

A unified account of distributivity, *for*-adverbials, and pseudopartitives

Lucas Champollion
Dept. of Linguistics
University of Pennsylvania

champoll@gmail.com

Abstract

This paper presents a diagnostic for identifying distributive constructions and shows that it applies to pseudopartitives and *for*-adverbials. On this basis, a unified account is proposed for the parallels between the constructions involved. This account explains why *for*-adverbials reject telic predicates (**run to the store for five hours*), why pseudopartitives reject count nouns (**five pounds of book*), and why both reject certain measure functions like temperature and speed (**30°C of water*, **drive for 5 mph*). These restrictions all follow from a general constraint on distributive constructions. Related concepts such as the *D* operator (Link, 1987), the subinterval property (Bennett and Partee, 1972), and divisive reference (Cheng, 1973) can be understood as formalizing special cases of this constraint.

1 Introduction

Pseudopartitives, also called measure constructions, are noun phrases that are used to talk about an amount of some substance (1). *For*-adverbials (2) are a class of adjuncts best known for their aspectual sensitivity: they can only modify atelic predicates (3).

(1) three liters of water

(2) run for five hours

There are two important semantic parallels between *for*-adverbials and pseudopartitives. Both reject predicates that fail to apply to the parts of the entities and events in their denotation. This category includes telic predicates (3a-b) and count nouns (3c). And both reject measure functions whose value tends to stay constant across the parts of any object or event they measure. Examples of such functions are speed (4a-b) and temperature (4c).

(3) a. run for five hours *vs.* *run to the store for five hours

- b. run for five miles *vs.* *run to the store for five miles
 - c. five pounds of books/rice *vs.* *five pounds of book
- (4)
- a. *run (to the store) for five miles an hour
 - b. five hours of running *vs.* *five miles an hour of running
 - c. five inches of snow *vs.* *five degrees Celsius of snow

This set of facts raises several interrelated questions. What is the precise nature of the restrictions on predicates and on measure functions? What part of the semantics of *for*-adverbials and pseudopartitives is responsible for them? Given that the two constructions share the same restrictions, are they related to each other? And is there a relation between the two restrictions that explains why they cooccur?

This paper argues that the key to answering these questions is distributivity. Entailments from larger to smaller parts, the signature property of distributive constructions, are present in *for*-adverbials as well as in pseudopartitives. These entailments provide evidence for classifying these constructions as distributive, and their presence can be captured by a general constraint on distributive constructions. The restrictions illustrated in (3) and (4) then turn out to be entailed by this constraint.

While the parallels between the constructions analyzed in this paper have not previously been drawn and formalized in a systematic way, many components of the composite picture presented here have been individually identified before. Krifka (1998) and its precursors are a source for many of the observations about *for*-adverbials and pseudopartitives; his analysis brings out some of their similarities, but does not establish their connection with distributive constructions. We will see that it undergenerates in certain cases. I have drawn essential insights on pseudopartitives from Schwarzschild (2006); as we will see, our accounts differ in important ways, but they are in the same spirit. This paper's formal framework is derived from Krifka (1998), Link (1998), Landman (2000), and the papers leading up to them. Some connections that are presented in this paper have been suggested or implied in previous work. For example, the aspectual sensitivity of *for*-adverbials has often been explained by modeling them as universal – and therefore distributive – quantifiers (e.g. Dowty, 1979; Moltmann, 1991).

2 A diagnostic for distributivity

This section reviews basic facts about distributivity and proposes a diagnostic to classify not only sentence-type but also noun phrase-type constructions as distributive. This is an essential prerequisite for classifying pseudopartitives as distributive constructions.

The signature property of distributivity is its licensing of entailments from larger to smaller parts. For example, sentence (5a) entails (5b): every scenario that verifies (5a) also verifies (5b). This is in contrast to (6a): in some (perhaps most) scenarios in which it is true, (6b) will be false.

- (5) a. Al, Bill, and Charles laughed / were boys / were visible.

- b. \Rightarrow Al and Bill laughed / were boys / were visible.
- (6) a. Al, Bill, and Charles shared a pizza together.
 b. \nRightarrow Al and Bill shared a pizza together.

VP coordination cases as in (7) show that the source of these *distributive entailments* is the predicate rather than the subject (Dowty, 1987; Roberts, 1987). For this reason, it is usual to classify predicates as distributive (e.g. *laugh*, *(be) boys*, *wear a sweater*, *(be) visible*), in opposition to collective predicates (e.g. *share a pizza together*, *be a good team*).¹

- (7) a. Al, Bill, and Charles laughed and shared a pizza together.
 \Rightarrow Al and Bill laughed.
 \nRightarrow Al and Bill shared a pizza together. (adapted from Dowty, 1987)

Numeral quantifiers also give rise to distributive entailments (8). This fact is important for our purpose because *for*-adverbials and pseudopartitives can contain numerals but not nominal conjunctions.²

- (8) a. Three boys laughed / were visible. \Rightarrow Two boys laughed / were visible.
 b. Three boys shared a pizza together. \nRightarrow Two boys shared a pizza together.

