Chapter 7
On Adverbs of (Space and) Time

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7.1 Overview

This paper presents a solution to a series of linked puzzles centering around what Cresswell 1977 called *adverbs of space and time*. Adverbs in this class include "quickly", "slowly", "suddenly", "immediately", "glacially", "fast", "rapidly", and others. The proposal I develop is that these adverbs in fact just measure time. In particular, I propose that the core meaning of these adverbs is a distributive degree predicate over events; a range of interpretive properties follow from the interaction of distributivity and event structure. I also propose that this distributivity has an effect on how the degree predication works, and in particular what type of measure function is used and what measure phrases are licensed. Cresswell's classification of these adverbs as spatial turns out to follow from the type of verbal predicate involved; they combine with VPs that involve directed change along some dimension of measurement, and VPs involving change in the spatial domain are a special case. For that reason they might be better called *adverbs of time and change*, though I will stick with Cresswell's label for this paper.[1] In the big picture, I propose that this notion of distribution of the adverbial property over the event structure leads to a unified notion of manner for some, but not all manner adverbs, and so the proposal is aimed in large part at an understanding of what a "manner" is.

The key new data centers around the distribution of what I will call *ratio* readings vs. *extent* readings of space/time adverbs. A concrete manifestation of this distinction comes in the form of the (surprising) fact that this class of adverbs in the

[1] Another term sometimes used in the cartographic literature is "celerative" adverbs (Cinque 1999).

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comparative takes two different types of measure phrases, characterizing rate and temporal extent, as in (1). (For the moment I will focus on adverbs adjoined low, in a "manner" position.)

(1) a. ✓ Alfonso ran to the park 2 miles per hour more quickly than Joanna.
b. ✓ Alfonso ran to the park 2 minutes more quickly than Joanna.

More familiar measure phrase constructions in the adjectival domain typically are compatible with only one type of measure phrase, determined by the dimension of the predicate, so clearly this in itself is a puzzle to be explained. Further, I will show shortly that the distribution of these types of measure phrases varies by lexical aspect, as well as position of attachment of the AdvP. (There will also be effects of grammatical aspect that I will largely set aside in this paper.) By giving an account of the distribution of ratio/extent measure phrases we can learn much about the properties of these adverbs, and adverbial modification in general.

A number of other authors have proposed that adverbs like "quickly" in the non-comparative form also give rise to ambiguities (Cresswell 1977; Travis 1988; Pustejovsky 1991; Tenny 2000; Thompson 2006; Eszes 2009). The terminology and particular characterization of the apparent ambiguity differs (I will expand on this later), but two paraphrases corresponding to ratio and extent measure phrases can be roughly mapped onto the previous proposals, as in (2).

(2) Alfonso ran to the park quickly.
a. ≈ Alfonso ran to the park in a quick manner.
b. ≈ Alfonso ran to the park in a short time.

On the ratio reading, "quickly" intuitively tells something about Alfonso's "manner" of running – he was running quickly. This reading can be paraphrased using "in a quick manner". But on the extent reading, the adverb tells us that the overall time it took to get to the park was short (this needn't be true on the ratio reading), and use of "in a quick manner" does not lead to this reading.[2]

One issue raised by much of this previous work is how we can differentiate the readings of space/time adverbs truth-conditionally, and how the readings are related. Many of these authors also discuss a third reading available only when the adverb is attached higher in the structure; see (11) below. Some authors also distinguish the ratio from the manner reading (where I have collapsed them into (a)), and/or set aside anything analogous to what I am calling the extent reading. My proposal is that the distribution of measure phrases, and the analysis necessary to account for it, must inform the analysis of any ambiguities in non-comparative space/time adverbs. In §7.3 I demonstrate using measure phrase data as well as a

[2]In general, I do not take "in an X manner" paraphrases to be a reliable diagnostic of actual manner readings; the distribution of this kind of adverbial does not closely match the distribution of the corresponding adverbs.

number of other arguments that certain proposed ambiguities in the literature must be collapsed, and that the availability of readings in the 'manner' position is greater than has been supposed. The result is a much simplified picture of what readings are available when, on a firmer empirical basis.

The above predicate ("run to the park") is an accomplishment predicate in lexical aspect terms (Vendler 1957; Dowty 1979 etc). This particular predicate shows both 'readings', but not all accomplishments pattern in the same way. An accomplishment predicate like "win the race"[3] allows only the extent reading and measure phrase.

(3) Alfonso won the race quickly.

(4) a. ✓ Alfonso won the race 10 minutes more quickly than last time.
b. * Alfonso won the race 2 miles per hour more quickly than last time.

I will propose that this distinction between accomplishments follows from a difference in the part-whole structure of the two types of events involved – "run to the park" involves an activity with a compositionally supplied culmination.

On that note, activity predicates pattern differently, allowing only ratio(/manner) readings and the corresponding measure phrases:

(5) Alfonso ran quickly.

(6) a. * Alfonso ran 10 minutes more quickly than Joanna.
b. ✓ Alfonso ran 10 miles per hour more quickly than Joanna.

Achievement predicates and semelfactives tend to be good with these adverbs only if they can be coerced to an accomplishment reading, with the adverb describing the time it took to get to the culmination:

(7) Alfonso reached the peak quickly.

(8) a. ✓ Alfonso reached the peak 10 minutes more quickly than Henry.
b. * Alfonso reached the peak 2 miles per hour more quickly than Henry.

In some cases, Rothstein's 2004 'slow motion' readings are available with adverbs of space and time (at least to the extent that they are available with parallel "for" adverbials; intuitions vary):

(9) (Regular slow motion readings)
a. Alfonso reached the peak for two minutes. (≈ the last step took 2 minutes.)
b. Alfonso sneezed for 15 seconds. (≈ a single sneeze extended for 15s.)

(10) a. Alfonso reached the peak very slowly. (≈ the last step was very slow.)
b. Alfonso sneezed slowly. (≈ a single sneeze was slow.)

[3]Note that "win" may also lead to achievement readings; these are blocked for reasons that will become clear, and aren't relevant to the present point.

My proposal is that in the case of 'processes' (in Bach's 1986 terminology, the type of event corresponding to an activity predicate), the measuring of time is distributed over the homogeneous part-whole structure of the process. In other cases, measuring does not distribute. Whether there is distributivity aligns with Krifka's 1989 distinction between quantized and non-quantized events. The basic idea that these adverbs are distributive is due to Cresswell 1977, but the account Cresswell develops is highly specialized, focusing just on manner modification of activity predicates and accomplishment predicates of the "run to the park" type, for verbs involving spatial movement. Cresswell also did not discuss the measure phrase data above (in fact, measure phrases are seldom discussed at all in the context of adverbial comparatives). I show how to generalize the core idea of Cresswell's account, distributivity, to handle the full range of data, and solve the puzzle of measure phrases as well. I give an account whereby regular measure function can be coerced into a ratio measure function in a composite dimension of comparison; this function measures change over time, where the dimension of change is supplied by the verbal predicate.

There is one more crucial type of example, much discussed in the literature. All of the above data involves the adverb being adjoined low, to VP. These adverbs can productively attach to a clause in a higher structural position. The difference in readings here goes beyond just the ratio vs. extent distinction, but along that dimension, adverbs of space and time allow only extent measure phrases regardless of lexical aspect. (There is, on the other hand, some interaction with grammatical aspect that I will mostly ignore.)

(11) Slowly, the students left the classroom.

a. ✓ 5 minutes more slowly than last class, a student left.

b. * 2 feet per minutes more slowly than last class, a student left.

The other main difference between (11) and a corresponding example with manner "slowly" is that, intuitively, (11) seems to measure the time that has passed since some previous event. The low-attached adverbs are more 'internal' in the sense that they characterize only properties of the event(s) described by the sentence itself. I develop an account of the distribution of these high-attached adverbs that reduces them to the same core meaning as the other cases, and derives this apparently anaphoric interpretation from the properties of the narrative discourses that it appears embedded in.

This last batch of data connects to an important puzzle for the account of adverbs across many classes, what I term the *scope puzzle*. This is that many classes of adverbs show apparent meaning alternations between their use in a high structural position, and in a lower/manner modifying position (Austin 1956; Jackendoff 1972; McConnell-Ginet 1982; Ernst 1984, 2002; Wyner 1994; Geuder 2000; Shaer 2004; Rawlins 2008; Martin this volume, a.o.). The alternation for "slowly" is visible in the above examples, where the primary distinction is anaphoricity and type of measure phrase. Here is a range of further examples drawn from various classes of

adverbs, where there are less subtle distinctions (see also Martin (this volume) for a more detailed overview of available readings):

(12) a. Clumsily, he trod on the snail. (Austin 1956)
b. He trod on the snail clumsily.

(13) a. Cleverly, John dropped his cup of coffee. (Jackendoff 1972)
b. John dropped his cup of coffee cleverly.

(14) a. Louisa rudely departed (McConnell-Ginet 1982)
b. Louisa departed rudely.

(15) a. Appropriately, Kim kissed Sandy. (Wyner 1994)
b. Kim kissed Sandy appropriately.

(16) a. Illegally, white moved a pawn. (Rawlins 2008)
b. White moved a pawn illegally.

For example, the sentence in (16a) is true if it was illegal for white to move a pawn at all, for instance if it wasn't their turn. But (16b) is compatible with scenarios where white was allowed to move a pawn somehow, but violated a rule in the particular move they made (e.g. moving a pawn diagonally without capturing).

The general problem can be framed in terms of *regular polysemy* (Rappaport-Hovav and Levin, 1998) in the adverbial domain: what is the shape of a systematic account of these alternations? Various approaches have been taken involving lexical (McConnell-Ginet 1982; Geuder 2000; Ernst 2002) or compositional (Thomason and Stalnaker 1973; Rawlins 2008) processes to derive the differences, but the jury is still out. Previous accounts of adverbs of space and time (Cresswell 1977; Schäfer 2002; Eszes 2009) imply a lexical solution – either there is simply accidentally polysemy, or the high-attaching adverbs are a metaphorical extension of the manner modifiers out of the spatial domain. Here I will pursue the hypothesis that adverbs of space and time, at least, share the same core meaning across positions, with the goal of deriving the differences from differences in compositional environment.[4] In particular, the behavior and distribution of high-attached adverbs of space and time will follow from independently motivated properties of narrative discourse.

In the remainder of this section I will set out some technical background about neo-Davidsonian approaches to events. In §7.2.1 I discuss the major previous analysis of adverbs of space and time, due to Cresswell. The goal there is not to argue against Cresswell per se, but rather to highlight the crucial ideas in Cresswell's analysis that mine will attempt to generalize. In §7.4 I present my own proposal, focusing first on manner modification, and then on sentence modification. Finally, in §7.5 I turn to the analysis of measure phrases and their distribution.

[4] See Piñón 2000 for a similar claim about "gradually".

