to change the direction of entailment between alternatives. When we exhaustify the restrictor directly, we end up with the set of entities who ordered the fish or the chicken, but not both.

(48) $[\![1\ \text{EXH}^{\mathcal{IE}}\ [\ x_1 \text{ ordered the fish }] \text{ or } [\ x_1 \text{ ordered the chicken }]]\!]^{w,u,g}$
$= \lambda x.[\![\text{EXH}^{\mathcal{IE}}\ [\ x_1 \text{ ordered the fish }] \text{ or } [\ x_1 \text{ ordered the chicken }]]\!]^{w,u,g[1\mapsto x]}$
$= \lambda x.(\mathsf{ordered}_w(x,\mathsf{f}) \lor \mathsf{ordered}_w(x,\mathsf{c})) \land \neg(\mathsf{ordered}_w(x,\mathsf{f}) \land \mathsf{ordered}_w(x,\mathsf{c}))$

The LF in (47-b) is thus interpreted as saying that everyone who ordered just the fish or just the chicken was charged \$10, which is consistent with everybody who ordered both being charged more money. Local scalar implicatures, as made possible by covert exhaustification operators in the syntax of sentences, allow us to explain why (42) is not perceived a contradiction. It is because it has available the parse in (47-b).

3.3.2 Polarity Sensitivity and Exhaustification

Though TIAs are not NPIs proper, they do show polarity sensitivity when they are perfect-level adverbials. A big part of the appeal of identifying the mechanism behind the distribution of TIAs with exhaustification is that the polarity sensitivity displayed by lexical item such as *any* has been explained in terms of whether or not they lead to pathological SIs (Krifka, 1995; Chierchia, 2004, 2006, 2013). Consider the sentences in (49). We see that *any* is not licensed in a simple positive sentence like (49-a), but is acceptable in (49-b) given the negation.

(49) a. *Mary saw any students.
b. Mary didn't see any students.

Accounts of polarity sensitivity along the lines just mentioned say that (49-a) leads to an SI that is a contradiction, whereas (49-b) doesn't. The rough idea is that whenever the output of exhaustification is trivial (i.e. it leads to a contradiction of a tautology), this leads to ungrammaticality. Below, I flesh out the core details of such proposals. First, *any* is assumed to denote an existential quantificational determiner, whose domain is restricted by an index to which g assigns a salient set of individuals.

(50) $[\![\text{any}_i]\!]^g := \lambda P_{et}\lambda Q_{et}.\exists x[g(i)(x) \wedge P(x) \wedge Q(x)]$

The alternatives assumed for *any* are defined in terms of changing the index that ends up restricting its domain.

(51) $\mathcal{A}\ell t(\text{any}_i) := \{\text{any}_j \mid j \in \mathbb{Z}^+\}$

I assume for (49-a) the LF in (52-a). Its intension is the set of worlds where Mary saw some students in $g(7)$, and its alternatives are all the sets of worlds where, for some j, Mary saw some students in $g(j)$.

(52) a. $[_{\mathbf{A}^+}$ [any$_7$ students] 1 Mary saw x_1]
b. $[\![\mathbf{A}^+]\!]^{u,g}_{¢} = \lambda w.\exists x[g(7)(x) \wedge \mathsf{students}_w(x) \wedge \mathsf{saw}_w(\mathsf{m}, x)]$
c. $\{\!|\mathbf{A}^+|\!\}^{u,g} = \{\lambda w.\exists x[g(j)(x) \wedge \mathsf{students}_w(x) \wedge \mathsf{saw}_w(\mathsf{m}, x)] \mid j \in \mathbb{Z}^+\}$

To make the logic of things easier to see, let's assume that $g(7)$ and the extension of *students* are the same set, e.g. $\{\mathsf{a}, \mathsf{b}\}$.[2] To say that Mary saw some

[2] I am assuming here that *students* includes student singularities, and ignoring the pluralities in this set.

students in $\{\mathsf{a}, \mathsf{b}\}$ is to say that either she saw a, or she saw b (or both). We can represent this with the formula $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$. If we use another index on *any*, we with might end up with a set whose only student is a. In this case, we end up with an alternative that says that Mary saw some students included in a set whose only student is a. This just means that Mary saw a, which we can represent using the formula $\phi(\mathsf{a})$. When we have an index which is assigned a set whose only student is b, we get a menaing we can represent as $\phi(\mathsf{b})$. Finally, we might end up with an index whose asignment contains no students. The alternative we then get says that Mary saw some students that are included in a set that contains no students. This is a contradiction, which we can represent by $\mathcal{F}$.

We thus have a set of alternatives whose members we can represent as $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$, $\phi(\mathsf{a})$, $\phi(\mathsf{b})$, and $\mathcal{F}$. These are called the subdomain alternatives of $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$. Every one of them, save for $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$ itself, strictly entails it. If we assume that (49-a) obligatorily triggers the SI that every stronger alternative to $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$ is false, we end up asserting $\phi(\mathsf{a}) \vee \phi(\mathsf{b})$ as well as $\neg\phi(\mathsf{a})$ and $\neg\phi(\mathsf{b})$. This is a contradiction, which we assume is responsible for (49-a)'s unacceptability.

It's important to note that if the index on *any* in (49-a) is assigned a set that contains just one student, say a, the sentence will simply be equivalent to $\phi(\mathsf{a})$. The only subdomain alternative of this sentence is $\mathcal{F}$, whose negation is a tautology. We would therefore not derive a contradiction from negating it, and might expect (49-a) to be acceptable in this case. We can rule out this option if we make the assumption that a quantificational DP with existential force, such as any_i *students*, cannot denote a generalized quantifier restricted to a singleton set. If there is only one salient student, we should avoid indefinite descriptions and use the definite description *the student* instead. Aside from this case, we derive a meaning that is contradictory given any other index. If the assignment to the index is a set containing no students, then the basic meaning of the sentence is just $\mathcal{F}$. If the assignment contains at least two students, the negation of subdomain alternatives will contradict the assertion that Mary saw at least one of them.

Now, contrast this with the negative sentence in (49-b), where *any* is suddenly acceptable. The LF in (53-a) denotes a proposition true of worlds where Mary didn't see any students that are members of $g(7)$, and its alternatives are all the propositions which, for some j, are true of worlds iff Mary didn't see any students who are members of $g(j)$.

(53) a. $[_{\mathbf{A}^-}$ not [any$_7$ students] 1 Mary saw x_1]

b. $[\![\mathbf{A}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists x[g(7)(x) \wedge \mathsf{students}_w(x) \wedge \mathsf{saw}_w(\mathsf{m}, x)]$

c. $\{\!|\mathbf{A}^-|\!\}^{u,g} =$
$\{\lambda w.\neg\exists x[g(j)(x) \wedge \mathsf{students}_w(x) \wedge \mathsf{saw}_w(\mathsf{m}, x)] \mid j \in \mathbb{Z}^+\}$

Let's turn back to our example where we assumed $g(7)$ and *students* both denote the set $\{\mathsf{a}, \mathsf{b}\}$. The LF $\mathbf{A}^-$ comes to say that Mary neither saw a nor b, which we can represent with the formula $\neg\phi(\mathsf{a}) \wedge \neg\phi(\mathsf{b})$. Here, the subdomain alternatives now include $\neg\phi(\mathsf{a})$, $\neg\phi(\mathsf{b})$, and $\mathcal{T}$. All of them are entailed by $\neg\phi(\mathsf{a}) \wedge \neg\phi(\mathsf{b})$, which means that it is itself already the strongest alternative. As such, no alternative is negated, and we derive no contradictory SI. This predicts (49-b) to be acceptable.

It's worth pointing out that we won't derive contradictions if there are more students than those in $g(7)$. Suppose, for example, that the set of students were $\{\mathsf{a}, \mathsf{b}, c\}$. We would have a superdomain alternative in $\neg\phi(\mathsf{a}) \wedge \neg\phi(\mathsf{b}) \wedge \neg\phi(c)$, which strictly entails $\neg\phi(\mathsf{a}) \wedge \neg\phi(\mathsf{b})$. If we negate it, however, the SI we derive is just that Mary saw either a, b, or c. This doesn't contradict Mary seeing neither a nor b, but simply implies that she saw c. Whether or not this is an SI that we actually intuit from an utterance of (49-b) is a seperate question. What we can show here is that what we never derive is a contradiction.

In Figures 3.6 and 3.7, I've represented the logical relations between (49-a) and its subdomain alternatives, as well as between (49-b) and its. In the first figure, I've highlighted the alternatives we want to end up negating for the former. There is a glaring issue with this: innocent exclusion will make it impossible to negate all of these alternatives. How then are we supposed to derive a contradictory SI given that we have an algorithm designed to make sure we don't derive them?