I am not aware that anyone has given an operational definition of the term “distributive construction”. I think the following diagnostic is in line with the common use of the term in the literature: Distributive constructions are constructions which give rise to distributive entailments (i.e. entailments from larger to smaller parts) through the constraints they impose on their constituents.

A classical example is the construction *DP each VP*. The diagnostic classifies it as a distributive construction because *each* is only compatible with VPs that give rise to distributive entailments:

- (9) a. Al, Bill, and Charles each laughed / were boys / were visible.
 b. \Rightarrow Al and Bill each laughed / were boys / were visible.
- (10) *Al, Bill, and Charles each shared a pizza together.

The distributivity/collectivity distinction is easily expressed in mereological semantics (Link, 1998). In this framework, the denotations of noun phrases are formulated

¹This popular classification is an idealization. Some of these predicates are ambiguous or underspecified between distributive and collective construals. It is hard to find clear-cut examples of distributive versus collective predicates, so hard that Winter (2001) argues that the distinction should be dropped altogether. Another complication is that distributive readings of noun phrases headed by numerals are dispreferred when a nondistributive reading is available, see Dotlačil (2010).

²The entailments shown in (8) reflect a common an – I believe – uncontroversial intuition. Modeling them is surprisingly difficult: neither an *at least* nor an *exactly* semantics for numerals distinguishes between (8a) and (8b).

with respect to a model that contains both singular and plural entities, which are partially ordered so that singular entities are atomic (i.e. they have only themselves as parts). For example, *Al and Bill* refers to a plural entity that is a part of the referent of *Al, Bill, and Charles*, another plural entity. Numeral quantifiers like *n boys* denote predicates over plural entities which consist of *n* boys. Among the parts of a three-boy entity we find boys and two-boy entities. Collective predicates apply directly to plural entities. When distributive predicates like *laugh* or *wear a sweater* apply to a plural entity, they also apply to all its atomic parts. Following Link (1987), this property is often formalized by assuming that a predicate *P* is made distributive by combining with a covert operator D , defined such that $D(P) = \lambda x \forall y [y \text{ is an atomic part of } x \rightarrow P(y)]$.

Not only sentence-type but also noun-phrase type constructions can be categorized as distributive. We cannot test directly for entailment relations between noun phrases because they do not denote truth values, so we will use an indirect approach. We have seen that *be visible* and *laugh* are distributive predicates, while *share a pizza together* is collective. In the following example, these predicates are used to identify the parts of entities denoted by noun phrases that contain relative clauses.

- (11) a. Three boys who laughed were visible.
 b. \Rightarrow Two boys were visible.
 c. \Rightarrow Two boys who laughed were visible.
- (12) a. Three boys who shared a pizza together were visible.
 b. \Rightarrow Two boys were visible.
 c. $\not\Rightarrow$ Two boys who shared a pizza together were visible.

Due to the distributive predicate *be visible*, sentences (11a) and (12a) both license distributive entailments (11b) and (12b). In addition, the distributive predicate *laugh* inside the relative clause of (11a) licenses entailments of its own (11c), while the collective predicate *share a pizza together* does not (12c). In a mereological account, these entailments translate to the following: among the parts of any entity denoted by *three boys who laughed* we find entities denoted by *two boys* and also by *two boys who laughed*; and among the parts of any entity denoted by *three boys who shared a pizza together*, we find entities denoted by *two boys* but not necessarily entities denoted by *two boys who shared a pizza together*.

From these facts, we can distill a diagnostic that allows us to decide whether a certain noun phrase licenses entailments to its parts, i.e. distributive entailments: we combine it with a distributive verb phrase and we check whether the predicate denoted by the noun phrase contributes to the distributive entailments, as in (11c), or not, as in (12c). If it does, then we conclude that the noun phrase is an instance of a distributive construction. For example, the following entailment shows that *Det N' who each VP* is a distributive construction, because the predicate *boys who each laughed* contributes to the distributive entailments:³

³According to this diagnostic, the inference in (ia) shows that plural numeral noun phrases like *three boys* are themselves distributive constructions, as opposed to e.g. attributive adjectives (ib). In

- (13) a. Three boys who each laughed were visible.
 b. \Rightarrow Two boys who each laughed were visible.