7.1.1 The Neo-Davidsonian Backdrop

Part of the goal of this paper is to develop an analysis of space-time adverbs that is framed in an event semantics (following Eszes 2009). As such I will be adopting a neo-Davidsonian approach to adverbial modification (Davidson 1967; Parsons 1990, etc.) The basic idea is that sentences describe eventualities, and both verbs and adverbs denote properties of eventualities. Compositionally, sentences come to describe eventualities via an "Existential Closure" operation over an unsaturated event variable. I will assume here that existential closure is a type-shifting operator applied in order to produce a sentence of type t (Landman 2000), though nothing hinges on this particular formulation. Before getting into the details I will give the type conventions I am assuming:

(17) Types: e = individuals
v = events
s = possible worlds
τ = intervals
d = degrees

I will follow Kratzer 1996 (a.o.) and assume that a subject argument is assigned a thematic role by an agentive little-v, rather than directly by the verb:

(18) $[\![\mathbf{v_{agent}}]\!] = \lambda P_{\langle vt \rangle} . \lambda x_e . \lambda e_v . \textsc{Agent}(e) = x \ \& \ P(e)$

Though this assumption is not crucial, it makes the types of adverbs much simpler to work with. In this paper I will attempt to ignore tense and grammatical aspect as much as possible, though it will not be entirely escapable.

Putting these pieces together leads to a standard neo-Davidsonian account of an adverb like "slowly" (Davidson 1967; Harman 1972; Parsons 1990):

(19) a. $[\![\textbf{danced}]\!] = \lambda e_v . e$ was a dancing

b. $[\![\textbf{slowly}]\!] = \lambda e_v . e$ is slow

c. $[\![\textbf{danced slowly}]\!] = \lambda e_v . e$ was a dancing & e is slow
(Predicate Modification)

d. $[\![\textbf{Alfonso danced slowly}]\!] =$
$\exists e_v . \textsc{Agent}(e) =$ Alfonso & e was a dancing & e was slow
(Function Application (x2) + existential closure)

The question now raised in this neo-Davidsonian context is what exactly is involved in predicating slowness of an event. A version of this question was raised as a potentially insurmountable challenge to Harman's neo-Davidsonian analysis by Lakoff 1977, but here I take this question to be instead an opportunity to deepen our understanding of adverbs, event structure, degrees, and many other issues (see also Reeves 1977).

7.2 Background

7.2.1 The Ratio Analysis and Its Challenges

A core question, therefore, is what it means for an event to be slow. Cresswell provides an answer to that question, though not framed in terms of events: "The semantics of *quickly* [etc.] is concerned with the ratio of spatial distance covered to time taken to cover it" (Cresswell 1977). The idea works best with movement verbs:

(20) John walked quickly.
($\approx$ most subintervals that are walkings are above average speed for walkings of that length.)

More formally:

(21) Let center(a, t, w) be a function from moments in the interval t such that for any $m \in t$, (center(a, t, w))(m) is the center point of the space occupied by t at m.

(22) Let d be a function (a "metric") such that:
   (i) For any interval t, $d(t) =_{\text{def}}$ a real number giving the temporal extent of t.
   (ii) for any function from moments to points f, $d(f) =_{\text{def}}$ a real number giving the distance traveled during the domain of f.
   (i.e. $d \approx$ a multi-sorted measure function)

(23) $[\![\textbf{John walks quickly}]\!]^{w,t} = 1$ iff
For most minimal subintervals $t*$ of t which are intervals of John's walking in w,

$$\frac{d(\text{center}(John, t*, w))}{d(t*)} > \text{avg}\left(\left\{ \frac{d(\text{center}(b, t', w))}{d(t')} : t' \text{ is an interval where } b \text{ is walking} \right\}\right)$$

Cresswell develops a compositional analysis that derives this interpretation, and I don't propose to go over the compositional details, except insofar as the analysis I later develop resembles Cresswell's. The key component is that "quickly" functions to compare the ratio of distance to time (speed) for subintervals of the described interval where John was walking, to some average or standard speed for similar intervals. While Cresswell did not use an event semantics, the idea could be implemented in one: events that involve some distance traveled have a spatio-temporal trace (Krifka 1989; Piñón 1993 a.o.), and the ratio in question can be calculated from this trace. This proposal seems entirely adequate to account for the

truth conditions of data like (20). The ratio analysis additionally captures something like the ratio/extent ambiguity I introduced in §7.1; a version of this difference follows from what constituent the adverb modifies (note that the following parses are Cresswell's):

(24) John [[quickly walks] to the station]
(≈ most subintervals that are walkings are above average speed for walkings of that length.)

(25) John [quickly [walks to the station]]
(≈ most subintervals that are walkings-to-the-station are above average speed for walkings-to-the-station of that length.)

The intuition here is that one reading involves a quick manner of walking, and the other a quick overall coverage of the path to the station. The analysis captures the difference in terms of quantification over subintervals of different granularity, and this follows compositionally.

This analysis has two main benefits, each providing important insights. The first is that it handles 'manner' readings well, and the insight is that manner readings involve quantification over (typically short) subintervals of the event the sentence describes, where the sortal predicate is still true (e.g. minimal subintervals that are still walkings). A way of rephrasing the insight that I will take away from this is that a manner is a property that characterizes these minimal subintervals in some way. The second benefit is that it makes at least some correct predictions about the distribution of measure phrases (this is not an issue Cresswell explored). That is, by virtue of involving comparison of ratios to a standard, it predicts "miles per hour"-type measure phrases (ratio MPs) in examples like (20), and this is the right prediction:

(26) Alfonso walked one mile per hour more quickly than Joanna.

Unfortunately, the proposal has a number of disadvantages. First, it (by design) does not handle the high-scope readings, such as one reading of Cresswell's (27) (this is the reading where the time from some previous event until someone entered was short):

(27) Someone quickly entered.

Cresswell has this to say: "this use… does not seem to bear the literal and physical meaning which we have so far been studying." That is, it doesn't seem to be about distance traveled per se, and in fact Cresswell suggests that high-attached readings could be about something more abstract, such as the rate of a proposition becoming true. Schäfer 2002 makes a similar suggestion, that high-scoping adverbs of this type involve a metaphorical extension of a more physical reading. (See also Piñón's 2000 discussion of high-attachment readings of "gradually".)

Two disadvantages are really opportunities for development – the account does not as-is explain the selectional/distributional puzzles involving lexical aspect, and

does not connect the interpretation of the adverbs with more current theories of comparatives. But there are obvious lines of development for Cresswell's proposal to solve both of these issues, and one contribution of the present paper is to explore these. In particular, I will reformulate the ideas in the context of an event semantics, and more recent approaches to comparatives.

Finally, there are two more serious empirical problems. First, as we have already seen, the full distribution of measure phrases is complex, and the ratio analysis would not ever lead us to expect temporal extent measure phrases. Nonetheless, we find temporal extent MPs in certain contexts (see data in §7.1), and this has to be explained. To account for this I will end up proposing that the ratio readings are derived, not basic. A closely related problem is that the analysis really only works with motion verbs, but adverbs of space and time can apply freely to nearly any verb that involves some kind of change. Here are a range of examples:

(28) The water heated slowly.

(29) Alfonso sneezed slowly.

(30) Alfonso solved the problem quickly.

(31) Alfonso changed slowly into a werewolf.

(32) Alfonso ran in place quickly. (after Lakoff 1977)

In most of the above examples there is no change in terms of distance, but the sentence still seems intuitively to express some rate or ratio. For example, in (28) a natural paraphrase along the lines of Cresswell's analysis would be that the ratio of temperature increase to time for most short subintervals of heating is smaller than in typical comparable subintervals of heating. (As we might expect, the properties of measure phrases are affected by the verb as well; see data in §7.5.) The example in (32) illustrates that even with motion verbs, on the manner reading there isn't necessarily a change at all in location, i.e. distance needn't be covered. How can Cresswell's analysis be generalized to cover the full range of verbs that adverbs of space and time can combine with?

7.3 More Ambiguities?

The proposals above involve a lexical ambiguity triggered by syntactic position of the adverb. A number of authors (Travis 1988; Tenny 2000; Ernst 2002; Thompson 2006; Eszes 2009) have explored similar ideas, and in fact suggested extra readings beyond the two originating from Cresswell. Here I will focus on Eszes's 2009 proposal, as it is the most detailed. Eszes, following Tenny, assumes that there are three possible readings for space/time adverbs. One (which this literature calls 'aspectual modification' or as in Schäfer, 'temporal reading') is the reading appearing in high-attached positions (e.g. (11) above), and its existence is uncontroversial. In certain positions, these authors further distinguish between

'true rate' modification, and manner modification, as in (33) (Tenny's paraphrases). Furthermore, Eszes claims that the low-attached adverb in (34) (after ex. 7 in that paper) has only the manner reading, not the rate reading.

(33) Kazuko moved quickly to the window. (Tenny 2000 ex. 66)

a. Paraphrase: Kazuko moved her body in quick motions while progressing to the window, although her traversal of the path to the window might not have been a fast one. ("pure manner modification")

b. Paraphrase: Kazuko's traversal of the path to the window was fast. ("modification internal to the core event (true rate modification)")

(34) Kazuko moved to the window quickly.

How can these two readings be disentangled, given the similarity of truth-conditions that result? In fact, I do not believe there is evidence to distinguish precisely these readings. First, though (a) above is phrased by Tenny to try to make sure that it doesn't entail (b), native speakers do not easily accept the content of the "although"-clause in the paraphrase, and so this lack of entailment is far from clear. Second, though the (b) paraphrase does not necessarily entail the (a) paraphrase in a logical sense, when enriched with background knowledge, it is almost impossible for it to be true while the (a) paraphrase is false. Finally, the claim that (34) selects only for one of these paraphrases is in clear contradiction with native speaker judgments, for English at least. (It should be noted that much of Eszes's 2009 data is in Hungarian, and I will not deal with that data here.) Consequently, native speaker intuitions do not support distinguishing Tenny's paraphrases as readings.[5] To find different readings we must look for further evidence.

That is not to say that these paraphrases are wrong per se, though. First, the 'pure manner' paraphrase above is much more salient when there is no path expression in the same clause:

(35) Kazuko moved quickly while going to the window.

So we must be able to account for the interaction of these adverbs in cases where the event characterized does not involve a path directly. This example, in contrast to (33), does seem to be able to support the pure manner reading described by the paraphrase in (a) without committing to the rate reading in (b).

[5] Eszes (2009) phrases the claim quite strongly: "At first we might suppose that an analysis would be adequate which uses a scale structure with degrees ordered along the dimension of speed for the minimal parts (which may be considered separate bodily motions). However, this would result in an incorrect prediction, considering that the minimal parts make up the whole event, so that their speed values add up and determine the rate of the event, which means that on this supposition the rate reading would depend asymmetrically on the manner reading. Obviously, we have to make sure this does not happen." This is far from obvious, for English at least, and the quoted claim seems to be based entirely on Tenny's paraphrases. It actually seems to be correct that any rate-like paraphrase does depend on a manner paraphrase, and vice versa, as shown by the data below. In fact my proposal amounts to reducing the manner reading to a distributive rate reading.