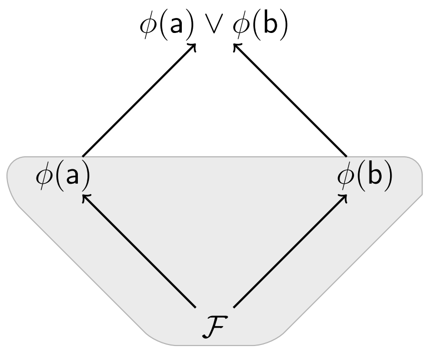

Figure 3.6: Alternatives of (52-a)

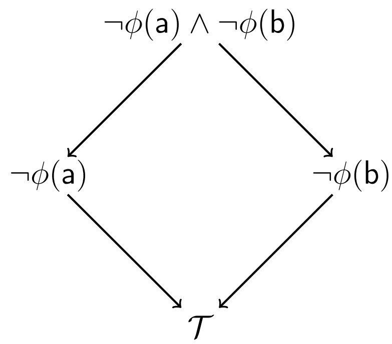

Figure 3.7: Alternatives of (53-a)

Chierchia (2013) proposes that the exhaustification operator responsible for the obligatory SIs associated with *any* is a variant of $\text{EXH}^{\mathcal{IE}}$ that can lead to contradictions. Rather than refer to innocently excludable alternatives, the operator simply looks at non-weaker alternatives to its prejacent, i.e. those alternatives not entailed by the prejacent.

(54) $\mathcal{NW}(p, \mathcal{Q}) := \{q \mid q \in \mathcal{Q} \text{ and } p \not\Rightarrow q\}$

This variant of exhaustification asserts its prejacent negates each of its non-weaker alternatives. We can follow Chierchia in assuming that *any* must always be in the scope of the operator $\text{EXH}^{\mathcal{NW}}$.

(55) $\mathcal{E}x\hbar^{\mathcal{NW}}_{w}(p, \mathcal{Q}) := p(w) \wedge \bigwedge_{q \in \mathcal{NW}(p,\mathcal{Q})} \neg q(w)$

(56) $[\![\text{EXH}^{\mathcal{NW}}\ \mathbf{X}]\!]^{w,u,g} := \mathcal{E}x\hbar^{\mathcal{NW}}_{w}([\![\mathbf{X}]\!]^{u,g}_{¢}, \{\!|\mathbf{X}|\!\}^{u,g})$

There is a great deal of conceptual appeal in assuming that like other polarity sensitive items, the acceptability of TIAs is tied to whether or not we derive contradictory SIs from them. This would fold them nicely into a broader account of polarity sensitivity, stretching the explanatory merits of my current proposal beyond simply accounting for the distributional facts surrounding TIAs.

3.4 Exhaustification and the Licensing of TIAs

3.4.1 The Mandatory Exhaustification Postulate

In §3.2, I mentioned the fact that the MIC can be reformulated as stating that a TIA is only licensed in a given LF if we can draw from it the SI that its numeral is maximally informative. I went on to discuss, in §3.3.2, how the distribution of some NPIs has been accounted for in terms of whether or not they lead to pathological SIs in the scope of an exhaustification operator. In this section, I attempt to derive the distribution of TIAs in terms of a requirement that their measure phrases be in the scope of an exhaustification operator. This is given as the Mandatory Exhaustification Postulate (MEP) in (57). As stated, the MEP leaves unspecified whether the relevant operator is $\text{EXH}^{\mathcal{IE}}$ or $\text{EXH}^{\mathcal{NW}}$. As I will show below, it makes no difference whichever we choose.

(57) **Mandatory Exhaustification Postulate:**
The numeral in a TIA "in ν μ" must be in the scope of an exhaustification operator at LF.

Behind the MEP is the idea that numerals, *qua* scalar items (Horn, 1972), are always to be found in the scope of an exhaustification operator (cf. Magri, 2009). The hope is for exhaustification to, on the one hand, be capable of generating the maximal informativity SIs upon which the MIC relies. On the other hand, exhaustification should derive pathological SIs whenever TIAs are unacceptable. We will see that while successful in achieving the first goal, exhaustification only achieves partial success with the second.

Let's begin by making sure that exhaustification can indeed derive maximal informativity SIs when E-TIAs combine with telic predicates. Given the MEP, EXH must be in the highest available syntactic position in (58-a)'s LF. In (58-b), and in all LFs throughout this section, I leave unspecified whether this operator is $\text{EXH}^{\mathcal{IE}}$ or $\text{EXH}^{\mathcal{NW}}$.

(58) a. Mary wrote up a chapter in three days.

b. EXH [$_{\mathbf{E}}$ [three days] 2 PAST_1 PFV [Mary wrote up a chapter] [in RUNTIME] t_2]

The alternatives of *three* are defined as the set of all linguistic expressions that denote a degree. Since I see no reason why we shouldn't be able to come up with a definite description for every degree, we can assume that each of them is represented in (59).

(59) $\mathcal{A}\ell t(\text{three}) := \{\nu \mid [\![\nu]\!]^{w,u,g} \in \mathcal{D}_d\}$

I assume that there are no scalar items other than *three* in **E**. Given that its intension is the set of worlds where Mary wrote a chapter in three days or less, its alternatives are, for every n, the sets of worlds where Mary wrote a chapter in n days or less.

(60) a. $[\![\mathbf{E}]\!]^{u,g}_{¢} = \lambda w.\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

b. $\{\!|\mathbf{E}|\!\}^{u,g} = \{\lambda w.\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n] \mid n \in \mathcal{D}_d\}$

To make things easier to follow in the text, I take the formula ϕ_n to mean that Mary wrote a chapter in n days or less. Observe that ϕ_3 entails every ϕ_n in which $n \geq_d 3$. This means that none of these can be negated consistently with ϕ_3. However, we can negate every ϕ_n where $n <_d 3$ and remain consistent with ϕ_3: this would simply mean that Mary wrote a chapter in exactly three days. The set of innocently excludable alternatives to ϕ_3 are therefore all of those where $n <_d 3$, which is precisely the set of its non-weaker alternatives. We thus end up negating the very same set of alternatives no matter the choice of exhaustification operator. In both cases, the meaning we obtain carries the desired maximal informativity inference.

(61) $\mathcal{IE}([\![\mathbf{E}]\!]^{u,g}_{¢}, \{\!|\mathbf{E}|\!\}^{u,g}) = \mathcal{NW}([\![\mathbf{E}]\!]^{u,g}_{¢}, \{\!|\mathbf{E}|\!\}^{u,g})$

$$= \{\lambda w.\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n] \mid n \in \mathcal{D}_d \text{ and } n <_d 3\}$$

(62) $[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{E}]\!]^{w,u,g} = [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{E}]\!]^{w,u,g}$
$$= \mathsf{max}^{\Rightarrow}_{w}(\lambda v \lambda n.\exists e[\mathsf{mwc}_{1,v}(e) \wedge \mathsf{days}(\tau_v(e)) \leq_d n]) = 3$$

Let me flag a potential worry here: the MEP states that a TIA's numeral obligatorily scopes below an exhaustification operator. We saw, however, that SIs can be cancelled with TIAs. We thus need to make sure that, even in the scope of this operator, we aren't forced to derive any inference (cf. Crnič & Fox (2019), who struggle with a similar issue). For the time being, I set aside this issue. I return to it in in §3.4.2, where I spell out an account of implicature weakening and cancellation. Let me now turn to the sentence in (63-a).

(63) a. Mary hasn't been sick in three days.
b. EXH [$_{\mathbf{G}^-}$ not [three days] 1 PRES PERF [PFV Mary has been sick] [in ID] t_1]
c. not EXH [$_{\mathbf{G}^+}$ [three days] 1 PRES PERF [PFV Mary has been sick] [in ID] t_1]

For the MEP to be satisfied, we can map (63-a) to one of two syntactic configurations. The first, represented in (63-b), assigns EXH the position above negation. The second, in (63-c), has EXH embedded below it. Let's begin by looking at the meaning we get for the first. Its intension is the set of worlds where Mary wasn't sick at any point in $\mathsf{t}_{\mathsf{days}}(3, u)$, and, assuming once again *three* to be the only scalar item, its alternatives are the sets of worlds where Mary wasn't sick at any point in $\mathsf{t}_{\mathsf{days}}(n, u)$, for every degree n.