Before we apply these diagnostics to other constructions, it is useful to introduce some terminology. Unfortunately, there is no uniform practice concerning the naming of the constituents involved in a distributive relation. Following Choe (1987, 1991), I will refer by **Key** to the constituent that instantiates⁴ the entity about whose parts a distributive construction licenses entailments, and by **Share** to the constituent whose meaning specifies the nature of these entailments. I will use these terms to refer to the constituents themselves as well as to their denotations. In our example (9a), the DP *three boys* is the Key of the sentential-level distributive construction because the sentence licenses entailments from three boys to two boys, and the VP *laughed* is the Share because it specifies the nature of these entailments (i.e. that they laughed). In (13a), the sentential-level distributive construction has *three boys who laughed* as a Key and *were visible* as a Share, and the DP-level one has *three boys* as a Key and *who laughed* as a Share. Following Neo-Davidsonian theories (e.g. Parsons, 1990), I assume that the semantic relation between verbs and their arguments is expressed by covert thematic roles such as *agent*, *patient*, etc. and that these thematic roles denote functions from events to individuals. Verbs and verb phrases are taken to denote predicates over events. In (5a), the thematic role *agent* provides a mapping from events denoted by the Share to individuals in the denotation of the Key. I will call this thematic role the **Map**. More generally I will use this term for any function from the Share to the Key.

The two following sections introduce pseudopartitives and *for*-adverbials in more detail and show that the signature property of distributivity holds in both constructions. This fact provides initial motivation for classifying them as distributive constructions. The Key-Share-Map terminology is extended to these constructions. This will provide us with a language in which we can express generalizations over the three constructions.

3 Pseudopartitives

Pseudopartitives, also called measure constructions, are noun phrases that instantiate an amount of some substance (e.g. Selkirk, 1977). Both the amount and the substance involved are specified with a noun; in English, the nouns are separated by the word *of*. Here is an example of a pseudopartitive:

- (14) three liters of drinkable water

mereological terms, the inference in (ia) below shows that any entity which is three boys has a part which is two boys. This shows that there is an intimate relationship between plurality and distributivity. On this point, see Landman (1989).

- (i) a. Three boys were visible. \Rightarrow Two boys were visible.
 b. Three-year-old boys were visible. $\not\Rightarrow$ Two-year-old boys were visible.

⁴Here and in the following, I use the term *instantiate* as a cover term for referring and existentially quantifying. Simply put, a predicate instantiates an entity if it can be used to talk about that entity.

In a pseudopartitive, the material to the left of *of* is a **measure phrase** headed by a **measure noun**.⁵ I refer to the noun that comes to the right of *of* as the **substance noun**, and to the substance noun together with any of its modifiers the **substance nominal**. In (14), the measure noun is *liters* and the substance noun is *water*; the measure phrase is *three liters* and the substance nominal is *drinkable water*.⁶

As described in Sect. 2, we can test for distributivity in noun phrases by combining them with a distributive predicate like *were visible*. The following entailment shows that pseudopartitives are distributive – cf. (5):

- (15) 3 pounds of vegetables were visible. \Rightarrow 2 pounds of vegetables were visible.

It is useful to contrast pseudopartitives with what Schwarzschild (2006) calls attributives, e.g. *a three-pound vegetable*. Attributive are not distributive, cf. (12): for example, *a three-pound vegetable was visible* does not entail *a two-pound vegetable was visible*.

Sect. 2 introduced the term “Key” for the constituent about whose parts entailments are licensed. The above entailment pattern suggests that the measure phrase in pseudopartitives is a Key. The substance nominal specifies the nature of this entailment: in (15), it specifies the substance of which the parts of the Key are amounts. This suggests that it is a Share. Key and Share of a pseudopartitive are related by a covert *measure* (Krantz et al., 1971) such as volume or weight. Schwarzschild (2006) notes that previous authors have repeatedly likened these measures to thematic roles. I will pursue this parallel further. I have called thematic roles in distributive constructions Maps. In keeping with this terminology, I will call measures in pseudopartitives Maps. For example, in (15) the covert relation *weight* is the Map.

One puzzling fact about pseudopartitives is that they only accept mass nouns and plurals as Shares (Krifka, 1998; Schwarzschild, 2006):⁷

- | | | | |
|------|----|------------------------|------------------------------|
| (16) | a. | ten minutes of music | <i>mass noun</i> |
| | b. | ten tons of containers | <i>plural count noun</i> |
| | c. | ?ten minutes of song | ? <i>singular count noun</i> |
| | d. | *ten tons of container | * <i>singular count noun</i> |

It is not surprising that plurals and mass nouns behave alike with respect to pseudopartitives, because they form a natural class with respect to their entailment properties (e.g. Bunt, 1979). Various authors have identified these properties with the notions

⁵See Gawron (2002) for syntactic arguments that the material to the left of *of* is a constituent.