I propose that the measure phrase data provides a useful independent window on the issue. There is clearly something like a rate reading, corresponding to the presence of a rate measure phrase. As we have seen, rate measure phrases appear with adverbs in the low-attaching position as in (34). This is clear evidence against the idea that this position doesn't allow for rate readings. With accomplishments, temporal extent measure phrases also work, as we have seen. Though I will have to largely set the intermediate positions aside for reasons of space, a rate MP also works there, but an extent MP is odd:

(36) Kazuko moved 1 m/s more quickly to the window than Henry.

(37) # Kazuko moved 1 s more quickly to the window than Henry.

Finally, in examples like (35) where apparently only the manner paraphrase works, we can still find rate MPs (an extent MP would be bad here, just as in (5) earlier):

(38) Kazuko moved 2 m/s more quickly than Henry while going to the window.

The evidence from measure phrases is completely inconsistent with the characterization of the ambiguities from previous literature. The low-attaching position supports both kinds of measure phrase. The intermediate positions supports only rate MPs. And examples which should have only a manner reading also support rate MPs. (As a reminder, the high-attaching 'aspectual' readings support only extent MPs.) In fact, the generalization that emerges is that rate MPs correlate with 'manner'. My proposal will be that the rate readings for space/time adverbs *are* the manner readings. Additionally, the previous literature would lead us to expect extent MPs only in the high-attached position, as this is the only position where the 'whole event' is modified (Travis 1988; Cinque 1999; Tenny 2000; see discussion in Tenny 2000 p. 322 and Eszes 2009 §4.2). In contrast, we find extent MPs in what previously have been described as manner-only slots. (While dealing with licensing of adverbs is not my main focus here, it is worth noting that this data is highly problematic for the Cinquean perspective that many of these authors have taken.)

Though the appearance of multiple MPs in low-attached positions is suggestive of an ambiguity, it is not in fact solid evidence that in examples without an MP we do have an ambiguity. For one thing, just as with Tenny's characterization, rate and extent paraphrases are not easy to disentangle truth-conditionally, so independent evidence is lacking. The alternative is that such examples are simply underspecified or vague. I will structure my analysis so that it is adaptable either way, though the precise proposal I develop here is on the ambiguity side.

Finally, I will briefly discuss Eszes's 2009 analysis, as I will be adopting several elements from it. In particular, Eszes gives an analysis in a neo-Davidsonian event semantics that treats adverbs of space and time as gradable predicates of properties of events or intervals. Depending on position, an adverb like "slowly" has access to the 'intensity' of the agent's atomic actions in the compositionally available event, or the rate of the event. "Slowly" would then tell us that whichever property it takes is low relative to the standard for similar atomic actions or events. Similarly to

Cresswell's ratio analysis, the manner/intensity readings involve distribution over event structure. The 'aspectual' readings (following Schäfer) involve comparison of contextually given intervals to a standard for similar intervals. The ambiguities that arise, arise from the range of things that the adverb can compare to a standard in a particular position. This account therefore allows for two additional possible answers beyond having a low rate to what it means for an event to be slow: the intensity of action is low, or its duration (as part of some salient interval) is long.

Since, as discussed above, neither the judgments nor the measure phrase evidence supports the ambiguities that the analysis is based on, I will not be adopting the proposal for generating these readings via lexical ambiguity. However, I will be adopting several components of the analysis. First, the treatment of adverbs of space & time as event predicates (from Tenny 2000; Ernst 2002; Torner 2003; Eszes 2009). Second, the idea of manner-like readings involving distribution over event structure (also present in Cresswell 1977). And most importantly, novel to Eszes's 2009 proposal, I will develop an account where adverbs of space and time are gradable predicates.

7.4 The Analysis

In this section I develop the analysis of adverbs of space and time in two parts: first I show how they work as manner (VP) modifiers, and then I turn to their properties when adjoined to a clause.

7.4.1 Manner Modification

My proposal for manner modification with adverbs of space and time involves two main ideas: (i) the core of the denotation of a space-time adverb is a degree function (following most directly Kennedy 1999, 2007; Kennedy and McNally 2005 on adjectives, as well as Eszes 2009), and (ii) the degree predication distributes over event structure (building on Cresswell's insight and Eszes's 2009 treatment of manner readings). I develop the proposal in two steps, corresponding to these ideas.

7.4.1.1 Manner Adverbs and Degrees

I develop the idea here that manner adverbs involve the same kind of degree predication as gradable adjectives. The idea is hardly unprecedented; there is a long tradition in the adjective literature of making just this assumption, most typically as a secondary issue (see Bowers 1970, 1975; Bresnan 1973; Cresswell 1977; von Stechow 1984; Rullmann 1995; Alexiadou 1997; Haumann 2004 a.o.). The idea has also been explored in the morphosyntax of adverbs and adjectives by Zwicky 1989, 1995. Why is a degree analysis important for understanding space-time

adverbs? It provides the key to understanding the derivation of Cresswell's ratio interpretation, as well as the conditions under which it is derived. It also provides the key to understanding the distribution of measure phrases, as well as the behavior of these adverbs with verbs of directed change that do not involve motion per se. It also provides the key to understanding how 'intensity' readings as in Eszes 2009 can be derived from a single entry for the adverb.

The main standard argument for connecting degree predication in adverbs to that in adjectives is that adverbs typically take the same sorts of degree morphology; intensifiers ("very"), comparative structure ("more ... than ..."), and comparison class marking ("for" phrases). And we have of course already seen that the comparative forms take measure phrases.

(39) Alfonso drove very slowly.

(40) Alfonso drove more slowly than Henry.

(41) Alfonso drove as slowly as Henry.

(42) Alfonso drove slowly for an American.

Degrees and Adjectives

On the Kennedy(/McNally) analysis of gradable adjectives Kennedy 1999, 2007; Kennedy and McNally 2005, the core lexical entry involves at least three parts: a measure function, a domain in which the measurement is occurring, and an ordering relation on that domain. For instance:

(43) $[\![\textbf{tall}]\!] = \lambda x_e \,.\, \textsc{Height}(x)$ type: $\langle ed \rangle$
DIMENSION: height, ORDERING RELATION: >

In cases where the adjective is used as a positive predicate without extra degree morphology, this core meaning composes with a covert "positive" degree operator, leading to a predicate that measures its argument along the relevant dimension, and compares that measurement to some standard (von Stechow 1984). The positive degree morpheme is defined in (44), and a composed example involving "tall" in (45).

(44) $[\![\textbf{pos}_{\textbf{adj}}]\!] = \lambda P_{\langle ed \rangle} \,.\, \lambda x_e \,.\, P(x) \succeq s(P)(C)(x)$ type: $\langle \langle ed \rangle \langle et \rangle \rangle$
where s is a contextually provided standard function, and C a contextually provided comparison class.

(45) $[\![\textbf{[pos [tall]]}]\!] = \lambda x_e \,.\, \textsc{Height}(x) \succeq s(\textsc{Height})(C)(x)$

I will be non-specific about how the standard and the comparison class get filled in, as this issue goes well beyond the scope of the present paper, but in all of the cases we are interested in, the comparison class has some dependence on the modified predicate.[6]

[6]The challenge, pointed out to me by an anonymous reviewer, is to ensure that the right comparison class is chosen when an event's atoms could have multiple true descriptions, e.g. the parts of a slow

I am assuming, informally at this point, that the $\succeq$ operator in the denotation of "pos" gets filled in with the lexically specified order (in this case $>$), and that the comparison is performed only along the specified dimension. For the moment, D_d can be treated as isomorphic to the reals, and so operators like $>$ have the usual definition as total linear orders. To implement this fully we would need a formalization of dimensions, but at this point that is not necessary. Dimensions will be necessary to handle the distribution of measure phrases, and so in §7.5 I will give a formalization of dimensions based on Alrenga 2007, 2009.

Degrees and Adverbs

This analysis can be applied directly to adverbs. I take the core of a space-time adverb to involve measuring the length of an event. A sample denotation for "quickly" is given in (48). Note that this entry is not fundamentally different than what might be used for the adjective "quick". Its antonym "slowly", I assume here, would involve simply reversing the order, analogous to pairs like "hot"/"cold".[7] This is shown in (49).

(46) For any event e, $\tau(e) \underset{\text{def}}{=}$ the temporal trace of e (a possibly discontinuous interval).

(47) For any (possibly discontinuous) temporal interval i,
$|i| \underset{\text{def}}{=}$ the maximal temporal extent of i.

(48) $[\![\textbf{quickly}]\!] = \lambda e_v\,.\ |\tau(e)|$ type: $\langle vd \rangle$
DIMENSION: temporal extent, ORDERING RELATION: $<$

(49) $[\![\textbf{slowly}]\!] = \lambda e_v\,.\ |\tau(e)|$ type: $\langle vd \rangle$
DIMENSION: temporal extent, ORDERING RELATION: $>$

As in the adjectival domain, in cases where we see a gradable adverb without overt degree morphology, I assume that there is a covert positive comparison operator. A first pass at this item is given in (50), and its syntax is shown in (51).

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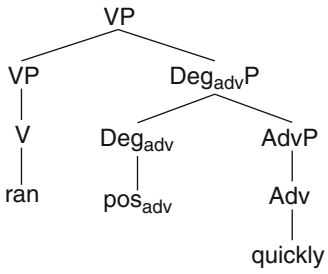
run might be non-differentiable from the parts of a fast jog. It is clear that we cannot simply extract this information from the event argument to s, as a previous version of this proposal suggested. This problem is very similar to the case where a short basketball player might be tall for a linguist; again we need a comparison class independent of the individual being measured. The analysis of "slowly" and "quickly" developed in the following sections adds in the additional problem of distribution to atoms, which makes it even more difficult to extract meaningful information about what the comparison class should be from the event itself.

[7] Intuitively, it seems plausible that "slowly" and "quickly" are further apart on the scale than mere reversal of order would suggest. We also would need to differentiate other adverbs such as "glacially", etc. This is analogous to understanding the lexical differentiation of e.g. "hot" and "warm". While formal semantic theories of degree modification have not focused on this kind of lexical difference, a natural solution has been developed in the computational semantics literature (Raskin and Nirenburg, 1996). This solution simply introduces an additional parameter into the lexical meaning, that allows adjusting the standard of comparison.

(50) **Positive adverbial degree morpheme, version 1**
$[\![\textbf{pos}_{\textbf{adv}}]\!] = \lambda P_{\langle vd\rangle} . \lambda e_v . P(e) \succeq s(P)(C)(e)$ type: $\langle\langle \text{vd}\rangle\langle \text{vt}\rangle\rangle$
where s is a contextually provided standard function, and C a contextually provided comparison class.