(64) a. $[\![\mathbf{G}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3, u)]$
b. $\{\!|\mathbf{G}^-|\!\}^{u,g} = \{\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u)] \mid n \in \mathcal{D}_d\}$

I once more represent each of these alternatives with a formula, in this case $\neg\phi_n$. Since they are all entailed by $\neg\phi_3$, the alternatives where $n \leq_d 3$ cannot be negated. On the other hand, we can negate all of those where $n >_d 3$, which ends up meaning that $\mathsf{t}_{\mathsf{days}}(3,u)$ is the biggest open interval whose RB is t and in which Mary wasn't sick at any point. We can rephrase this as saying that Mary's last moment of sickness was exactly three days ago. This subset of alternatives is both the set of ϕ_3's innocently excludable alternatives, as well as its non-weaker alternatives. No matter which exhaustification operator we use, we once more obtain the desired maximal informativity SI.

(65) $$\mathcal{IE}([\![\mathbf{G}^{-}]\!]^{u,g}_{¢}, \{\![\mathbf{G}^{-}]\!\}^{u,g}) = \mathcal{NW}([\![\mathbf{G}^{-}]\!]^{u,g}_{¢}, \{\![\mathbf{G}^{-}]\!\}^{u,g}) = \{\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)] \mid n \in \mathcal{D}_d \text{ and } n >_d 3\}$$

(66) $$[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{G}^{-}]\!]^{w,u,g} = [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{G}^{-}]\!]^{w,u,g} = \mathsf{max}^{\Rightarrow}_{w}(\lambda v\lambda n.\neg\exists e[\mathsf{mbs}_v(e) \wedge \tau_v(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)]) = 3$$

Let's now turn our attention to the LF in (63-c), where EXH scopes below negation. The intension of $\mathbf{G}^{+}$, the LF it combines with, is the set of worlds where Mary was sick at some point in $\mathsf{t}_{\mathsf{days}}(3,u)$. Its alternatives are, for every degree n, the sets of worlds where Mary was sick at some point in $\mathsf{t}_{\mathsf{days}}(n,u)$.

(67) a. $[\![\mathbf{G}^{+}]\!]^{u,g}_{¢} = \lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)]$
b. $\{\![\mathbf{G}^{+}]\!\}^{u,g} = \{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)] \mid n \in \mathcal{D}_d\}$

If Mary was sick in $\mathsf{t}_{\mathsf{days}}(3,u)$, then she was sick in all of its superintervals. This means that ϕ_3 entails every ϕ_n where $n \geq_d 3$, and thus that we can't assert it and negate any of them. It is also the case that whenever $n <_d 3$, ϕ_n entails ϕ_3. However, we saw in Chapter 2 that if Mary was sick in the open interval $\mathsf{t}_{\mathsf{days}}(3,u)$, she must have been sick in $\mathsf{t}_{\mathsf{days}}(n,u)$ for some $n <_d 3$. It follows from this that we cannot consistently assert ϕ_3 and all of those alternatives.

Since innocent exclusion is an algorithm designed to avoid producing contradictory SIs, and because we can't negate all the alternatives that entails ϕ_3 without producing a contradiction, we might think that innocent exclusion prevents us from negating any of them. However, as first pointed out by Gajewski (2009), our definition of innocent exclusion is not entirely contradiction free: we can still get contradictions if we have a set of alternatives that is densely ordered by entailment. To show this, let's suppose that $\mathcal{Q}$ is a set of alternatives to ϕ_3 whose members can all be negated while remaining consistent with it. We can reach two conclusions about $\mathcal{Q}$'s makeup. The first is that $n <_d 3$ for every $\phi_n \in \mathcal{Q}$. The second is that $\mathcal{Q}$ contains some ϕ_m such that $m \geq_d n$ for every $\phi_n \in \mathcal{Q}$. The idea is that we can only be consistent with ϕ_3 if we negate alternatives up to a point. To make sure that while we assert that Mary was sick in $\mathsf{t}_{\mathsf{days}}(3, u)$, we aren't saying that she wasn't sick in $\mathsf{t}_{\mathsf{days}}(n, u)$ for every $n <_d 3$, there must be some $\phi_l \notin \mathcal{Q}$ such that $3 >_d l >_d m$. A consequence of this is that every member of $\mathcal{Q} \cup \{\phi_l\}$ can also be negated consistently with ϕ_3. This means that, no matter our choice of $\mathcal{Q}$, it is always the proper subset of another set whose members can be consistently negated with ϕ_3. There is thus no biggest such set of alternatives to ϕ_3, as we can, so to speak, always negate one more alternative.

(68) $\quad \mathscr{maxCons}([\![\mathbf{G}^+]\!]^{u,g}_{¢}, \{\![\mathbf{G}^+]\!\}^{u,g}) = \emptyset$

We have defined the innocently excludable alternatives of some sentence as the intersection of all the biggest sets of alternatives whose members can be consistently negated with it. When this set is empty, however, this gives us the generalized intersection of the empty set. Set theoretically, this would give us the universe, which is the class containing all things. This includes truth-values, but also my kitchen sink. Since we want to understand what it means to negate the innocently excludable alternatives to ϕ_3, and since I have no idea what it means to apply negation to a plumbing fixture, I will simply assume that, in the context of innocent exclusion, the output of generalized intersection is always restricted to the propositions it contains.[3] On this definition, what we get is the set of all propositions.

(69) $\quad \mathcal{IE}([\![\mathbf{G}^+]\!]^{u,g}_{¢}, \{\![\mathbf{G}^+]\!\}^{u,g}) = 2^{\mathcal{D}_s}$

[3]Formally, we can use the definition of generalized intersection below.

$$\bigcap \Omega := \{p \mid p \subseteq \mathcal{D}_s \text{ and } \forall \mathcal{Q}[\mathcal{Q} \in \Omega \rightarrow p \in \mathcal{Q}]\}$$

If we negate every single proposition, we obviously produce a contradiction. If the operator in (63-c) were $\text{EXH}^{\mathcal{IE}}$, the material below negation would be contradictory. The same would be true if it were $\text{EXH}^{\mathcal{NW}}$. The set of ϕ_3's non-weaker alternatives consists of all those propositions ϕ_n in which $n <_d 3$. We already saw that negating them all contradicts ϕ_3.

(70) $\mathcal{NW}([\![\mathbf{G}^+]\!]^{u,g}_{\cent}, \{\!|\mathbf{G}^+|\!\}^{u,g}) =$
$\{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)] \mid n \in \mathcal{D}_d \text{ and } n <_d 3\}$

Once again, we find that our choice of exhaustification operator makes no difference. In both cases, we obtain a contradiction in the embedded position. This means that (63-c) as a whole is tautological. Like contradictions, tautologies are completely trivial. Based upon this, we can rule out this LF as an available parse for (63-a).

(71) $[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{G}^+]\!]^{w,u,g} = [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{G}^+]\!]^{w,u,g}$
$= \mathcal{F}$

We can now see that the MEP affords us with an explanation for (72-a)'s unaccepatbility. The only LF available for the sentence is (72-a), but we just saw that this gives us a contradiction. We therefore can never license G-TIAs in perfective positive sentences.

(72)
a. *Mary has been sick in three days.
b. EXH $[_{\mathbf{G}^+}$ [three days] 1 PRES PERF
[PFV Mary has been sick] [in ID] t_1]

Since it's good form to put on display all of our successes before our failures, let's turn to the sentence in (73-a). This sentence is important because it served as our initial motivation for the MEP. There are in it two possible scope cites for EXH: it could scope above the negation as in (73-b), or below it as in (73-c). We want to make sure that in the embedded position, the sentence does not lead to pathological SIs.

(73)
a. Mary didn't write this chapter in three days.

b. $\textsc{exh}$ [$_{\mathbf{D}^-}$ not [three days] 2 $\textsc{past}_1$ $\textsc{pfv}$
[Mary wrote this chapter] [in $\textsc{runtime}$] t_2]

c. not $\textsc{exh}$ [$_{\mathbf{D}^+}$ [three days] 2 $\textsc{past}_1$ $\textsc{pfv}$
[Mary wrote this chapter] [in $\textsc{runtime}$] t_2]

Once again, our choice of exhaustification operator is here inconsequential. Let's begin by looking at the meaning we predict for (73-b). The intension of $\mathbf{D}^-$ is the set of worlds where Mary didn't write this chapter in three days or less, and its alternatives are, for all $n \in \mathcal{D}_d$, the sets of worlds where Mary didn't write it in n days or less.