⁶The term *pseudopartitive* was introduced by Selkirk (1977) to distinguish this construction from true partitives such as *three liters of the drinkable water*. An extension of the present account to true partitives is straightforward on the assumption that the “of”-PP has divisive reference (as in Ladusaw (1982) and accounts following him), but not everyone shares this assumption (Matthewson, 2001).

⁷Like all judgments involving constraints against count nouns, this one is subject to the caveat that the mass/count distinction is somewhat elastic. Thus, (16c) is marginally acceptable but does not necessarily refer to a single 10-minute song. This suggests that *song* is coerced into a mass noun here. Acceptability further declines with count nouns that are not easily coerced into a mass sense (16d).

of *cumulative reference* (Quine, 1960) (any sum of parts that are P is P) and *divisive reference* (Cheng, 1973) (any part of something that is P is P).⁸ Of course, identifying plurals and mass terms as a natural class is not by itself an explanation of why pseudopartitives call for this class. An explanation is proposed in Sect. 5.

Another puzzle concerns the nature of the Maps (measures) that relate substance and amount in pseudopartitives (Krifka, 1998; Schwarzschild, 2006). This relation is not expressed overtly and is sometimes only recoverable from context. For example, Schwarzschild (2006) points out that the expression *three inches of water* could refer, in different contexts, to a certain amount of water whose depth is three inches, or whose width is three inches. However, pseudopartitives will reject all Maps whose value can remain constant across the parts of entities instantiated by the substance noun. Intuitively, the temperature of any amount of water we encounter remains approximately constant across its parts, in contrast to its volume. While (17a) is acceptable as a way of referring to water whose volume is thirty liters, it is not possible to refer to water whose temperature is thirty degrees Celsius as (17b).

- (17) a. thirty liters of water
 b. *thirty degrees Celsius of water

Even setting aside the question of why this constraint exists, it is not easy to characterize the class of measures that occur in pseudopartitives to begin with. For example, it is not literally true that all water has constant temperature. Even if we are willing to disregard small local fluctuations in temperature, it is easy to find counterexamples since water has cumulative reference. Suppose I have a glass of water whose temperature is 20 °C, and suppose you have a glass of water whose temperature is 5 °C. The sum of the content of the two glasses is water, but its temperature is not constant.

My own proposal is presented in Sect. 6 below (in (34), if you wish to skip ahead). Here I review previous proposals. Krifka (1998) claims that all measures that occur in pseudopartitives are extensive. One of the necessary conditions for a measure to be extensive is what Schwarzschild (2006) calls monotonicity: a measure μ is monotonic iff for any x and y , if x is a proper part of y , then $\mu(x)$ is less than $\mu(y)$. Since temperature is not monotonic, it is correctly ruled out on such an account. However, the monotonicity condition is too restrictive as it stands. Suppose we are told that on a certain cold (war) winter night, two feet of snow fell on Berlin. A proper part of that snow is the snow that fell on West Berlin. We may not conclude that less than two feet of snow fell on West Berlin, so height is not monotonic, and therefore not extensive. Yet *two feet of snow* is a fine way to refer to a snow cover whose height is two feet.

From similar examples, Schwarzschild (2006) concludes that pseudopartitives do not test for monotonicity with respect to the mereological part-whole relation, but with respect to a contextually supplied part-whole relation. In our example, the assumption would be that context provides a relation according to which the snow that fell on

⁸There is some variation here. Some authors refer to this property as distributive reference. I follow Krifka (1989) in calling it divisive reference.

West Berlin is not a part of the snow that fell on the entire city. The fact that one is a mereological part of the other does not enter the picture. I see several problems with this suggestion. The first problem is lack of predictive power: in the absence of a way of testing whether two entities stand in this contextual part relation, it is unclear how to test the predictions of this account. The second problem is redundancy: many measures like temperature are correctly ruled out by Schwarzschild's account on the mereological part-whole relation, so the two relations must coincide to a large extent. For these reasons, in contrast to Schwarzschild (2006) but in keeping with Krifka (1998), my own account is based on the mereological part relation; in contrast to both authors, I reject the monotonicity requirement.

In sum, the puzzles posed by pseudopartitives echo the ones posed by *for*-adverbials and presented in the previous section. Why do pseudopartitives accept only mass terms and plurals as Shares? What is the condition on Maps that determines whether they are acceptable? And why do pseudopartitives impose this condition?