(51)



Again, I am assuming that $\succeq$ fills in for the ordering relation provided by the adverb; see §7.5 for details. As in the adjectival domain, Deg heads can be transitive, and a standard analysis of "more…than…" can be imported. Assuming that a "than"-phrase denotes a degree:

(52) $[\![\textbf{more}_{\textbf{adv}}]\!] = \lambda P_{\langle vd\rangle} . \lambda d_d . \lambda e_v . P(e) \succ d$ type: $\langle\langle \text{vd}\rangle\langle \text{d}\langle \text{vt}\rangle\rangle\rangle$

Other degree heads can be transferred to the adverbial domain similarly. In fact, the differences are so minimal that we might well give a single cross-categorial denotation to them, and apply type-shifts to coerce them into event or individual measurement as necessary (though I will not pursue this idea further here).

7.4.1.2 Distributivity

This sketch illustrates how to import the Deg analysis of gradable adjectives into the adverbial domain, but unfortunately it won't yet capture most of the interpretive patterns we are interested in. For example, in combination with an activity predicate (as in "Alfonso ran quickly"), it would predict that we compare running events of indeterminate length against each other. It seems that we should allow for Alfonso running quickly for an hour, even if Joanna ran slowly for an hour. To solve this we need some alternative way of measuring durations of events that doesn't rely on the entire run-time, and that works for both telic and atelic predicates. The analysis as it stands also leads to the expectation that we should use only temporal extent measure phrases in comparatives, the inverse of the ratio analysis' incorrect prediction.

The first step at remedying these problems is this: I propose that manner modifiers distribute over event structure, if they can. To condition how and when distribution happens, I will appeal to Krifka's 1989 distinction between quantized and non-quantized events (corresponding basically to activities on the one hand, and achievements/accomplishments on the other). An event's part-whole structure,

on Krifka's 1989 terminology, is non-quantized if it has a part-whole structure that is homogeneous with respect to the verbal predicate. It is quantized if this is not the case. For instance, a running event is non-quantized because because it has many parts that are themselves runnings, and those parts have such parts, etc. A running-to-the-park event is quantized because, while it has many parts that are running events, it has no proper parts that are also running-to-the-park events. This distinction in quantization turns out to predict much of the behavior of space-time adverbs. This idea for handling adverbs is really due to Cresswell 1977: there it effectively corresponds to whether the verbal predicate is homogeneous over the interval, or not.

One piece of evidence that ratio readings are distributive is that overt ratio measure phrases are compatible with "on average":

(53) Alfonso ran two miles per more quickly on average than Joanna.

(54) # Alfonso ran to the park two minutes more quickly on average than Joanna. (Ok on non-episodic reading.)

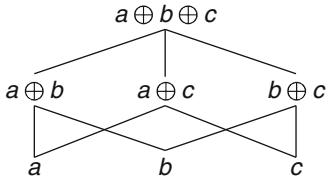
This use of "on average" requires a set of multiple measured events to average over, and distributivity over activities supplies this.[8] Its infelicity with extent measure phrases in episodic readings follows from the fact that there is only one event to average over.

Distributivity operators are more typically applied to individuals, except in the case of pluractional operators (Lasersohn 1995), and van Geenhoven's notion of cross-domain distributivity (van Geenhoven 2004, 2005). A central part of this proposal therefore is that adverbs of space and time are a species of pluractional operator. The idea is that what "quickly" etc. measure the length of, on ratio readings, is not the whole event, but minimal parts of the event. (In extent readings, the whole event will trivially be the only minimal part of the event.)

The implementation of distributivity I adopt here is standard. I assume that eventualities have a plural structure analogous to individuals (Bach 1986; Link 1987, 1998; Krifka 1989; Zucchi and White 2001 etc.), which in some cases can be modeled as join semi-lattices. A join semi-lattice is a set with a partial order and a binary join operator ($\oplus$) – the ordering relation here models part-whole structure, and the join operation the combination of parts into wholes. The set must be closed under join. For the moment I will focus on atomic semi-lattices, where there are minimal elements in the ordering relation, and all other members of the set can be constructed from these atoms using joins. A simple three-element atomic join semi-lattice is illustrated in (55). The top element ($a \oplus b \oplus c$) represents a plural event, and the bottom nodes are atoms.

[8] See Kennedy and Stanley 2009 for an analysis of a fairly different set of cases of "average" that involves averaging a series of measurements.

(55) **Example three-element atomic join semi-lattice**



I will make use of this kind of part-whole structure in a somewhat complicated way. A more standard approach is to assume that events have non-trivial part structure only when that structure forms a join semilattice. I do not assume that here, as I don't think it allows us to adequately explains the data. Rather I will allow more complex part structures (being mostly agnostic about how they work), but provide machinery for getting at homogeneous semilattices as a privileged special case. First, some basic tools for identifying the right kind of part-whole structures:

(56) A set of events X is homogeneous with respect to a property P iff $\forall e \in X : P(e) = 1$.

(57) $\text{lat}(e, P) =$ the maximal set of parts of e that form an join semilattice that is homogeneous with respect to P

Now, to put these to use. In order to handle the ambiguities with complex accomplishments (see §7.4.1.4 below) I will define a notion of immediate accessibility: this makes the event itself (e in this definition) accessible, and also any immediate parts. The goal here is to capture the behavior of accomplishments that consist of activities plus a culmination (e.g. "run to the park"). I then define the set of atoms from some homogeneous part-whole structure.

(58) An event e' is immediately accessible from another event e iff
$$e' \leq e \wedge [\forall e'' : e' \leq e'' \leq e](e'' = e \vee e'' = e')$$

(59) $\text{HATOMS}(e, P) \underset{\text{def}}{=}$ the set of atomic parts in $\text{lat}(e', P)$, where e' is an event immediately accessible from e.
Defined only if $\text{lat}(e', P)$ is atomic.

Note that despite using "the" in the definition of 'HATOMS' in (59), I intend this definition to be underspecified. The point of underspecification is the choice of e', for which there can be multiple options in certain special cases. A fully quantized event will return the trivial lattice structure containing only itself. (I.e. $\text{HATOMS}(e, P) = \{e\}$). But in the case of e.g. "run to the park", this operator can return either the trivial accomplishment lattice, or the lattice corresponding to the running activity leading up to the arrival at the park, depending on the choice of e'. (I return to this in §7.4.1.4.) In most cases, the behavior of "HATOMS" is simple, however; for a quantized event it returns the singleton set containing that

event itself, and for a non-quantized event, the part-whole structure that forms a join semi-lattice.

In the context of an atomic join semi-lattice, some generalized distributivity operators can be defined as follows: (These are most directly from Landman 2000, but similar operators can be found in Link 1983, 1987, 1998; Schein 1993; Lasersohn 1995; Schwarzschild 1996 a.o.)

(60) Where C_H is some highly salient property of events (supplying a homogeneity criterion):
For any f of type $\langle\alpha\langle \text{vt}\rangle\rangle$, ${}^{D}f \underset{\text{def}}{=} \lambda P_{\alpha}.\lambda e_{v}.\forall e' \in \text{HATOMS}(e, C_H),\ f(P)(e')$
For any f of type $\langle\alpha\langle\beta\langle \text{vt}\rangle\rangle\rangle$,
${}^{D}f \underset{\text{def}}{=} \lambda P_{\alpha}\ .\ Q_{\beta}\ .\ \lambda e_{v}\ .\ \forall e' \in \text{HATOMS}(e, C_H),\ f(P)(Q)(e')$

The only mysterious part of these operators is the source of C_H, the homogeneity criterion. There are various ways to go, but here I have chosen for it to be contextually supplied. (Compare Cresswell, who effectively supplies a homogeneity criterion compositionally, from the predicate the adverb modifies.) This is perhaps too weak, as in the vast majority of cases I intend it to provided be the modified VP. (Once again, the complication is to handle accomplishments with an initial activity part.)

A distributive version of the "pos" operator is shown in (61):[9]

(61) **Positive adverbial degree morpheme, version 2**
$[\![{}^{D}\textbf{pos}_{\textbf{adv}}]\!] = \lambda P_{\langle vd\rangle}\ .\ \lambda e_{v}\ .\ \forall e' \in \text{HATOMS}(e, C_H) : P(e') \succeq s(P)(C_C)(e')$
Defined for e only if $\text{HATOMS}(e, C_H)$ is defined, and where s is a contextually provided standard function, and C_H is some highly salient property of events providing a homogeneity criterion, and C_C is a salient comparison class.

This operator composes with the core of an adverb as before, but now leading to comparison of the atoms of the event to a standard. Since the standard is relativized to the events in question, I assume that the comparison relates atoms of the event in question to other similarly atomic events.[10]

(62) $[\![[\textbf{DegP}\ {}^{D}\textbf{pos}_{\textbf{adv}}\ [\textbf{AdvP}\ \textbf{quickly}]]]\!] =$
$\lambda e.\forall e' \in \text{HATOMS}(e, C_H) : |\tau(e')| \succeq s\left(\lambda e''_{v}\ .\ |\tau(e'')|\right)(C_C)(e')$
Defined for e only if $\text{HATOMS}(e, C_H)$ is defined.

The intuition for e.g. "runs quickly" is that we look at the minimal parts of a running event that are still runnings (the verbal predicate provides the homogeneity criterion,

[9]The distributivity operator applies straightforwardly to "more", but forces us into some tricky assumptions. In particular, I will assume that a "than"-phrase with a distributive gradable predicate applying to the degree gap denotes the average degree for that distribution.

[10]Can the homogeneity criterion and the comparison class be identified? It seems plausible that they could be, but I will not try to settle the issue now.

and thus defines the semi-lattice structure), and check whether they are all[11] shorter than typical comparable minimal runnings (determined by C_C. For a running event, these atoms naturally correspond to something like individual steps or motions, similar to the distribution over actions in Eszes 2009. While it is important to understand how C_C is supplied, the issue goes beyond the scope of the present paper. I do not believe that it is a fundamentally different problem than supplying the comparison class for attributive adjectives, and thus will assume that any correct solution for that case can be applied here.

In consequence, when a degree predicate distributives over a quantized event, it involves trivial universal quantification over a single element – that event itself. This derives the fact that with accomplishments, space-time adverbs seem intuitively to describe the length of the entire event, and the type of measure phrases allowed match.

7.4.1.3 Atomicity

I have so far assumed that distribution happens to atoms. This is intuitively plausible for running events, but it makes the prediction that combination of "slowly" etc. with a verb that describes an event without atoms will be infelicitous. (The presupposition introduced by the distributivity operator will fail.) This may be right in some cases[12], but there are many felicitous combinations, for example driving quickly, falling quickly, etc., that seem to challenge this idea. It is entirely unclear that driving events, though homogeneous, should have atoms of the right type, or at all; driving is much more continuous, and the agent's actions are not what an adverb describes. For that matter, native speakers tend to lack access to intuitions as to precisely what the atoms of running events are. As a matter of natural language metaphysics, it has proven surprisingly difficult to adjudicate questions of whether processes have atoms in general (see Link 1998 ch. 12, Rothstein 2004 for discussion), but for the account to go forward, I will need to make an assumption one way or the other.