(74) a. $[\![\mathbf{D}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

b. $\{\!|\mathbf{D}^-|\!\}^{u,g} = \{\lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d n] \mid n \in \mathcal{D}_d\}$

As with local exhaustification of G-TIAs below negation, global exhaustification of E-TIAs above negation leads to a contradiction. Let's begin by determining what is the set of $\neg\phi_3$'s innocently excludable alternatives. Since $\neg\phi_3$ entails every $\neg\phi_n$ in which $n \leq_d 3$, we can't negate any of them without producing a contradiction. However, we also can't negate every alternative $\neg\phi_n$ in which $n >_d 3$. As we saw in §3.2, this would be saying that Mary didn't write the chapter in three days or less, but wrote it in n days or less for every $n >_d 3$. This implies that there is no definite amount of time in which Mary wrote it. Any set $\mathcal{Q}$ of alternatives to $\neg\phi_3$ that is consistently negatable with it must satisfy two conditions. Firstly, it must only contain alternatives $\neg\phi_n$ where $n >_d 3$. Secondly, it must contain some $\neg\phi_m$ such that $m \leq_d n$ for every $\neg\phi_n \in \mathcal{Q}$. This is because it is only possible to remain consistent with $\neg\phi_3$ if we negate alternatives down to a point. To avoid a contradiction, there must be some $\neg\phi_l \notin \mathcal{Q}$ where $3 <_d l <_d m$. But this implies the existence of a set of alternatives $\mathcal{Q} \cup \{\neg\phi_l\}$ whose every member can also be negated without contradicting $\neg\phi_3$. Once again, density makes it so that there is no biggest set of alternatives to $\neg\phi_3$ that can be consistently negated with it, which makes the set of innocently excludable alternatives of $\neg\phi_3$ the set of all propositions.

(75) $\mathcal{IE}([\![\mathbf{D}^-]\!]^{u,g}_{¢}, \{\!|\mathbf{D}^-|\!\}^{u,g}) = 2^{\mathcal{D}_s}$

Negating all of the innocently excludable alternatives of $\neg\phi_3$ produces a contradiction. This is also the case with its non-weaker alternatives, which are all and only those propositions $\neg\phi_n$ where $n >_d 3$. We therefore find that no matter the exhaustification operator we use, the LF in (73-b) carries a pathological meaning.

(76) $\mathcal{NW}([\![\mathbf{D}^{-}]\!]^{u,g}_{¢}, \{\![\mathbf{D}^{-}]\!\}^{u,g}) =$
$\{\lambda w.\neg\exists e[\mathsf{mwt}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq n] \mid n \in \mathcal{D}_d \text{ and } n >_d 3\}$

(77) $[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{D}^{-}]\!]^{w,u,g} = [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{D}^{-}]\!]^{w,u,g}$
$= \mathcal{F}$

However, the LF in (73-c) allows us to apply the exhaustification operator below the scope of negation. Here, we simply have EXH attached to an LF where an E-TIA combines with a telic predicate. We already know that this combination doesn't cause any problems: in the present case it simply states that the maximally informative number of days in which Mary wrote the chapter is three. The negation of this statement is simply the same as saying that Mary either wrote the chapter in less than three days, or in more than three days. Since there is nothing pathological about this meaning, we predict it to be an available parse for (73-a).

(78) $[\![\text{not EXH}^{\mathcal{IE}}\ \mathbf{D}^{+}]\!]^{w,u,g}$
$= [\![\text{not EXH}^{\mathcal{NW}}\ \mathbf{D}^{+}]\!]^{w,u,g}$
$= \mathsf{max}^{\Rightarrow}_{w}(\lambda v\lambda n.\exists e[\mathsf{mwt}_{1,v}(e) \wedge \mathsf{days}(\tau_v(e)) \leq n]) \neq 3$

Unlike the MIC, which systematically rules out the sentence in (73-a), the MEP correctly predicts that it should be available under the parse in (73-c). Moreover, the MEP successfully explains the unacceptability of the sentence in (72-a). This is, however, where the MEP's successes stop. First, it fails to predict the unacceptability of (79-a).

(79) a. *Mary was sick in three days.
b. EXH $[_{\mathbf{C}^{+}}$ [three days] 2 PAST$_1$ PFV

$$[\text{ Mary was sick }]\ [\text{ in RUNTIME }]\ t_2\ ]$$

The sole LF available to this sentence is (79-b). We saw in Chapter 2 that, because of the subinterval property of the verbal predicate, the TIA in (79-b) makes no semantic contribution at all. The sentence's intension is simply the set of worlds where Mary was sick. Since the alternatives are defined only in terms of substitutions of the numeral in the TIA, and since all TIAs are redundant in this environment, the sentence's alternatives are just the singleton set containing the set of worlds where Mary was sick.

(80) a. $[\![\mathbf{C}^+]\!]^{u,g}_{¢} = \lambda w.\exists e[\mathsf{mbs}_{1,w}(e)]$

b. $\{\!|\mathbf{C}^+|\!\}^{u,g} = \{\lambda w.\exists e[\mathsf{mbs}_{1,w}(e)]\}$

It is of course impossible to negate any alternative of $\{\!|\mathbf{C}^+|\!\}^{u,g}$ without contradicting $[\![\mathbf{C}^+]\!]^{u,g}_{¢}$, since it is itself the only alternative. It follows that the set of innocently excludable alternatives is again the same as the non-weaker alternatives, viz. the empty set.[4] Irrespective of our choice of operator, the exhaustification of $\mathbf{C}^+$ is vacuous: we just end up asserting that Mary was sick. There is nothing pathological about this meaning. Unlike the MIC, the MEP is incapable of accounting for (79-a)'s unacceptability.

(81) $$\mathcal{IE}([\![\mathbf{C}^+]\!]^{u,g}_{¢}, \{\!|\mathbf{C}^+|\!\}^{u,g}) = \mathcal{NW}([\![\mathbf{C}^+]\!]^{u,g}_{¢}, \{\!|\mathbf{C}^+|\!\}^{u,g}) = \emptyset$$

(82) $$[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{C}^+]\!]^{w,u,g} = [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{C}^+]\!]^{w,u,g} = \exists e[\mathsf{mbs}_{1,w}(e)]$$

The MEP won't account for the unacceptability of the negation of (79-a) either. There are, for (83-a), two possible scope cites for EXH.

(83) a. *Mary wasn't sick in three days.

[4]A word of caution: we saw that given a proposition p and set of alternatives $\mathcal{Q}$, it follows that whenever $maxCons(p, \mathcal{Q}) = \emptyset$, exhaustification leads to a contradiction. In the case of $[\![\mathbf{C}^+]\!]^{u,g}_{¢}$ and $\{\!|\mathbf{C}^+|\!\}^{u,g}$, however, $maxCons([\![\mathbf{C}^+]\!]^{u,g}_{¢}, \{\!|\mathbf{C}^+|\!\}^{u,g}) = \{\emptyset\}$. The set of innocently excludable alternatives is here not the set of all propositions, but just the empty set (i.e. the set of all propositions that are in the empty set).

b. EXH [$_{\mathbf{C}^-}$ not [three days] 2 PAST$_1$
PFV [Mary was sick] [in RUNTIME] t_2]

c. not EXH [$_{\mathbf{C}^+}$ [three days] 2 PAST$_1$
PFV [Mary was sick] [in RUNTIME] t_2]

If it scopes above the negation, we have the LF in (83-b). The TIA is no less redundant in $\mathbf{C}^-$ as it is in $\mathbf{C}^+$. The intension of $\mathbf{C}^-$ is just the set of worlds where Mary wasn't sick, and its set of alternatives the singleton set that contains it. Exhaustification will be vacuous here too. If EXH scopes below negation, we already saw that it is vacuous. Neither LF is predicted to be unacceptable.

(84) a. $[\![\mathbf{C}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists e[\mathsf{mbs}_{1,w}(e)]$
b. $\{\!|\mathbf{C}^-|\!\}^{u,g} = \{\lambda w.\neg\exists e[\mathsf{mbs}_{1,w}(e)]\}$

Moreover, while we saw that the MEP could account for the unacceptability of (72-a) on an E-perfect reading, which results from the sentence being in the perfective, we don't rule out a U-perfect reading for the sentence. The LF for this reading is (85), where the aspectual head is IMPV.

(85) EXH [$_{\mathbf{F}^+}$ [three days] 1 PRES PERF
[IMPV Mary has been sick] [in ID] t_1]

We saw in Chapter 2 that the G-TIA is semantically redundant here: the intension $\mathbf{F}^+$ is just the set of worlds where Mary has been sick from a point in the past up until now, and it has no alternatives other than this. Once again, exhaustification is vacuous. Unlike the MIC, the MEP actually predicts (72-a) to be acceptable on one reading.