4 *for*-adverbials

for-adverbials are best known for their aspectual sensitivity (e.g. Verkuyl, 1972). They can be applied without problems to atelic predicates like *run*, while telic predicates like *run to the store* are unacceptable:⁹

- (18) a. John ran for five minutes / for three hours / for miles.
 b. *John ran to the store for five minutes / for three hours / for miles.

for-adverbials stand in near-complementary distribution with *in*-adverbials, which reject atelic predicates and accept telic predicates. The entailment pattern in (19) shows that sentences with *for*-adverbials, but not those with *in*-adverbials, are distributive constructions:¹⁰

- (19) a. John ran for five minutes.
 \Rightarrow John ran for four minutes.
 b. John ran to the store in five minutes.
 $\not\Rightarrow$ John ran to the store in four minutes.

In terms of Sect. 2, the entailment pattern in (19a) suggests that the complement of *for* (e.g. *five minutes*) is the Key, the predicate with which the *for*-adverbial combines (e.g. *ran* or *John ran*, depending on syntactic assumptions) is the Share, and the semantic relationship between Key and Share (e.g. duration) is the Map. Put in these

⁹As in the case of the count-mass distinction (see fn. (15)), the telic-atelic distinction shows a certain amount of elasticity. To some extent, *run to the store* may be reinterpreted as an atelic predicate. I abstract away from this complication.

¹⁰At first sight, the entailment pattern in (19) might look suspect. However, it is important to keep in mind that the entailment that is checked here holds between literal meanings. As noted in Krifka (1998), "John ran for four minutes" implicates but does not entail that he ran for exactly four minutes.

terms, *for*-adverbials pose the puzzle why they accept only atelic predicates as Shares.

The entailment properties of atelic predicates with respect to a large range of other phenomena, including tense, the progressive, and aspectualizers, can be represented by modeling the denotations in terms of the *subinterval property* (Bennett and Partee, 1972): if atelic predicates (or sentences headed by them) are true at some interval i , then they are also true at every subinterval of i .¹¹ As is often noted (e.g. Bach, 1986), this subinterval property is analogous to the concept of divisive reference introduced for mass terms and plurals. So the Shares of *for*-adverbials are subject to a constraint which parallels the constraint on Shares of pseudopartitives. On the present view, this is not surprising, since both are distributive constructions.

Just like pseudopartitives, *for*-adverbials impose constraints not only on their Shares but also on their Maps. As was already shown in (3b) and (18), English has not only temporal but also spatial *for*-adverbials (Gawron, 2005). It appears, however, that there are no other categories of *for*-adverbials, for example, there are none based on weight, temperature, or speed:

- | | | |
|------|--|-----------------------|
| (20) | a. drive \emptyset /for thirty hours | <i>duration</i> |
| | b. drive \emptyset /for thirty miles | <i>spatial extent</i> |
| | c. *drive \emptyset /for thirty kilograms | * <i>weight</i> |
| | d. *drive \emptyset /for thirty degrees Celsius | * <i>temperature</i> |
| | e. drive \emptyset / for thirty miles an hour | * <i>speed</i> |

To some extent, these gaps are unsurprising. Unlike pseudopartitives, *for*-adverbials measure events rather than substances, and (20c-d) as well as common sense suggest that driving events do not have weights or temperatures. What is surprising, however, is that (20e) is unacceptable with a *for*-adverbial but acceptable otherwise. It seems that even though we can talk in principle about the speed of an event, *for*-adverbials reject speed as a Map.¹² One might assume this is just an idiosyncratic fact about *for*-adverbials. However, we have seen in Sect. 3 that speed is rejected as a Map by pseudopartitives as well. This coincidence would be unexplained on the idiosyncrasy assumption. So I will explore the idea that something like the Krifka-Schwarzschild monotonicity constraint is also at work in *for*-adverbials.

In sum, *for*-adverbials pose the following puzzles: Why do they accept only atelic predicates as Shares? What is the condition on Maps that determines whether they are acceptable? And why do *for*-adverbials impose this condition? These puzzles correspond to the puzzles posed by pseudopartitives as described in the previous section, which suggests that whatever solution can be given to one set of puzzles can also explain the other set. I will now propose such a solution.

¹¹ Formally, $\text{Subinterval}(P) =_{def} \forall e[P(e) \rightarrow \forall i[i < \tau(e) \rightarrow \exists e'[P(e') \wedge e' < e \wedge i = \tau(e')]]]$. Here, τ is the temporal trace function, described in Sect. 5, that maps events to their runtimes.

¹²That speed is among the possible properties of events is also suggested by the example of a sphere that rotates slowly and heats up quickly at the same time (Quine, 1985). Provided that the rotating and the heating up are two separate events, and that *quickly* and *slowly* are event modifiers, we can avoid the undesirable conclusion that the sphere is both quick and slow.