An analogous problem has appeared in the literature on mass terms, the canonical non-quantized expression in the individual domain. Chierchia 1998 made a similar assumption, that even mass terms like "water" involve atomic part-whole (join semi-lattice) structures. Chierchia 2010 develops this idea in an interesting way that I will follow here. In particular, he proposes that what mass terms like "water" lack is not atoms, but rather, a stable way of individuating the atoms. The proposal is that the part-whole structures for these terms are vague, and don't identify a single individuation scheme, but that for any way of making the part-whole structure precise, there are identifiable atoms. (One way of thinking of an individuation

[11] Substituting a "most"-type quantifier, to more closely parallel Cresswell's analysis, would be straightforward.

[12] A potential example is "*Alfonso slept quickly" (Katz, 2003); but here I think the problem may be lack of directed change rather than lack of atoms.

scheme is as a minimal cover of the part-whole structure; cf. Schwarzschild 1996.) Plural terms that involve stable atoms (e.g. count plurals, and some mass terms such as "rice" or "furniture") don't characterize a part-whole structure that is vague in this way. See also Rothstein 2010 for a related, independent proposal – that some mass terms are atomic relative only to a particular context, and some are atomic in a context-independent way.

I will adopt the same assumption for the part-whole structure characterized by non-quantized event predicates. That is, such part-whole structures are vague but for any way of making the structure precise, there are identifiable atoms. Distributivity is still well-defined for any precisification (way of making the atoms precise), but vague. I won't import Chierchia's formal implementation of this idea (using supervaluations) to the event domain, but the importation is straightforward. In fact, I will suggest in §7.5 that it is the instability that drives coercion to ratio measures.[13]

7.4.1.4 Explaining the Aspectual Patterns

Before turning to adverbs of space and time in the high structural position, I will briefly go through the details of the interaction of the above proposal with lexical aspect. As noted above, the interactions follow from the part-whole structure of the events.

First, the two clearest cases are accomplishments with no internal activity component, and activities. I showed in the introduction that accomplishments like "win the race quickly" involve only extent readings and measure phrases. For example:

(63) We chatted a bit and it dawned on me that he'd won the entire race 20 minutes faster than it took me to complete the first 62 miles. (via Google)

(64) The 4G iPod touch booted 2 seconds more quickly (26 seconds versus 28 seconds), but apps launched equally as fast on the two iPods and the two performed nearly identically in a variety of applications. (via Google)

In both examples the adverb requires a temporal extent measure phrase, and even without it, would describe the length of the whole winning/booting event. There is no intuition that the adverb describes the manner of motion or change, and "in a quick manner" can't be substituted (for the same reading; other manner-ish readings may be available). This follows straightforwardly on the account developed above. Assume that "win the race" is the only highly salient predicate that could be used to individuate events in a part-whole structure. There is only one winning-the-race event, and its parts are not winning-the-race events, so the only homogeneous join semi-lattice is the trivial one consisting of that event itself. (That is, the event is

[13] An alternative idea, along the lines of Schwarzschild 1996, would be to assume that the part-whole structure is not necessarily atomic, but that when it is not, we construct an atomic approximation using minimal covers.

quantized.) Consequently, distribution over event structure is trivial, and the event that is measured is the entire winning-the-race event itself.

Activities are the inverted case. They take only ratio measure phrases, and have only ratio/manner readings. For example:

(65) Alfonso ran 2 miles per hour more quickly than Joanna.

(66) and the car stops from high speeds with little drama (as we found out on the autobahn when an old plastic Communist-era car pulled into our lane going about 75 mph more slowly), aided by standard Brake Assist. (via Google.)

(67) It's tremendous; indescribable. With most of the traffic travelling 20 to 25 mph faster than anyone else. (via Davies 2004)

I will not deal with the measure phrases until §7.5. But the reason for the ratio reading becomes clear: distributivity is not trivial, and what is being measured is the length of the (unstable) atoms of the running/driving/etc. event, rather than the whole thing. In cases where these atoms involve some particular type of motion by an agent (e.g. running, jogging, walking), from the length of the atoms we learn something about other, more manner-esque, characteristics.

Many accomplishments are derived compositionally, and these are often composed of processes and culminations. The empirical generalization is that such accomplishments freely permit both temporal extent measure phrases, and ratio measure phrases. (Most speakers accept the ratio examples, but I haven't found any attested examples.)

(68) His wife, Annabel, had run the London marathon three minutes faster than he managed at Reykjavik. (via Google)

(69) Alfonso ran the marathon 3 miles per hour faster than last time.

On the present analysis this is captured by making the activity subevent of the running-the-marathon event 'immediately accessible' from the running-the-marathon event itself. The 'HATOMS' function therefore will either return the singleton set containing the entire event, or the atoms of the activity subevent, depending on the choice of e'.[14] This differs from Cresswell's proposal, which tries to derive differences of this type purely from attachment ambiguities. The reason I have differed in this way is that I do not take sentence-final adverbs to be plausibly ambiguous as to their attachment site[15], but both readings and measure phrases are clearly available.

[14]See Torner 2003 for a similar proposal to explain the behavior of Spanish space/time adverbs in this type of context.

[15]Though on a Cinque 1999/cartographic approach one might expect that apparent right-adjunction is accomplished via (possibly remnant) movement of VP past a higher attachment point for the adverb than is apparent from surface structure.

Achievements and semelfactives (as in "sneeze") are quantized, but not normally considered to be durative. Since the adverbs in question measure time, we would not expect them to be compatible with a non-durative event, and this is the correct prediction. They are licensed only if a "slow motion" reading (Rothstein 2004) is available, and in this case, we get an extent reading.

(70) Alfonso sneezed for 0.23 seconds.

(71) Alfonso sneezed 0.23 seconds more slowly than Joanna.

Finally, adverbs of space and time aren't compatible with stative VPs at all in this low-attached position. This isn't entirely surprising, as by and large, manner modifiers aren't compatible with stative predicates at all (Katz 2003). Katz' account is that (following Kratzer 1995) state verbs don't have an eventuality argument at all, so there is no state variable to be modified. This is a potential explanation for this special case; but here I will be (mostly) agnostic about the presence of state variables. Part of the proposal for the distribution of sentence modifying adverbs of space and time is that they have a strict sortal restriction to events proper, and this would also explain the inability to modify stative VPs.

This completes the core analysis of manner modification with space/time adverbs, though I will revisit many of these issues in the context of measure phrases. Now I turn to sentence modifiers.

7.4.2 Sentence Modification

When an adverb of space and time modifies a whole clause, it apparently measures the time from some previous event until the event described in the modified sentence.[16] For example, in (72), the contribution of "slowly" is to tell us that it took a while after the instructor's arrival before they got set up. In fact, if the discourse does not set up a prior event, as in (73), a high-attached adverb is not acceptable (though a manner adverb would be fine).

[16]One extremely interesting case I will not deal with is noted by Shaer 1998; when these adverbs attach to questions or commands they have a different effect:

(i) Quickly, talk to Alfonso.

(ii) Quickly, what is the capital of Spain?

What is measured here, apparently, is the time between the present speech event and the event that would occur if the command is obeyed, or the speech event that would be involved in answering the question. Similar effects happen with other types of high-attached adverbs in non-assertions, e.g. "frankly" (Isaacs and Potts, 2003).

(72) The instructor walked in. ✓ Slowly, he set up.

(73) (beginning of narration) The class was taking forever to get going.

a. # Slowly, the instructor set up his computer.

b. ✓ The instructor set up his computer slowly.

The puzzle that this data presents is how to give a unified account of adverbs of space and time for both structural attachment positions. As noted earlier, this challenge resembles problems of adverb interpretation and scope that span a wide range of adverb classes (Austin 1956; Jackendoff 1972; McConnell-Ginet 1982; Ernst 1984, 2002; Wyner 1994; Geuder 2000; Shaer 2004; Rawlins 2008 a.o.)

A second generalization, not discussed in previous literature, is that high-attached adverbs of space/time are not generally acceptable unless the clause they attach to is embedded in a narrative discourse. (By narrative discourse I mean the kind found in e.g. narration of stories, where events are described one after the other; see Kamp and Rohrer (1983) and other references below.) How can this generalization be captured?

One obvious move is to posit two lexical entries for each of these adverbs. This has been the dominant approach in the literature so far, with Cresswell 1977 and Schäfer 2002 assuming that the different uses are only indirectly related (Schäfer specifically proposing a metaphorical extension analysis for the high-attached adverbs), and a similar though more motivated proposal by Eszes 2009. I think this is the wrong move for a number of reasons. Cresswell's motivation for separating out these cases were that they didn't involve a ratio reading, and they didn't involve physical movement. But we have seen that non-ratio readings are also available with low-attached adverbs, and these adverbs in general don't require physical movement (see data in §7.5). Furthermore, a lexical ambiguity approach doesn't explain why interpretive differences correlate with position, or why so many classes of adverbs show scopal alternations resembling this one (see §7.1). McConnell-Ginet 1982; Geuder 2000; Ernst 2002 make use lexical processes for deriving one reading from another, leading to (in some sense) a more explanatory account of adverb scopal alternations, but this kind of analysis still leaves the direct connection to scope unexplained. The Cresswell/Schäfer approach fits into this class: proposing that high-attached adverbs of space and time involve metaphorical extension fails to explain two issues: (i) how freely these adverbs do appear, at least in narrative discourse, and (ii) the similarities between non-ratio readings across positions. Furthermore, no precise version of the metaphorical extension account has yet been given, so it is more of a straw-man than a worked out competitor. Ideally we would want the interpretive differences to follow from the compositional semantics, as in the accounts of Thomason and Stalnaker 1973; Rawlins 2008. Rawlins in particular proposes that adverbs attach and compose freely, but their interpretation at different points of attachment is mediated by a family of adverbial type shifts. For adverbs of space and time, I will give an account that does not require type-shifting, but

involves free attachment with interpretation following compositionally from the structure at the point of attachment.[17]

The proposal I develop here is that adverbs of space and time are predicates of events, and only events (not other abstract entities such as propositions, intervals, facts, states, etc.). This follows part of Schäfer's 2002 proposal – that adverbs of this type are "pure manner adverbs" along the lines of "loudly", which in general have only event-predicate interpretations in ad-clausal positions. Furthermore, I propose that at the structural point where these adverbs attach high, events are only compositionally available in sentences embedded in a narrative discourse. This idea is an extension of existing treatments of narrative discourse, though as we will see, the present analysis needs a slightly more complicated event structure than the standard. The kind of event compositionally available, which I refer to as a "narrative event", is always quantized, and so ratio readings are never available.

7.4.2.1 Narrative Discourse

There are three core properties of narrative discourse, two of which will be key to the distribution of adverbs of space and time. The most commonly addressed one is *ordering*: the temporal order of events described in a narrative discourse matches the utterance order (Kamp and Rohrer 1983; Partee 1984; Dowty 1986; Hinrichs 1986; Lascarides and Asher 1993; Kehler 1994; Asher and Lascarides 2003 a.o.; cf. Grice's 1975 maxim of manner).