(86) a. $[\![\mathbf{F}^+]\!]^{u,g}_{¢} = \lambda w.\ \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$
b. $\{\!|\mathbf{F}^+|\!\}^{u,g} = \{\lambda w.\ \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]\}$

(87) $$\begin{aligned}[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{F}^+]\!]^{w,u,g} &= [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{F}^+]\!]^{w,u,g} \\ &= \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]\end{aligned}$$

In addition, the MEP doesn't block the U-perfect reading of (63-a), for which both the LFs in (88-a) and (88-b) are available. Exhaustification is both redundant below and above negation.

(88) a. EXH [$_{\mathbf{F}^-}$ not [three days] 1 PRES PERF [IMPV Mary has been sick] [in ID] t_1]

b. not EXH [$_{\mathbf{F}^+}$ [three days] 1 PRES PERF [IMPV Mary has been sick] [in ID] t_1]

(89) a. $[\![\mathbf{F}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

b. $\{\![\mathbf{F}^-]\!\}^{u,g} = \{\lambda w.\neg\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]\}$

We are left in an awkward position. On the one hand, the MEP has several advantages over the MIC. For starters, it can account for why E-TIAs are licensed even when they scope below negation. It also naturally captures why TIAs are unlicensed when we can't derive from them maximal informativity SIs, and offers an account of their licensing in tune with accounts of other polarity sensitivity items. On the other hand, the MEP is incapable of explaining why E-TIAs are unacceptable with atelic predicates, and why G-TIAs are unacceptable with imperfective. Whereas the MIC was too strong, the MEP is too weak. If we want full empirical coverage, we need an independently motivated explanation for the cases left unaccounted for by the MEP. Before turning to this, let me conclude this section with a discussion of the optionality of SIs, and how to address it in the context of my analysis.

3.4.2 Implicature Weakening and Cancellability

In the previous section, I mentioned the fact that SIs are optional with TIAs. This is evidenced by the consistency of the sequences in (90-a) and (90-b). How do we square an account of the distribution of TIAs based on whether or not they lead to pathological SIs with the fact that these SIs aren't obligatory?

(90) a. Mary wrote up a chapter in three days. What's more, she did so in two.

b. Mary hasn't been sick in three days. What's more, she hasn't been in four.

If we have the option of not deriving SIs with TIAs, we need to enforce their being obligatory whenever exhaustification leads to pathological meanings. To set this up, I will first lay down what I assume to be the mechanism through which SIs are cancelled. Given the MEP, which stipulates that TIAs must always be in the scope of an exhaustification operator, I cannot assume that the cancellability of these SIs comes from $\text{EXH}^{\mathcal{IE}}$ being optional. Instead, I follow Magri (2009) in assuming that cancelling SIs is the limiting case of a more general pruning mechanism, whereby SIs are weakened by restricting the set of relevant alternatives involved in an exhaustification operation (Fox & Katzir, 2011). The need for such a mechanism is easily motivated. One need only observe that in normal conversation, we don't derive maximal informativity SIs from TIAs. Take the example sentences in (91) and (92).

(91) Mary wrote up a chapter in three days.
$\rightsquigarrow$Mary didn't write up a chapter in two days.
$\not\rightsquigarrow$Mary didn't write up a chapter in 2.99 days.

(92) Mary hasn't been sick in three days.
$\rightsquigarrow$Mary was sick within the last four days.
$\not\rightsquigarrow$Mary was sick within the last 3.01 days.

When we hear (91) in out of the blue contexts, we derive the inference that Mary didn't write a chapter in two days. We are, however, unlikely to derive the inference that Mary didn't write a chapter in very slightly less than three days, e.g. in 2.99 days. A similar point is true of (92): while we normally draw the inference that Mary was sick within the last four days, we don't draw the inference that her sickness ended exactly three days ago. Indeed, the sentence doesn't imply that she was sick within the last 3.01 days. What we can conclude from this is that natural language allows us some degree of imprecision when it comes to the SIs we derive from TIAs. To account for this, we can assume that exhaustification operators are interpreted relative to an assignment, as in (93). For the purposes of this discussion, I will only be discussing $\text{EXH}^{\mathcal{IE}}$.

(93) $[\![\text{EXH}_i^{\mathcal{IE}}\ \mathbf{X}]\!]^{w,u,g} := \mathcal{E}x\hbar_w^{\mathcal{IE}}([\![\mathbf{X}]\!]_{¢}^{u,g}, g(i) \cap \{\!|\mathbf{X}|\!\}_{¢}^{u,g})$

The index associated with a particular instance of exhaustification is mapped to a set of propositions by the assignment function g: this set can be thought of as the context's **question under discussion** (QUD). This is used to prune from the set of the prejacent's alternatives the propositions that are not relevant to the QUD. Looking back at (91), it is clear that the very exact number of days in which Mary wrote a chapter isn't relevant to everyday conversation. We want the context to set the level of granularity of the SI we derive. Let's take a look at how we can implement this for (94-a).

(94) a. Mary wrote up a chapter in three days.
b. $[_{\mathbf{E}}$ [three days] 2 PAST_1 PFV
[Mary wrote up a chapter] [in RUNTIME] t_2]
c. $[\![\mathbf{E}]\!]_{¢}^{u,g} = \lambda w.\ \exists e[\mathsf{mwc}_{1,w} \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$
d. $\{\!|\mathbf{E}|\!\}^{u,g} = \{\lambda w.\ \exists e[\mathsf{mwc}_{1,w} \wedge \mathsf{days}(\tau_w(e)) \leq_d n] \mid n \in \mathcal{D}_d\}$

In a normal context of utterance for (94-a) is uttered, the QUD is only ever concerned with whether Mary wrote a chapter in one day, two days, three days, and so on. We could give $\text{EXH}^{\mathcal{IE}}$ an index like 10, which g maps to this QUD in (95-b). This is a proper subset of $\{\!|\mathbf{E}|\!\}^{u,g}$, so intersecting the two simply means exhaustifying $[\![\mathbf{E}]\!]_{¢}^{u,g}$ relative to $g(10)$. This gives us the meaning carrying the desired weak SI, viz. that Mary wrote a chapter in three days or less, but not in two days or less.

(95) a. $[\![\text{EXH}_{10}^{\mathcal{IE}}\ \mathbf{E}]\!]^{w,u,g} = \exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3] \wedge$
$\neg\exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 2]$
b. $g(10) = \{\lambda w.\ \exists e[\mathsf{mwc}_{1,w} \wedge \mathsf{days}(\tau_w(e)) \leq n] \mid n \in \mathbb{Z}^+\}$

One way to completely cancel an SI is to assume that the QUD is only concerned with whether or not the prejacent of $\text{EXH}^{\mathcal{IE}}$ is true. This is the assignment that g maps 11 to in (96-b). Since only the prejacent itself is at the intersection of $\{\!|\mathbf{E}|\!\}^{u,g}$ and $g(11)$, exhaustification is vacuous and no SI is delievered.

(96) a. $[\![\text{EXH}^{\mathcal{IE}}_{11}\ \mathbf{E}]\!]^{w,u,g} = \exists e[\mathsf{mwc}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$

b. $$g(11) = \left\{ \begin{array}{c} \lambda w.\ \exists e[\mathsf{mwc}_{1,w} \wedge \mathsf{days}(\tau_w(e)) \leq_d 3], \\ \lambda w.\ \neg\exists e[\mathsf{mwc}_{1,w} \wedge \mathsf{days}(\tau_w(e)) \leq_d 3] \end{array} \right\}$$

The very same mechanism can be used to account for the different levels of granularity we want for the SIs associated with (97-a), and the optionality of any SI here as well.

(97) a. Mary hasn't been sick in three days.

b. [$_{\mathbf{G}^-}$ not [three days] 1 PRES PERF [PFV Mary has been sick] [in ID] t_1]

c. $[\![\mathbf{G}^-]\!]^{u,g}_{¢} = \lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)]$

d. $\{\!|\mathbf{G}^-|\!\}^{u,g} = \{\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u) \mid n \in \mathcal{D}_d\}$

Normally, we are only concerned with the question of in how many days Mary hasn't been sick in integer values. The index on $\text{EXH}^{\mathcal{IE}}$ in a normal utterance of (97-a) could be 12, which g maps to this QUD. Here, we get the weak SI we want, which says that Mary hasn't been sick in three days, bust she was sick at some point in the last four days.

(98) a. $[\![\text{EXH}^{\mathcal{IE}}_{12}\ \mathbf{G}^-]\!]^{w,u,g} = \neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)] \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(4,u)]$

b. $g(12) = \{\lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n,u)] \mid n \in \mathbb{Z}^+\}$

We can also get rid of any SI by assuming that the QUD concerns only whether Mary hasn't been sick in three days, to which g maps 13.