5 The account

Let me first introduce some background assumptions. Basically, they are a combination of the frameworks in Krifka (1998) and Landman (2000). As mentioned earlier, I assume a mereological framework in which individuals, events, and intervals are each ordered in part structures (Link, 1998). Intervals are instantiated by measure phrases like *one hour* and *three pounds* (Schwarzschild and Wilkinson, 2002) and have other intervals as parts. All scales of measurement are dense (Fox and Hackl, 2006), i.e. there are no atomic intervals.¹³ I assume that measures are functions from entities to intervals.

Following Krifka (1998) and many others, I assume that events are mapped to temporal intervals by a function τ , the *temporal trace*, also sometimes called the runtime function. The runtimes of events are not necessarily equal to the runtimes of their parts; for example, if there is an event of John running from 2pm to 4pm then among its parts there is an event of John running from 2pm to 3pm. However, the interval from 2pm to 3pm is a part of the interval from 2pm to 4pm. More generally, τ is a homomorphism with respect to the sum operation: we assume that the runtime of the sum of any two events is the sum of their runtimes. Following e.g. Landman (2000) and Kratzer (2007), I assume that event predicates as well as thematic roles are lexically specified as cumulative (closed under sum). Therefore thematic roles are also homomorphisms: the agent of the sum of any two events is the sum of their agents, or as Landman calls it, the *plural agent*.¹⁴

As surveyed in the previous sections, the entailment relations of acceptable Shares in all the constructions considered in this paper have all been characterized using similar concepts: the presence of Link’s D operator for distributive predicates; divisive reference for plurals and mass nouns; and the subinterval property for atelic predicates. It is tempting to adopt one of these ideas and extend it to all three cases. However, all these characterizations are binary distinctions. For example, a predicate either has divisive reference or not. For this reason, adopting only one of them would predict that a predicate should be an acceptable Share either in all the constructions considered here, or in none of them. This is obviously wrong. For example, predicates like *run to the store* are distributive but not atelic:

- (21) a. Al, Bill, and Charles ran to the store.
 \Rightarrow Al and Bill ran to the store.
 b. *John ran to the store for five minutes.

Intuitively, we want to express a distinction like the following: the predicate *run to the store* is divisive with respect to agents, but not with respect to time. But the

¹³I assume that the word *zero* is a scope-taking element, as shown by its ability to license negative polarity items as in *Zero deaths have ever occurred with this product*. So measure phrases like *zero hours* quantify over intervals of arbitrary length, rather than denoting atomic intervals of “zero length”.

¹⁴Williams (2009) warns that assuming cumulativity for thematic roles leads to problems in connection with the interpretation of resultatives unless thematic roles are verb-specific (instead of *agent* we have *agent_{carry}*, *agent_{wear}*, etc.). So I assume that, for example, *agent_{wear}(e) \oplus agent_{carry}(e')* is not defined.

notion of divisive reference as previously defined, e.g. by Krifka (1989) as in (22), does not allow us to make such a distinction, because it is a property of predicates. For this reason, I propose to relativize the concept of divisive reference to take an additional parameter into account. (23) defines what I will call **relativized divisive reference**.¹⁵

- (22) $DIV(P) =_{def} \forall x \forall y [P(x) \wedge y < x \rightarrow P(y)]$
 A predicate P has divisive reference iff P holds of every proper part of any entity of which it holds.
- (23) $DIV_f(P) =_{def} \forall x [P(x) \rightarrow \forall z [z < f(x) \rightarrow \exists y [P(y) \wedge y < x \wedge z = f(y)]]]$
 A predicate P has relativized divisive reference with respect to a function f iff f maps every entity x of which P holds to a value each of whose proper parts is the value of some proper part of x that is itself in P .

The D operator, divisive reference, and the subinterval property are all special cases of relativized divisive reference in the following sense. It is easy to show that for an arbitrary predicate P , the following are all true, where id denotes the identify function:

- (24) a. $DIV_{id}(^D P)$
 b. $DIV_{\tau}(P) \leftrightarrow \text{Subinterval}(P)$ ¹⁶
 c. $DIV_{id}(P) \leftrightarrow DIV(P)$

We can now formulate the central proposal of this paper. Recall the diagnostic proposed in Sect. 1: Distributive constructions are constructions which give rise to distributive entailments through the constraints they impose on their constituents. I propose to formalize this idea as follows:

- (25) **Distributivity Constraint:**
 Every distributive construction presupposes that $DIV_{[Map]}(\llbracket Share \rrbracket)$.

Let me illustrate with a few examples how this constraint works. In a sentence like *John ran for an hour*, this constraint will presuppose the following:

- (26) $\forall e [\text{run}(e) \rightarrow \forall i [i < \tau(e) \rightarrow \exists e' [\text{run}(e') \wedge e' < e \wedge \tau(e') = i]]]$
 Every proper part of the temporal trace of a running event e is the temporal trace of another running event which is a proper part of e .