A second constraint is what I will call *immediateness*. This states that if e_1 precedes e_2 in a narrative event sequence, by default e_2 closely or immediately follows e_1. Dowty 1986 characterizes immediateness by saying that "no event of crucial importance to the narrative overlaps with the two successive events or intervenes temporally between them." The reason this constraint is a default constraint is that overt time adverbials can directly affect the alignment of events. An alternative formulation of immediateness due to Asher et al. 1996; Asher and Lascarides 2003 is that e_1's post-state must overlap with e_2's pre-state. (On this view, what I will characterize as the narrative event is the minimal event temporally containing e_1's pre-state $\oplus e_1$.)

A third constraint that is less important for present purposes is *topichood* (Lascarides and Asher, 1993): narrative sequences share a common topic (in some sense). For simplicity I will take all of these properties for granted as atomic constraints, though obviously an account of narrative discourse itself should explain them (see discussion in the papers cited above).

[17] I won't take a stand here on how widely this approach can be applied, and it does seem like lexical derivation may be necessary for some adverb classes. For example, it is hard to give an account along these lines that directly relates the (ad-sentential) speaker-oriented and (ad-VP) non-speaker-oriented readings of adverbs like "frankly" (Potts, 2003; Ernst, 2009).

I will assume here a somewhat novel implementation of narrative discourse structure, that simplifies the account of adverbs of space and time. I assume that narrative discourse is chunked into "narrative events". These must be closely aligned. A narrative event contains but is not identical to the event described in the sentence itself. The relation between a narrative event and the described event is exactly analagous to the relation between reference time(/interval) and event time(/interval) in Reichenbach 1947; Klein 1994; Kratzer 1998: in the English simple past (e.g. past perfective) the narrative event/reference time contains the described event/event time. The correlate of the immediateness constraint on this proposal is actually a constraint that tries to maximize the time-span described event relative to the narrative event.[18] One way of putting this assumption is that narrative discourse involves a specialized *narrative aspect*, resembling the perfective, but leading to a slightly different compositional structure (narrative events, instead of intervals). I'll leave the details for another time, but this idea gains some plausibility given two points: (i) the narrative present in English clearly does not have the semantics of a normal present tense (see e.g. Comrie 1976), and (ii) a range of languages (e.g. Bantu languages) do overtly have a specialized narrative aspect (Dahl, 1985). A defining characteristic of this marker according to Dahl is that it shows up in any verb in a narrative discourse except the first. The constraint against discourse-initial adverbs of space and time therefore follows from the distribution of narrative aspect.

7.4.2.2 Back to Adverbs

A major stumbling block that I believe led previous accounts to propose lexical ambiguity is the seeming anaphoricity of high-attached adverbs of space and time. Here I propose that this apparent anaphoricity follows from their appearance in narrative discourse – the alignment constraint for narrative events means that the beginning of a narrative event will be aligned with the end of a previous one. The adverbs aren't truly anaphoric, and the relationship to a contextually salient previous time is mediated by narrative discourse. To constrain them to narrative discourse, I propose that these adverbs have a strict sortal restriction to events. On the account of narrative discourse sketched above, events will only be compositionally available in this position in narrative discourse. See Rawlins 2008 for a recent defense of the claim that a large range of other adverbs appearing in this position act like propositional operators, an idea that goes back to Thomason and Stalnaker 1973 – i.e. the case of high-attached adverbs of space and time is not typical. This idea is

[18] An alternative way of going about this would be to have adverbs of space and time simply measure an interval, and apply a type-shift in the case of manner modification. I don't take this route here because it complicates the task of explaining the restriction to narrative discourse, but further research is clearly needed.

partly inspired by Schäfer's 2002 proposal that adverbs of space and time are a kind of "pure manner adverb"; a more canonical example of this class being "loudly".

I'll sketch the account in detail by going through an example. I assume that the denotation of a simple sentence appearing in a narrative discourse prior to any existential closure would have the following structure (τ-contains means temporally-contains):

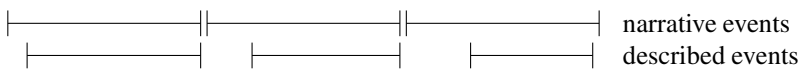
(74) (In a narration, before $\exists$-closure) $[\![$**Alfonso sneezed**$]\!] =$
$\lambda e_v \,.\, \tau(e) < now \wedge (\exists e' : \tau\text{-contains}(e, e') \wedge Ag(e') = \text{Alfonso} \wedge \text{sneezing}(e'))$

In the above formula, e is the narrative event, introduced by narrative aspect. I assume this event is always quantized/atomic (i.e. $\text{HATOMS}(e, C) = \{e\}$), and that the homogeneity criterion is supplied by the sister of the adverb (i.e. the property above). This formula will combine with adverbs like "quickly" just as before, except now the predicated-of event is distinct from the described event. Where C is the above function,

(75) $[\![$**Quickly, Alfonso sneezed**$]\!] =$
$\lambda e_v \,.\, \tau(e) < now \wedge (\exists e' : \tau\text{-contains}(e, e') \wedge Ag(e') = \text{Alfonso} \wedge \text{sneezing}(e'))$
$\wedge\, (\forall e'' \in \text{HATOMS}(e, C_H) \;:\; |\tau(e'')| \preceq s(\lambda e_v \,.\, |\tau(e)|)(C_C)(e''))$

What is 'quick' is the narrative event itself. Because this event contains the described event, an upper bound is placed on the duration of the embedded event. Furthermore, because the narrative event is aligned with the previous narrative event in discourse (not formally represented here), the adverb functions to additionally express a relationship between the previous event and the present one. The described event is contained in the narrative event, and is aligned to it, but not necessarily in a maximal way, at least for the initial part of the narrative event. Dowty's version of the immediateness constraint can be restated in the present view: there is no event of importance to the discourse that is part of the narrative event that precedes any part of the described event. (This would be most easily stated, on the account I am developing here, as a presupposition on narrative aspect.) This allows for a time gap, but not any events in that time gap. This can be visualized as in (76):

(76) Example: narrative sequence with described events temporally contained in narrative events



This diagram shows a sample discourse configuration of narrative events in time; the narrative events follow immediately after each other, and the described events are closely contained. I have assumed that there does not tend to be a gap at the end (it seems sensible to take this as a hard constraint), but there may be a time gap at the beginning of a narrative event, that is not included in the runtime of the described event.

This conception of narrative discourse serves so far to explain the apparent anaphoricity of adverbs of space and time, by reducing it to the anaphoricity of narrative 'aspect' itself. It also explains both the distribution of measure phrases, and the lack of interaction with lexical aspect. While the described event is part of the narrative event, the narrative event itself is guaranteed to lack any homogeneous part structure. If we were to try to categorize it into some aspectual class, in fact, it would most closely resemble an accomplishment. The account of the interaction with aspect for manner modification, therefore, predicts we should get only extent readings and measure phrases, and this is exactly the right prediction.

Furthermore, the account predicts that we should expect licit combinations of clausal space/time adverbs in cases where they can't attach as manner modifiers, e.g. achievements, semelfactives (on a non-slow-motion reading), and perhaps even statives. This is again the correct prediction. Across these classes, we find what Dowty 1986 called *inceptive* readings (sometimes called *inchoative* readings, e.g. Homer 2010).

It is well known in the literature on narrative discourse that stative sentences tend to be infelicitous, modulo appearance of grammatical aspects that allow the clause to act non-statively.[19] This is fairly unsurprising on an intuitive level, as narrative discourse involves events happening one after the other, but states tend to hold for more unbounded periods of time. What Dowty 1986 noticed is that in certain special cases, in particular where adverbs like "suddenly" and "quickly" appear, statives are licensed. An example after Dowty is given in (77):

(77) Alfonso walked into the room. Suddenly/quickly, the students were asleep.

The reading is one where, a short time after Alfonso walked into the room, it became true that the students were asleep. The class of licensing adverbs includes the adverbs under study here. There are two questions to address: (i) why are adverbs of space and time licensed attached high to stative sentences only under inceptive readings? (ii) why do these adverbs license inceptive readings at all? I.e. the corresponding discourse to (77) without the adverb does not have an inceptive reading available:

(78) Alfonso walked into the room. The students were asleep.

The natural reading for (78) is one where Alfonso discovers the students being asleep, and the discourse structure here would not involve narration, but rather something like background (or possibly elaboration).

[19] Except, of course, in complex discourse structures where they e.g. provide explanations or elaborations for part of a narrative sequence, as in:

(i) Joanna walked into the room. Alfonso was asleep. She walked over to the bed.

I suggest that the strict sortal restriction of adverbs of space and time to events explains both of these puzzles. Inceptive readings are only available under a kind of aspectual coercion, which I take to be a last resort. A concrete coercion operator that leads to the desired reading (following Homer 2010, who motivates this operator for entirely independent reasons) appears in (79):

(79) $\textsc{Inceptive} = \lambda P_{\langle v_s t \rangle} \, . \, \lambda e_{v_e} \, . \, \exists s \in D_{v_s} \, . \, P(s) \wedge \textsc{result}(e) = s$

A space-time adverb can't combine with a stative sentence directly (even assuming there is a state argument analogous to the event argument) because of the sortal restriction, so some coercion must apply to make it possible. Similarly, a stative sentence isn't licensed in discourse (i.e. because the verb is not compatible with narrative aspect). In a discourse structure like (78) there is no reason to coerce an eventive reading, because there is a perfectly acceptable non-narrative (elaboration) reading already. But with an adverb of space and time, an eventive reading is required, i.e. elaboration is not possible, and this forces a narrative reading.

It is clearly a complicated matter to fully describe what constrains operators like (79), and beyond the scope of this paper. An adverb of space and time is not absolutely obligatory, but it is often helpful. We would also want the operator to appear with achievements, and even some activities (e.g. "Slowly, Alfonso slept.").

In summary, I have proposed that high-attached adverbs of space and time measure the length of a "narrative event" – an event sequenced in a narrative discourse. This event has a consistent part-whole structure that is determined independently of lexical aspect[20], and consequently we see only extent readings/measure phrases. Verbs of any aspectual category are acceptable as long as they can be coerced into "inceptive" readings. Crucially, the core denotation of the adverb, its sortal restriction to events proper, and its interaction with degree morphology, are the same across different positions – what is different is the compositional environment it appears in, and the part-whole structure of the events it interacts with (cf. Ernst 2002).

The account makes an important prediction. We might have expected these adverbs to measure the gap between two sequenced events, and in fact many previous discussions would also lead us to expect this, but this is not the prediction of the present account: they should measure the duration of the narrative event, which at least includes the described event. This is correct; the example in (80) cannot have a reading where just the time until Alfonso started the novel was short – he has to complete it.

(80) Alfonso's bank account started getting low. Quickly, he wrote another novel.

[20]Though we might expect some interaction with grammatical aspect, which is not consistently compatible with narrative discourse. But this is complicated by the interaction between what I have called narrative aspect, and other grammatical aspectual operators, which I will leave for the future.