(99) a. $[\![\text{EXH}^{\mathcal{IE}}_{13}\ \mathbf{G}^-]\!]^{w,u,g} = \neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)]$

b. $$g(13) = \left\{ \begin{array}{c} \lambda w.\neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)], \\ \lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3,u)] \end{array} \right\}$$

However, this pruning mechanism risks allowing us to license TIAs that we know are unacceptable. Take for example the sentence in (100-a).

(100) a. *Mary has been sick in three days.

b. $[_{\mathbf{G}^+}$ [three days] 1 PRES PERF [PFV Mary has been sick] [in ID] t_1]

c. $[\![\mathbf{G}^+]\!]^{t,g,}_{¢} = \lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3, u)]$

d. $\{\!|\mathbf{G}^+|\!\}^{t,g,} = \{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u) \mid n \in \mathcal{D}_d\}$

If we were to set the level of granularity to the positive integers, we would not derive a contradiction from exhaustifying this sentence anymore. What we would end up saying is that Mary was sick within the last three days, but she wasn't sick within the last two. This is a perfectly consistent meaning, which is in fact how we normally interpret the sentence *Mary hasn't been sick in two days.*

(101) a. $[\![\text{EXH}^{\mathcal{IE}}_{14}\ \mathbf{G}^+]\!]^{w,u,g} = \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3, u)] \wedge \neg\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(2, u)]$

b. $g(14) = \{\lambda w.\exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(n, u)] \mid n \in \mathbb{Z}^+\}$

If we indexed $\text{EXH}^{\mathcal{IE}}$ with 6 again, we could also get rid of any SI whatsoever.

(102) $[\![\text{EXH}^{\mathcal{IE}}_{13}\ \mathbf{G}^+]\!]^{w,u,g} = \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{t}_{\mathsf{days}}(3, u)]$

We need to bite the bullet here and assume that pruning cannot be used as a rescue mechanism against pathological SIs. One way to state this is to that sets of alternatives that lead to contradictions are always relevant, and we cannot prune from them. This is in the spirit of a similar proposal made in Bar-Lev (2023). We can thus avoid ever licensing sentences like (100-a) by postulating the constraint on pruning in (103).

(103) **Constraint on Pruning:**
If $[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{X}]\!]^{u,g}_{¢} = [\lambda w.\mathcal{F}]$, then for any i in $[\![\text{EXH}^{\mathcal{IE}}_i\ \mathbf{X}]\!]^{w,u,g}$, $g(i) = \{\!|\mathbf{X}|\!\}^{u,g}$.

3.5 Numerals and Economy

3.5.1 Buccola & Spector

To explain the unacceptability of E-TIAs with atelic predicates, as well as that of G-TIAs with the imperfective, I will draw a comparison between the interaction of TIAs with the subinterval property, and that of *less than n* modified numerals with distributivity. Consider the example of the sentence in (104-a), which contains the distributive predicate *smiled*.

(104) a. Less than three students smiled.
b. $\neg\exists x[\mathsf{amount}(x) > 2 \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

Intuitively, we assign to *less than three* in (104-a) what Buccola & Spector (B&S; 2016) call the **upper-bound** reading in (104-b). It says that no more than two students smiled. Contrast this with the interpretation we give to (105-a) when *lifted the piano* is interpreted collectively.

(105) a. Less than three students lifted the piano.
b. $\exists x[\mathsf{amount}(x) < 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{lifted}_w(x)]$

While (104-a) and (105-a) differ only in the choice of verbal predicate, this small difference greatly impacts how each sentence is interpreted. Unlike (104-a), we don't assign to (105-a) an upper-bound reading. Rather than stating that no more than two students lifted the piano, the sentence only conveys that some group of less than three students did. It leaves open whether or not some other group of three or more students also did. This is what B&S call the **non-upper-bound** reading for *less than three.*

I follow Buccola & Spector (B&S; 2016) in assuming that the non-upper-bound reading for (104-a) is blocked by a principle of structural economy. A full coverage of B&S's paper poses a substantial challenge given its structure. The authors propose four ways of accounting for the different readings associated with (104-a) and (105-a), but do not definitively argue in favor of any one of them. However, all four proposals share a common core, viz. that they rely on the same principle of structural economy to rule out non-upper-bound readings for (104-a).

For no reason other than to expedite the presentation of this principle, I will present only the first of the proposals given by B&S. Before I do this, however, I must spell out some preliminary assumptions required to derive the meaning of the sentence in (106).

(106) Three students smiled.

Quite clearly, we understand (106) as asserting the existence of a group of three students who all smiled. To arrive at this compositionally, B&S assume two things. First, as is common, they assume that whenever a numeral n modifies a predicate of individuals, it first combines with the silent operator that creates an intersective adjective that denotes the set of pluralities composed of n singularities. Following Hackl (2001), I call this operator MANY. They also assume that bare plural nouns fall under the scope of a covert element SOME, which shares its meaning with overt quantificational determines with existential strength.

(107) a. $[\![\text{MANY}]\!] = \lambda n_d \lambda x_e.\ \mathsf{amount}(x) = n$
b. $[\![\text{SOME}]\!] = \lambda P_{et} \lambda Q_{et}.\ \exists x[P(x) \wedge Q(x)]$

The LF we can therefore assume for (106) is the one given in (108-a). The meaning assigned to this LF is (108-b), which asserts that a plurality of three students is such that it is in the extension of *smiled*.

(108) a. [SOME [three MANY] students] smiled
b. $\exists x[\mathsf{amount}(x) = 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

What is missing from this reading is the entailment that, whenever a plurality is in the extension of *smiled*, each of its atomic parts also is. Much like we assumed that certain predicates of eventualities are endowed with lexical properties such as the subinterval property, we can assume for *smiled* the **distributive property**. This higher-order property is true of predicates whose extensions are closed under the parthood relation. If the extension of *smiled* includes some entity x, it will also include every part y of x.

(109) **Distributive Property:**
A property of entities $\mathcal{P}_{set}$ has the distributive property iff
$\forall w, x, y[\mathcal{P}(w, x) \wedge y \sqsubseteq_e x \rightarrow \mathcal{P}(w, y)]$

If, for instance, the plurality formed of Mary, John, and Sue is in the extension of *smiled*, so will the pluralities formed of Mary and John, Mary and Sue, and John and Sue. Moreover, the singularities Mary, John, and Sue will also all members of this extension. It follows from this that if a plurality of three students is in the extension of *smiled*, then all three of them smiled.

By assuming that distributivity is a higher-order property tied to the lexical meaning of some verbal predicates, we can easily explain the difference between the distributive inference in (106), and the lack of any such inference in (110-a). The latter of these sentences simply asserts that a plurality of three students lifted the piano, which does not entail that any member of this plurality individually lifted said piano.

(110) a. Three students lifted the piano.
b. [SOME [three MANY] students] lifted the piano
c. $\exists x[\mathsf{amount}(x) = 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{lifted}_w(x)]$

The LFs in (108-a) and (110-b) differ only in their predicate. As such, the interpretation of the latter is what we want, viz. that a plurality of three students is in the exstension of *lifted the piano*. If we simply assume that, as a matter of lexical semantics, the predicate *lifted the piano* does not have the distributive property, then it follows that we don't derive from this any distributive inference. This difference between predicates that do and don't have the lexical property is key to B&S's account of why (105-a) has a non-upper-bound reading, but not (104-a). To show this, let me first provide one last semantic definition, viz. that of *less than*'s denotation. Similar to what Hackl (2001) assumes, this is a function which first combines with a degree n and, after combining with a set of degrees D, asserts that the greatest element of D is less than n.

(111) $[\![\text{less than}]\!] = \lambda n_d \lambda D_{dt}.\ \exists m[m <_d n \wedge \mathsf{max}(D) = m]$

Any LF for (104-a) will contain the lexical items *less than* as well as SOME. Since both denote quantificational determiners after they've combined with their first argument, we expect them to interact scopally. Assuming that *less than three* is base generated as the sister of MANY, there should be an LF like (112-a), where it is extracted to a position above SOME.

(112) a. [less than three] 1 [SOME [n_1 MANY] students] smiled

b. $\exists m[m <_d 3 \wedge \mathsf{max}(\lambda n.\ \exists x[\mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]) = m]$
$\equiv \mathsf{max}(\lambda n.\ \exists x[\mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]) <_d 3$

Semantically, this produces a reading in (112-b), where the component of maximality in *less than three* outscopes the existential force of SOME. This states that the greatest plurality of students who smiled amounts to less /three students. This quite straightforwardly corresponds to the sentence's observed upper-bound reading.[5]

There should also be available an LF where *less than three* undergoes a

[5]As B&S point out, this isn't quite right. Given that the distributive property holds of *smiled*, we get that there is no plurality of more than three students whose every member smiled. However, we don't predict the sentence to be true if there are two disjoint pluralities of three students who smiled. Doing so requires assuming that *smiled*, in addition to having the distributive property, has the cumulative property below.