This entails that, for example, if John ran during a certain time, then at each subinterval of this time there was a running. This is compatible with what we know about running since *run* is atelic (it has the subinterval property). By contrast, the sentence *John ran to the store for an hour* is unacceptable because *for*-adverbials are

¹⁵The variables x, y, z in definitions (22) and (23) are unsorted. They range over individuals, events, and intervals. P ranges over one-place predicates and f over one-argument functions. $<$ denotes the mereological proper part relation.

¹⁶For the definition of Subinterval, see fn. 11.

distributive constructions, so the Distributivity Constraint presupposes the following:

$$(27) \quad \begin{aligned} &\forall e[e \in \llbracket \text{run to the store} \rrbracket] \rightarrow \\ &\forall i[i < \tau(e) \rightarrow \exists e'[e' \in \llbracket \text{run to the store} \rrbracket \wedge e' < e \wedge \tau(e') = i]] \end{aligned}$$

Every proper part of the temporal trace of an event e in the denotation of *run to the store* is the temporal trace of another event in the denotation of *run to the store* which is a proper part of e .

This presupposition would require that, for example, if John ran to the store during a certain time, then at each subinterval of this time there was a running to the store. This is ruled out because *run to the store* is telic (as predicted by theories of aspectual composition such as Krifka (1998)).

By contrast, the distributive construction *John and Mary each ran to the store* is acceptable because the Distributivity Constraint produces the following entailment:

$$(28) \quad \begin{aligned} &\forall e[e \in \llbracket \text{run to the store} \rrbracket] \rightarrow \\ &\forall x[x < \text{agent}(e) \rightarrow \exists e'[e' \in \llbracket \text{run to the store} \rrbracket \wedge e' < e \wedge \text{agent}(e') = x]] \end{aligned}$$

Every proper part of the (possibly plural) agent of a running-to-the-store event e is the (possibly plural) agent of another running-to-the-store event which is a proper part of e .

This is compatible with our world knowledge (namely that *run to the store* is distributive). We can represent this kind of world knowledge more formally as meaning postulates (constraints on models) of the following form:

$$(29) \quad \begin{array}{ll} \text{a. } & DIV_{\text{agent}}(\llbracket \text{run} \rrbracket) & \textit{run} \text{ is distributive} \\ \text{b. } & DIV_{\tau}(\llbracket \text{run} \rrbracket) & \textit{run} \text{ is atelic} \\ \text{c. } & DIV_{\text{agent}}(\llbracket \text{run to the store} \rrbracket) & \textit{run to the store} \text{ is distributive} \\ \text{d. } & \neg DIV_{\tau}(\llbracket \text{run to the store} \rrbracket) & \textit{run to the store} \text{ is not atelic} \end{array}$$

The Distributivity Constraint embodies the claim that the dimension along which the presuppositions of a distributive construction must hold is determined by the Map (e.g. the measure in pseudopartitives). Evidence for this claim comes from an observation in Schwarzschild (2006): (30) only has the interpretation (30a), not (30b).

$$(30) \quad \begin{array}{l} \text{three inches of cable} \\ \text{a. "cable with a length of three inches"} \\ \text{b. \# "cable with a diameter of three inches"} \end{array}$$

If divisive reference in the strict sense, as formalized in (22), was a necessary condition on substance nouns of pseudopartitives, we would expect (30a) to be unacceptable because not every part of a cable is a cable: world knowledge tells us that only parts with shorter length but equal diameter are cable, while parts with smaller diameter

are not. Or, we would need to appeal to pragmatics, as Schwarzschild (2006) does. However, the facts are expected on the present account since this world knowledge can be seen as evidence for the meaning postulates in (31). These postulates entail that (30) satisfies the Distributivity Constraint if the Map is length, but not if it is diameter.

- (31) a. $DIV_{length}(\llbracket \text{cable} \rrbracket)$
 Every cable of length 3in has as part a cable of length 2in.
 b. $\neg DIV_{diameter}(\llbracket \text{cable} \rrbracket)$
 Not every (in fact, no) cable of diameter 3in has as part a cable of diameter 2in.

Similarly, *for*-adverbials are compatible with predicates that do not have divisive reference in the strict sense as long as these predicates can be interpreted as having the subinterval property, i.e. as long as having relativized divisive reference with respect to time. Examples are predicates with one bounded and one unbounded argument:

- (32) a. Snow fell throughout the area for two straight days.¹⁷
 b. Wine flowed from the jar to the floor for five minutes. (Beavers, 2008)

The predicate *fall throughout the area* is not divisive because it describes events which have as parts events whose location is some proper part of the area. The predicate *flow from the jar to the floor* is not divisive because it describes events which have as parts events whose location is some proper part of the path from the jar to the floor. But both predicates have a continuous interpretation which has the subinterval property. Simply put, both predicates can describe events which go on and on.