7.5 The Measure Phrase Puzzle

The major remaining task is to explain the complicated distribution of measure phrases with adverbs of space and time. There are two types of measure phrases that co-occur with these adverbs in the comparative form: temporal extent measure phrases such as "20 min", and ratio measure phrases such as "20 miles/h", "20° per min", etc.[21] The basic generalization is that a ratio measure phrase can occur if distribution over the event structure can happen non-trivially. In particular, it appears in cases where the event involves some homogeneous part-whole structure that the predication can distribute over. As long as this distributivity must happen, extent measure phrases are not possible.[22] A case of particular interest is high-attached space-time adverbs, which only ever receive extent measure phrases (see (11)) on the 'anaphoric' reading discussed in §7.4.2. (In some cases regular ratio/extent readings are marginally available; I will set these aside assuming they involve topicalized adverbs.)

The proposal is that extent phrases are unavailable in distributive cases exactly because of the property adopted from Chierchia 2010 in §7.4.1.3. Distributivity requires measuring the atoms, but pure extents are not useful because the atoms themselves aren't stable – there is not a unique way of making the atomization precise, making it difficult to compare the extents of atoms across different events. As proposed in §7.4.1.3, a stable measure (that achieves independence from the particular way of making the atomization precise) is available as a ratio of some measure of change, to time, e.g. speed (as in (81) below) or the ratio of temperature to time (as in (82)). The type of change is derived from the verb/event itself. For evidence for the last claim, it is helpful to consider cases where the direction of measurement, or the measure itself, can be determined by the verb, or even by the direct object:

(81) The left gap widened 1.2 meters per second more quickly than the right one.

(82) The temperature rose 2 degrees per hour more quickly than on the same day last year.

(83) The tank filled 2 gallons per seconds more quickly than I expected.

(84) Alfonso picked apples 2 apples per minute more quickly than Joanna.

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[21] One important type of measure phrase I will not deal with here is exemplified by "three times more slowly".

[22] We do get extent measure phrases with activities to the extent they can be treated as semelfactives (i.e. atomic). This can be seen in Krifka's 1989 wine-drinking competition example, and extends to measure phrases modifying adverbs of space and time.

(i) Ann drank wine in 0.43 s. (Krifka 1989 ex. 19)

(ii) Ann drank wine 0.21 s more quickly than Joanna.

Not all speakers accept wine-contest readings, but the judgment is always the same for (i) and (ii).

(This data supports the overall theme of the paper: what is constant across uses of adverbs of space and time is in fact only time.)

To make this idea precise, I will sketch a mechanism for deriving a measure function with the right properties to license ratio measure phrases. The denominator dimension, I claim, comes from the measure function provided by the adverb. Determining the numerator dimension is somewhat more complicated. In general, it is determined by whatever units of change are salient from the verb or the VP. In many examples this is distance, but not always; in (82) it is degrees. In some cases, as in (84), it is determined by the direct object (especially in V+bare plural combinations). While I will not give a compositional mechanism for extracting the dimension of change from a VP denotation, one is clearly important.

Up until now I have left the notion of a dimension informal, but to give the details of this derived measure phrase, we need to make it more explicit. Here I adopt a variant of Alrenga's 2007, 2009 analysis of dimensions for scalar adjectives (see also Kennedy 1999 ch. 4., Schwarzschild 2002; Heim 2006, 2008 a.o.). A dimension, on this view, is a sort of the domain of degrees (i.e. a subset of D_d); this domain can be constructed from the set of dimensions (which are disjoint).

(85) $D_d = \textsc{SpatExt} \cup \textsc{TempExt} \cup \textsc{Temperature} \cup \ldots$

Measure functions will now return intervals in their specified sort (functions of type $\langle \text{dt} \rangle$), and also supply an ordering relation as part of the actual denotation (recall that above, this was left informal as well). Two revised denotations for "quickly" and "slowly" are given below:

(86) $[\![\textbf{quickly}]\!] = \lambda e_v \,.\, \lambda d_d \,.\, d \in \textsc{TempExt} \wedge |\tau(e)| \leq d$ type: $\langle \text{v}\langle \text{dt} \rangle \rangle$

(87) $[\![\textbf{slowly}]\!] = \lambda e_v \,.\, \lambda d_d \,.\, d \in \textsc{TempExt} \wedge |\tau(e)| \geq d$ type: $\langle \text{v}\langle \text{dt} \rangle \rangle$

For example, an event measured by the above core entry for (the positive) $[\![\textbf{slowly}]\!]$ will return an interval that extends from the minimal temporal extent (0, on any unit) up to the degree corresponding to the actual length of the event. It might seem counterintuitive to include more degrees than the one actually corresponding directly to the measured object, but in this framework, the ordering differences between antonyms are encoded by this idea (Heim 2008), as well as several other important notions. So the interval measured will have to properly contain the interval corresponding to the standard of comparison (see below). $[\![\textbf{Quickly}]\!]$ reverses the relation, and includes all larger intervals in the domain.

The denotation for the covert positive comparative operator also needs revision; it will now make reference to a standard interval over degrees, and compare the measured degree against that interval. These standard intervals typically range from the 0 measure up to some maximal degree. The restriction on dimensions is captured with the notion of *commensurability*, defined in (89) (switching implicitly to "set talk" when discussing intervals).

(88) $[\![\textbf{pos}_{\textbf{adv}}]\!] = \lambda A_{\langle v\langle dt\rangle\rangle} . \lambda e_v . A(e) \supset s(A)(C_C)(e)$ type:$\langle\langle \mathrm{v}\langle \mathrm{dt}\rangle\rangle\langle \mathrm{vt}\rangle\rangle$
Where $s(A)(C_C)(e)$ is a contextually provided standard interval commensurable with $A(e)$

(89) Two intervals P, Q are commensurable only if $Q \subset P \vee P \subset Q \vee P = Q$.

Note that two intervals are commensurable only if they are drawn from the same sort. (But also, for instance, antonymic intervals will not be commensurable.) An entry for "more" can be given similarly to "pos" as follows:

(90) $[\![\textbf{more}_{\textbf{adv}}]\!] = \lambda A_{\langle v\langle dt\rangle\rangle} . \lambda Q_{\langle dt\rangle} . \lambda e_v . A(e) \supset Q$ type: $\langle\langle \mathrm{v}\langle \mathrm{dt}\rangle\rangle\langle\langle \mathrm{dt}\rangle\langle \mathrm{vt}\rangle\rangle\rangle$
defined only if $A(e)$ and Q are commensurable.

In (90) I am assuming that the denotation of a "than"-phrase is an interval. This denotation is more satisfactory than the earlier version in (52) in that it captures the fact that the dimension of the "than"-clause has to match the dimension supplied by the gradable predicate. (This is also how this type of framework captures cross-polar anomalies; see Kennedy 1999 for discussion.) The distributivity operators apply straightforwardly to these revised Deg heads. (Recall the earlier assumption that a "than"-phrase denotes an average degree if it involves distributive degree predication of its gap.)

If Δ is the symmetric difference operator (i.e. $(A - B) \cup (B - A)$), then commensurability guarantees that Δ will measure the gap between the two intervals (regardless of which one is the larger one if any; this is the reason for symmetry). To measure such a gap using some defined unit, we would need to scale the degrees according to that unit. I will simply assume that this can be done – e.g. that there is a function "minutes" as follows:

(91) minutes(d) = the size of the interval d scaled to minutes.
defined only if d is commensurable with TEMPEXT

I will not here assume any general theory of measure phrases, though one is clearly desirable (see Schwarzschild 2006); here is a specific entry for a measure phrase tailored to combine with a "more…than…" adverbial comparative:

(92) $[\![\textbf{2 min}_{\textbf{Adv}}]\!] = \lambda D_{\langle\langle v\langle dt\rangle\rangle\langle\langle dt\rangle\langle vt\rangle\rangle\rangle} . \lambda A_{\langle v\langle dt\rangle\rangle} . \lambda Q_{\langle dt\rangle} . \lambda e_v . D(A)(Q)(e) \wedge$ minutes$(A(e) \Delta Q) = 2$
defined only if $A(e)$ and Q are both commensurable with TEMPEXT and with each other.

This approach takes measure phrases to be Deg modifiers. In (92), the D argument is a transitive Deg head, and a function with the same type as D is returned – it then combines with the adverb (A), and the "than"-phrase (Q), as before. This entry implements the idea discussed by Schwarzschild 2006 (see also McConnell-Ginet 1973), that measure phrases in comparatives are predicates of gaps, and it does it in a fairly uninteresting way, by compositionally ensuring that the measure phrase

has access to the two intervals that there is a gap between.[23] I leave the challenge of generalizing this to the future. Note that on this version, we must assume that the measure phrase combines with the Deg head before the distributivity predicate is applied – not an issue for cases where distribution is trivial, which involve extent phrases, but it will be an issue shortly.

Given the notion of a dimension, composite ratio dimensions can be constructed straightforwardly (setting aside some issues in properly defining division):

(93) **Ratio dimensions** For any dimensions DIMA and DIMB:
$\text{ratio}(\text{DIMA}, \text{DIMB}) \underset{\text{def}}{=} \left\{ x \;\middle|\; \exists d_1 \in \text{DIMA} : \exists d_2 \in \text{DIMB} : d_2 > 0 \wedge x = \frac{d_1}{d_2} \right\}$

Now we come to the key definitions for understanding adverbs of space and time. First I will define a "lattice induced measure function" (the name is based on Krifka's 1990 "object-induced measure phrases"), that takes a dimension, an adverbial core, and some (verbal) measure function, and constructs a composite measure function that measures the ratio of the verbal to the adverbial measure.

(94) **Lattice induced measure function**
If DIM is a dimension, A is a space/time adverb core, and M is a positive event measure function:
$\text{LIMF}(\text{DIM}, A, M) \underset{\text{def}}{=} \lambda e'_v \,.\, \lambda d_d \,.\, d \in \text{ratio}(\text{DIM}, \text{TEMPEXT}) \wedge \exists d_2 \in A(e') : d = \frac{max(M(e'))}{d_2}$

(95) **Unstable atom coercion**
If e is an unstable atomic event involving change in dimension DIM, Adv the core of an adverb of space/time, and M a measure function available for e whose domain is commensurable with DIM. then $[\![\textbf{Adv}]\!](e)$ can be coerced to be interpreted as $\text{LIMF}(\text{DIM}, [\![\textbf{Adv}]\!], M)(e)$

The coerced MP combines with the Deg head as normal. So, if the adverb meaning distributes over a homogeneous part/whole structure (e.g. with an activity predicate), and the minimal atoms involve directed change and are unstable (=not present on all ways of making the atoms precise), then we can instead coerce the measurement to be about some ratio based on the type of change involved. In the canonical cases, this will be a ratio of space to time. I remain agnostic about whether this shift is always required in the face of unstable atoms, but I do assume it is obligatory if there is an overt measure phrase – i.e. that the level of precision required by a measure phrase is not compatible with the vagueness of these part-whole structures. I also assume that this coercion will not take place unless it must, leaving extents the default.