(113) **Cumulative Property:**
A property of entities $\mathcal{P}_{set}$ has the cumulative property iff
$\forall w, x, y[\mathcal{P}(w, x) \wedge \mathcal{P}(w, y) \rightarrow \mathcal{P}(w, x \oplus_e y)]$

With this assumption, having two disjoint pluralities of three students smiling would imply there being a plurality of six smiling students. This would of course falsify (112-b).

local movement inside the AP modifying *students*, as in (114-a). Here, the maximality component in *less than three*'s meaning scopes below the existential force of SOME.[6]

(114) a. [SOME [2 [less than three] 1 x_2 [n_1 MANY]] students] smiled

b. $\exists x[\exists m[m <_d 3 \wedge \mathsf{max}(\lambda n.\ \mathsf{amount}(x) = n) = m] \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

$\equiv \exists x[\mathsf{amount}(x) <_d 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

This new LF is interpreted as (114-b). It asserts that there exists some plurality of less than three students that smiled. This would be a non-upper-bound reading for (104-a), which is consistent with there being a plurality of more than three students that smiled. On the face of it, this reading seems innocuous enough that blocking it seems difficult. This is until we remember that the distributive property holds of *smiled*, which makes the modified numeral semantically vacuous in the sentence. Indeed, observe first that the reasoning in (115) is valid: if a group of less than three students smiled, then some plurality of students smiled.

(115) $\exists x[\mathsf{amount}(x) <_d 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

$\therefore\ \exists x[\mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

Now observe that the reasoning in (116) also holds. If some plurality of students smiled, and if every plural part of this plurality smiled, then no matter the size of this plurality, there exists some one student who smiled. This naturally entails that there exists a plurality of less than three students (viz. one student) that smiled.

(116) $\exists x[\mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

$\forall x[\mathsf{smiled}_w(x) \wedge y \sqsubseteq x \rightarrow \mathsf{smiled}_w(y)]$

$\therefore\ \exists x[\mathsf{amount}(x) <_d 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{smiled}_w(x)]$

From this, we can conclude that the meaning of (114-a) is equivalent to just

[6] B&S are following Heim & Kratzer (1998) in assuming that APs have internal subjects which can be abstracted over.

asserting that some plurality of students smiled. The modified numeral *less than three* serves no semantic purpose whatsoever with distributive predicates like *smiled*. This is true no matter the numeral that combines with *less than*. B&S use this fact to argue in favor of the pragmatic economy constraint (PEC) in (117), which blocks any LF $\mathbf{X}$ which contains a numeral whose substitution for some other numeral would not impact the interpretation.

(117) **Pragmatic Economy Constraint:**
A numeral ν_1 is acceptable in an LF $\mathbf{X}$ only if
$\neg\exists\nu_2[\nu_1 \neq \nu_2 \wedge [\![\mathbf{X}]\!]^{u,g}_{¢} \Leftrightarrow [\![\mathbf{X}[\nu_1 \mapsto \nu_2]]\!]^{u,g}_{¢}]$.

The PEC rules out non-upper-bound readings for sentences with distributive predicates like (104-a), but not for sentences with collective predicates like (105-a). On its collective interpetation, the LF in (118-a) is interpreted as saying that there exists a plurality of three students that lifted the piano together.

(118) a. [SOME [2 [less than three] 1 x_2 [n_1 MANY]] students] lifted the piano

b. $\exists x[\mathsf{amount}(x) <_d 3 \wedge \mathsf{students}_w(x) \wedge \mathsf{lifted}_w(x)]$

Since *lifted the piano* lacks the distributive property, there is no logical equivalence between a sentence saying that a plurality of less than three students lifted the piano, and saying that, for some $n \neq 3$, less than n students lifted the piano. Saying that a plurality of less than 3 students lifted the piano together doesn't entail that a plurality of less than two students did, and isn't itself entailed by saying that a plurality of less than four students did. The modified numeral *less than three* is not vacuous on a non-upper-bound reading of (105-a), and the PEC does not in fact block this reading from arising.

As B&S point out, we might want the PEC to follow from a more general principle of economy that is motivated in terms of Gricean maxims. More specifically, the idea is a principle motivated by *manner* that blocks an LF whenever a simpler LF is available. B&S are, however, quick to point out the challenges in defining a metric for the comparative simplicity of two LFs.

For example, such a metric cannot rule out (119-a) in terms of its being more complex than (119-b). Although they point at the proposal in Katzir (2007) as a potential candidate for such a metric, they leavethe work of reducing the PEC to this proposal undone. I likewise make no attempt at such a reduction.

(119) a. I read a book that is very interesting.
b. I read a very interesting book.

B&S's proposal accounts for why sentences with distributive predicates don't have non-upper-bound readings, and why such readings are available for sentences that contain collective predicates. To be sure, this particular proposal predicts (105-a) to also have an upper-bound reading. Whether such readings are truly available for sentences with collective predicates is not clear. Since answering this question would take us far away from the main goals of the present chapter, I choose to ignore it here. I direct the interested reader to B&S's paper, which offers some alternative proposals to the one given above that do in fact block upper-bound readings for sentences like (105-a). What is important, however, is that all their proposals require the PEC.

3.5.2 Economy and TIAs

In light of B&S's proposal, we can appeal to the PEC to block LFs where an E-TIA combines with an atelic predicate, and those where a G-TIA occurs with the imperfective. We just saw that in any sentence with a *less than* modified numeral, a non-upper-bound readings of the sentence is redundant whenever its verbal predicate has the distributive property. In much the same way, E-TIAs are entirely redundant with atelic predicates because they have the subinterval property. The meaning we get for (120-a) is equivalent to simply asserting the existence of an $\mathsf{mbs}_{1,w}$ eventuality. This is true no matter the numeral in the TIA's measure phrase. We can immediately use the PEC to rule out (120-a): we can substitute for *three* some other numeral and obtain the very same meaning. This is true no matter the value of the numeral and, provided we assume that all atelic predicates have the subinterval property, no matter the atelic predicate we choose.

(120) a. *Mary was sick in three days.

b. $\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$
$\equiv \exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 2]$
$\equiv \exists e[\mathsf{mbs}_{1,w}(e)]$

On an imperfective reading of (121-a), the predicate of intervals modified by the TIA has the (generalized) subinterval property. The imperfective aspect combines with the sentence radical to create the predicate of intervals that are included in the runtime of some mbs_w eventuality. Any part of an interval that is a member of the extension of this predicate is itself one of its members. When a TIA modifies this predicate, the existential closure over it renders its contribution redundant.

(121) a. *Mary has been sick in three days.

b. $\exists t^1[\mathsf{days}(t^1) = 3 \wedge \exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(t^2, u) \wedge t^2 \subseteq t^1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]]$
$\equiv \exists t^1[\mathsf{days}(t^1) = 2 \wedge \exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(t^2, u) \wedge t^2 \subseteq t^1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]]$
$\equiv \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t, u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

Like we ruled out E-TIAs with atelic predicates using the PEC, the very same principle can be used to rule out the LF for (121-a) where the sentence is in the imperfective. The interpretation of this LF is given in (121-b), which shows that it is equivalent to the interpretation we would obtain by substituting *two* for *three*. No matter the numeral in the TIA, the TIA will always be redundant.

As we already saw, the polarity of a sentence has no effect whatsoever on the redundancy of these TIAs. The TIA in the negations of (120-a) is no less redundant than in its negatum. The PEC thus correctly derives the unacceptability of (124-a) and the unavailability of an imperfective reading for (123-a).

(122) a. *Mary wasn't sick in three days.

b. $\neg\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 3]$
$\equiv \neg\exists e[\mathsf{mbs}_{1,w}(e) \wedge \mathsf{days}(\tau_w(e)) \leq_d 2]$
$\equiv \neg\exists e[\mathsf{mbs}_{1,w}(e)]$

(123) a. Mary hasn't been sick in three days.

b. $\neg\exists t^1[\mathsf{days}(t^1) = 3 \wedge \exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(t^2, u) \wedge t^2 \subseteq t^1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]]$
$\equiv \neg\exists t^1[\mathsf{days}(t^1) = 2 \wedge \exists t^2[\mathsf{open}(t^2) \wedge \mathsf{rb}(t^2, u) \wedge t^2 \subseteq t^1 \wedge \exists e[\mathsf{mbs}_w(e) \wedge t^2 \subseteq \tau_w(e)]]]$
$\equiv \neg\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t, u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

The PEC can thus complement the MEP so that, together, they are able to cover the empirical landscape satisfactorily. As mentioned earlier, the advantages of the MEP over the MIC were offset by the fact that it was too weak to rule out E-TIAs with atelic predicates or G-TIAs in the imperfective. This is remedied by the PEC, which is independently motivated by *less than n* modified numerals.