[23] The observation that measure phrases with adverbs require comparatives has been lurking in the background of this paper for some time. But actually this isn't an interesting property; it turns out that it is those adjectives that take measure phrases without the comparative that are unusual; see Schwarzschild 2006.

How exactly is the measure function M supplied by the verb? The details will have to remain unclear, but Piñón 2000 provides a mechanism that covers two relevant sources: it could be provided directly by the verb (for degree achievements like "widen"), and it could be provided by constructing a measure function from the measuring out of a direct object. It seems that in many dimensions (spatial change) there is a 'standard' measure function (e.g. distance of the spatial trace of an event) for that dimension, and this is the one used. It also may be that what is measured is not always the event, but the event participant (cf. Cresswell's analysis, where the modifier has compositional access to participants).

Notice that by dividing the maximal element in $M(e')$ by all the degrees in the temporal interval, we reverse the polarity of the resulting interval from the simple temporal extent reading – "quickly" becomes positive (i.e. its interval extends from 0 to a maximal degree) and "slowly" becomes negative; this is the right result. That is, if an interval is quick, its time is lower than the standard, but if a speed is quick, it exceeds the standard. The following example illustrates a partly composed denotation. If this combined with the verb "runs", we would further substitute SPATEXT in for the dimension, and a distance measure on a eventuality trace function, for M.

(96) $[\![[\mathbf{_{DegP}}\ ^{D}\mathbf{pos_{adv}}\ [\mathbf{_{AdvP}}\ \mathbf{quickly}]]]\!]$ (with coercion) =

$$\lambda e\ .\ \forall e' \in \text{HATOMS}(e, C_H) : \begin{pmatrix} \left[\text{LIMF}(\text{DIM}, \lambda e''\ .\ |\tau(e'')|, M)\right](e') \\ \supset s\left(\text{LIMF}(\text{DIM}, \lambda e''\ .|\tau(e'')|, M)\right)(C_C)(e') \end{pmatrix}$$

There is much future work to do here; for instance, it is unclear whether an event itself should encode a dimension of change, or whether this coercion would require compositional access to the verb/VP. This coercion mechanism (for other denominator dimensions) might have far reaching application across many manner adverbs as long as they are distributive, but unfortunately, in terms of overt measure phrases, many adverbs measure along some dimension that lacks units in the vocabulary. (Or possibly, many adverbs involve qualitative dimensions which behave somewhat differently; see Alrenga 2007, 2009), and it is far from clear which adverbs are distributive. I will set these issues aside for now.

It is useful at this point to summarize the range of contextual variables that are filled by information originating mainly in the VP. First, there is the standard of comparison, and the comparison class, each of which has parallels in attributive adjectival modifiers. But I have also needed to introduce variables providing a homogeneity criteria, for deciding how distribution happens; for providing a dimension of change determined by the VP, and for some measure function in that dimension, also typically determined by the VP. Future work may lead to a more elegant way of transmitting this information to the modifier. But this also fits into the general pattern that Kamp and Partee 1995 described with the *head primacy principle*: in modification structures, the head determines the context for the modifier. In the case of adverbial modification, there are simply more parameters than have been discovered in attributive adjectival modification.

In summary, the main claim is that the presence of ratio readings and ratio measure phrases is due to the conceptual difficulty of measuring atoms of processes in any stable way. I have given a coercion mechanism that provides a (more) stable measure in the face of vagueness, and proposed that the numerator dimension is determined by the verb(/event), not by the adverb itself. Though it isn't formally implemented above (since I am considering adverbs that use the same dimension), we would also expect in general the denominator dimension to be supplied by the adverb. This result, that a single component of gradability in the adverbial domain, the choice of dimension, derives from both the verb and the adverb in question, is quite strikingly different than what is standardly assumed for adjectives.

7.5.1 Gradually

Before concluding, I will make a brief comparison between the behavior of "slowly" and "gradually", which has some similar properties (Piñón 2000). The similarities are mainly in high-attachment configurations, and with so-called "degree achievements" such as "expand" (Hay et al., 1999; Kennedy and Levin, 2008).

(97) a. Gradually, the Nigerians pushed the rebels out of Freetown. (Piñón 2000 ex. 6a)

b. Slowly, the Nigerians pushed the rebels out of Freetown.

(98) a. The economy expanded gradually (based on Piñón 2000 ex. 16a)

b. The economy expanded slowly.

It isn't clear that these pairs have precisely the same truth conditions, but what differences there may be are fairly subtle.[24] A further descriptive parallel is that the predicates that combine with "gradually" are restricted to those that involve directed change. However, the parallels end here. "Gradually" cannot productively take measure phrases at all (despite appearing in the comparative), and to the extent that there are good examples, only ratio measure phrases are allowed.[25] Furthermore, it

[24]Fabienne Martin (p.c.) pointed out attested examples that suggest "gradually" does not entail "slowly", such as (i):

(i) About a week ago my car gradually, but quickly, lost a lot of its power.

Speakers I have consulted did not find such examples entirely coherent, but it is unclear then why they should be as easy to find as they are.

[25]Kristen Johannes (p.c.) constructed the following example, which speakers do tend to accept. Interestingly, speakers that find (i) grammatical still have trouble providing a coherent paraphrase. Erin Zaroukian (p.c.) also pointed out that "gradually" takes "two times"-style MPs, which I have been ignoring.

(i) The temperature on Earth dropped two degrees per year more gradually than on Venus.

doesn't ever seem to serve as a manner modifier in the sense that "slowly" does, and can't combine in a low-attached position with most verbs (directed change is not a sufficient condition for licensing):

(99) * Alfonso ran (to the park) gradually.

Because of these differences, Piñón's 2000 account does not extend to adverbs of space and time in general. His proposal is that "gradually" characterizes a morphism from degree structure to event structure, that preserves temporal ordering in the event's part-whole structure (for initial parts) as ordering of degrees on the scale. The scale can be provided in three ways: (i) by the verb directly, in the case of degree achievements, (ii) by a derived scale that corresponds to how the verb measures out a direct object, and (iii) by a scale supplied by some other adverbial such as "more and more". The general impossibility of low-attachment readings is because most verbs don't supply a scale (or the right kind of scale) lexically. For high-attached "gradually", Piñón proposes (but doesn't implement the idea) that the scale is based on what leads up to the described event. In this case especially there is an obvious similarity to my proposal, but nonetheless, "gradually" itself on this account does not measure anything about the event, but rather acts as a higher-order operator on measure functions and event predicates. (This is a place for development of Piñón's analysis, as "gradually" takes all the normal degree morphology.) If the proposal is right, "gradually" is not an adverb of space and time at all. Nonetheless, the similarities are suggestive, and suggest the logical next step of broadening the scope of inquiry of the present analysis to include adverbs like "continuously", "smoothly", "gradually", "incrementally" etc., that all take degree morphology, and seem to measure something about the nature of change in an event. Adverbs of space and time simply measure temporal extent or its first derivative in some dimension, but these other adverbs may measure more complex properties of change in event structure.

7.6 Conclusions and Further Puzzles

In this paper I have defended an account of adverbs of space and time that explains the full range of data, with Cresswell's ratio data falling out as a special case. The core ingredients of my proposal are that (i) adverbs of space and time are distributive degree predicates of events, measuring temporal extent only, (ii) different readings follow from interaction of distributivity and event structure, in particular lexical aspect and narrative discourse, and (iii) the distribution of types of measure phrases follows from the same thing. On the proposal, no metaphorical extension to handle e.g. the high-adjoined case is needed.

The investigation of adverbs of space and time is far from done. One major question concerns the range of cross-linguistic variation; the literature is mostly silent about this. (Two exceptions are Torner's 2003 study of space/time-like adverbs in Spanish, and Eszes's 2009 examination of the Hungarian facts.) The

proposal I have developed here makes strong cross-linguistic predictions about such adverbs if they exist in a language: their interaction with lexical aspect, measure phrases, and narrative discourse should be the same (to the extent these phenomena are independently stable cross-linguistically). A particularly interesting test would be to investigate parallel adverbs in a language with an overt narrative verb form.

On the analysis I have developed, adverbs of space and time are really just time predicates, and the spatial component (if present) follows from the meaning of the verbs. This raises the question of how other time adverbials work, and how similar they actually are to these adverbs – how do adverbs of space, time, and change fit into the general theory of time adverbials? One starting place is Shaer's 2004 discussion of the effect of discourse structure on high (but not low) attached temporal adverbs, which appears parallel. A second point of departure for future work is the investigation of other manner adverbs. Intuitively, adverbs of space and time most characterize the "manner" of some event when combined with an activity predicate such as "run". I have effectively claimed here that what a manner is, for this kind of adverb, is a property of a minimal atom of such an event, distributed across the event structure. The reason why "run slowly" seems to describe something about the manner of motion is because what is characterized is the speed of the minimal steps that make up running. Is this notion of manner more general? It is far from clear at this point (see e.g. Landman and Morzycki 2003), but the idea must clearly fit into a larger theory of manners in some way. There are other types of adverbs where the idea seems to apply (e.g. "noisily"), but many adverbs with manner-like readings, e.g. many of those discussed in Martin (this volume), do not involve distributivity. The following example (from Fabienne Martin p.c.) involves what is intuitively a manner reading, but it is the entire drinking events that have a 'stupid' manner:

(100) Twice this weekend I drank stupidly.

In general, it seems that oriented adverbs have a dispreference for distributive readings, though much more empirical work is needed. How does the type of manner explored in the present paper meet up with the typology of adverbs developed in Martin (this volume)? Martin suggests that in the classes examined there, psychological adverbs involve distributive manner readings, and dispositional adverbs involve manner readings which do not need to be distributive, and points to a potential explanation in terms of the adjectival source. The distributivity hypothesis may therefore shed new light on adverbs beyond the space-time category.

I end with the issue of adjectives. Can the account be extended to handle "quick" and "slow"? It can, effectively unchanged, on Larson's 1998 account of subsective modifiers (though I leave the details for a future time).[26] Consider the following examples:

[26]This is especially interesting given that it is far from clear that adjectives and corresponding adverbs in general have a synchronic relationship of this type (Geuder, 2000).

(101) a. The concert was (very) slow. (event predicate)

b. Alfonso is a (very) slow dancer. (subsective modifier, -er nominal)

c. That is a (very) slow car. (subsective modifier, individual)

Larson proposes that many subsective modifiers are actually event predicates, of an event that is bound by some generic operator. The example in (101a) involves direct predication of an eventive nominal, and works straightforwardly.[27] On Larson's account, (101b) has a natural analysis where both "slow" and "dancer" are event predicates (with the same gradable machinery for "slow"), and there is a covert generic operator. The paraphrase might be, "for a typical dancing event with Alfonso as the agent, that event is slow". A similar approach extends slightly less naturally with (101c), where we can assume that the generic operator quantifies over typical events involving the car in a standard use (e.g. "driving"). The success of this sketch provides a final piece of evidence that my analysis of adverbs of space and time is on the right track.

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[27] Example like "John is slow" on a non-metaphoric reading can perhaps be handled like "slow car".

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