3.5.3 Definite Measure Phrases

Unlike the MIC, the PEC can shed light on the difference in the licensing conditios of TIAs containing definite, as opposed to indefinite, measure phrases. Observe that while *in three days* is unacceptable in combination with an atelic predicate, *in the last three days* is fine.

(124) a. *Mary was sick in three days.

b. Mary was sick in the last three days.

The sentence in (124-b) has a straightforward interpretation: it says that at some point in the last three days, Mary was sick. If we understand the definite description *the last three days* as picking out the interval corresponding to this period, we don't need any amendments to our semantics to arrive at this meaning. We can assume for the sentence the LF in (125-a), where *the last* *three days* is left *in situ*. The meaning assigned to this LF is (125-b). Here, the function tld maps any n to the interval corresponding to the last n days.

(125) a. [$_{\mathbf{B}}$ PAST$_1$ PFV [Mary was sick] [in RUNTIME] the last three days]
b. $[\![\mathbf{B}]\!]^{u,g}_{¢} = \lambda w.\exists e[\mathsf{mbs}_{1,w}(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(3)]$
c. $\{\!|\mathbf{B}|\!\}^{u,g} = \{\lambda w.\exists e[\mathsf{mbs}_{1,w}(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(n)] \mid n \in \mathcal{D}_d\}$

This TIA is not redundant: to say that Mary was sick in a specific interval is not equivalent to just saying that she was sick. Moreover, the PEC doesn't rule out **B** since (125-b) is not equivalent to anything we would obtain by substituting in some other numeral for *three*. An $\mathsf{mbs}_{1,w}$ eventuality being included in $\mathsf{tld}(3)$ is strictly entailed by one being included in $\mathsf{tld}(n)$ whenever $n <_d 3$, and strictly entails one being included in it whenever $n >_d 3$. The same could be said about **B**'s negative counterpart.[7]

I defined the MIC, as well as the MEP, solely for indefinite TIAs, where the measure phrase is composed just of a numeral ν and a measure word μ. Both, however, could be extended to apply to definite TIAs, provided their definite descriptions contain numerals. But it's not clear that we want to do this. To begin, we can't actually draw a maximal informativity SI from (124-b). All the sentence says is that at some point in the last three days, Mary was sick. In fact, we would obtain very strange meaning if we tried to draw from the sentence an SI. The sets of innocently excludable and non-weaker alternatives

[7] As already mentioned, B&S hint at a possible reduction of the PEC to a more general principle of manner. There is actually good evidence of this coming from TIAs. The contrast in (126) can be explained in effectively the same way that in (124) was.

(126) a. *Mary was sick in the amount of time during which Sue spoke.
b. Mary was sick in the period during which Sue spoke.

In (126-a), the definite measure phrase is redundant because it denotes a duration rather than an interval. Presumably, the meaning of this sentence says that the duration of some eventuality of Mary's sickness is less or equal to the duration of Sue's speech. Given the subinterval property, the TIA is utterly redundant. This is in contrast to (126-b), which locates Mary's sickness in time, circumventing redundancy. As currently stated, the PEC won't draw this distinction, as it is only defined for LFs that contain numerals.

are the same: they are just the set of alternatives where $n < 3$. If we negate them all, we end up saying that Mary was sick in the last three days, but not in the last n days for any $n <_d 3$.

(127) $$[\![\text{EXH}^{\mathcal{IE}}\ \mathbf{B}]\!]^{w,u,g}$$
$$= [\![\text{EXH}^{\mathcal{NW}}\ \mathbf{B}]\!]^{w,u,g}$$
$$= \exists e[\mathsf{mbs}_{1,w}(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(3)] \wedge \forall n[n < 3 \rightarrow \neg\exists e[\mathsf{mbs}_{1,w}(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(n)]]$$

Provided that we assume that $\mathsf{tld}(3)$ is a closed interval, this is not a contradiction. It simply says that the last moment of Mary's sickness coincides with the interval's LB. Thus, sickness is indeed contained in $\mathsf{tld}(3)$, but not in any $\mathsf{tld}(n)$ such that $n <_d 3$. While consistent, this is far too strong a reading for (124-b). We could conclude from this that the MEP does not apply to TIAs where the measure phrase is a definite description. In other words, we need to assume that, for some reason beyond my understanding, numerals cease to be scalar items in the scope of definite descriptions.

This opens the floor to an important question: if we aren't drawing SIs from *in the last three days*, what does this say about its possibly acting as a G-TIA in (128)? After all, if the polarity sensitivity of G-TIAs comes from the SIs they lead to, then definite G-TIAs should not exhibit any polarity sensitivity.

(128) Mary has been sick in the last three days.

On an perfective G-TIA reading, the sentence is given the LF in (130-a). This is interpreted as the set of worlds where Mary was sick in some open interval whose RB is u and which is included in $\mathsf{tld}(3)$. But this is just equivalent to saying that Mary was sick in $\mathsf{tld}(3)$: Mary was sick in that interval iff she was sick in an open interval whose RB is u which is itself contained in $\mathsf{tld}(3)$. There is nothing wrong with this reading, which is indeed how we interpret the sentence.[8]

[8] We can also get this reading if we have *in the last three days* be an E-TIA, as in (129-a).

(130) a. PRES PERF [PFV Mary has been sick] [in RUNTIME] the last three days

b. $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge s \subseteq \mathsf{tld}(3) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq t]]$
$\equiv \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(3)]$

The sentence could also be interpreted in the imperfective, as represented by the LF in (131-a). This LF denotes $\mathcal{T}$ iff some mbs eventuality contains an open interval whose RB is u, which is itself also contained in $\mathsf{tld}(3)$.

(131) a. PRES PERF [IMPV Mary has been sick] [in RUNTIME] the last three days

b. $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge t \subseteq \mathsf{tld}(3) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$
$\equiv \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge t \subseteq \mathsf{tld}(2) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$
$\equiv \exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge t \subseteq \tau_w(e)]]$

It turns out that the TIA is completely redundant here. If an mbs_w eventuality contains an open interval t^1 whose RB is u, then necessarily one of its own open subinterval t^2 will have u as its RB and also be a subset of $\mathsf{tld}(3)$, whose own RB happens to be u. The TIA is redundant no matter the numeral used, and so (131-a) is ruled out by the PEC. There is therefore no issue in assuming that definite G-TIAs don't give rise to SIs. This assumption generates no undesirable reading.

3.6 Concluding Remarks

To conclude, I have shown that the distributional conbstraints on TIAs can be accounted for in terms of two principles. The first is the MEP, according to which numerals in the measure phrases of TIAs must always be in the scope of an exhaustification operator. This can block G-TIAs from appearing in simple

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The sentence denotes the set of worlds where an eventuality of Mary being sick is contained both in $\mathsf{tld}(3)$ and an open interval right-bounded at u. Again, this is the case iff Mary was sick in $\mathsf{tld}(3)$. So the scopal difference for the TIA is inconsequential here.

(129) a. PRES PERF PFV [Mary has been sick] [in RUNTIME] the last three days

b. $\exists t[\mathsf{open}(t) \wedge \mathsf{rb}(t,u) \wedge \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(3) \wedge \tau_w(e) \subseteq t]]$
$\equiv \exists e[\mathsf{mbs}_w(e) \wedge \tau_w(e) \subseteq \mathsf{tld}(3)]$

positive sentences, while at the same time making it possible for E-TIAs to be embedded under negation. The second principle is Buccola & Spector's (2016) PEC, which allows us to rule out E-TIAs with atelic predicates as well as G-TIAs in the imperfective.

These principles offer not only better empirical coverage than the MIC, but are also better motivated. The MEP can be understood in terms of a more general requirement that scalar items always be in the scope of an exhaustification operator. This is more or less in the spirit of Magri (2009), who shows that pathological scalar implicatures can never be avoided with other scalar items. Based on this, he argued for mandatory exhaustification at every clause. The PEC finds motivation in more general principles of conversation, which require that unnecessary lexical material be avoided.

Here ends my dissertation. Though some ground has been covered on TIAs, much is left to be done. The task ahead is clear: we must describe the acceptability of TIAs within a broader set of linguistic environments, and see where my proposal succeeds and fails to account for the data.

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