Finally, *for*-adverbials also show evidence for the claim that the Map determines the dimension along which divisive reference must be relativized. Example (33a) is acceptable on an iterative interpretation, i.e. John went back and forth and accomplished his task little by little. This is expected if *push carts to the store* has the subinterval property, or in our terms, $DIV_{\tau}(\llbracket \text{push carts to the store} \rrbracket)$. Example (33b) is unacceptable on any interpretation, apart from atelic reinterpretation. This is expected if $\neg DIV_{\sigma}(\llbracket \text{push carts to the store} \rrbracket)$, i.e. the predicate *push carts to the store* has relativized divisive reference with respect to time but not with respect to space. Krifka (1998) assumes that *for*-adverbials essentially test for divisive (not relativized divisive) reference, and undergenerates as a result: his analysis rules out (32a), (32b), and (33b) alongside (33a). For more discussion of this point, see Champollion (2009).

- (33) a. John pushed carts to the store for five minutes.
 b. #John pushed carts to the store for fifty meters.

To sum up this section, we have identified a constraint that prevents telic, collective, and count terms from being Shares. Predicates like *run to the store* can be formally described as distributive but not atelic. The next section describes how this constraint

¹⁷Attested example (<http://community.lawyers.com/forums/t/17235.aspx>).

derives the restriction on measures in *for*-adverbials and pseudopartitives.

6 Why one can't say "thirty degrees Celsius of water"

In Sect. 3, we have seen that pseudopartitives reject Maps (i.e. measure functions) like *temperature* and *speed* that tend to return constant values on the parts of the entity or event instantiated by the Share (i.e. the substance noun). Sect. 4 has hypothesized that *for*-adverbials and pseudopartitives impose the same constraint on Maps. This section shows that the Distributivity Constraint, which was independently motivated in the previous section, rules out such measure functions in both cases.

I show the reasoning for pseudopartitives only. Let μ be the Map of a distributive construction. The following is an immediate consequence of the Distributivity Constraint, and my official prediction on admissible measure functions in pseudopartitives:

$$(34) \quad \textbf{Constraint on measure functions in pseudopartitives}$$

$$\forall x[x \in \llbracket \textit{substance nominal} \rrbracket \rightarrow \forall i[i < \mu(x) \rightarrow \exists y[y < x \wedge i = \mu(y)]]]$$

This constraint will reject, among other things, any measure that is constant on some entity in the denotation of the substance nominal. Proof: Let us call a measure μ constant on x iff $\forall y[y < x \rightarrow \mu(y) = \mu(x)]$. Suppose that μ is constant on some $x_0 \in \llbracket \textit{substance nominal} \rrbracket$. By our background assumptions, $\mu(x_0)$ is nonatomic, so there exists an $i < \mu(x_0)$. By (34), there exists a part y of x_0 such that $\mu(y) = i$, so $\mu(y) < \mu(x_0)$. Since μ is constant on x_0 , it holds that $\mu(y) = \mu(x_0)$. Contradiction.

An interesting prediction of (34) is that even measures like *temperature* should be acceptable in pseudopartitives and in *for*-adverbials as long as their Share only applies to entities or events on which the measure is not constant. Arguably, such nominals include *fever* and *warming* (cf. also the verb *cool*): for example, a sum of two consecutive one-degree warmings is a two-degree warming. Formally, we can express this as $DIV_{\textit{temperature}}(\llbracket \textit{fever} \rrbracket)$ and $DIV_{\textit{temperature}}(\llbracket \textit{warming} \rrbracket)$ but $\neg DIV_{\textit{temperature}}(\llbracket \textit{water} \rrbracket)$. This prediction is confirmed:

- (35)
- a. Emilia was lying on her bed, with 41 degrees Celsius of fever.¹⁸
 - b. The scientists from Princeton and Harvard universities say just two degrees Celsius of global warming, which is widely expected to occur in coming decades, could be enough to inundate the planet.¹⁹
 - c. The sample continued to cool for several degrees to point N and then suddenly increased to a temperature between the transition points of Form I and Form II with no indication of the presence of Form III.²⁰

¹⁸From <http://www.fanfiction.net/s/3616691/>.

¹⁹Calgary Herald, *Two degrees is all it takes – Warming may trigger floods*, December 17, 2009, online at <http://www.calgaryherald.com/technology/degrees+takes/2350903/story.html>.

²⁰From Daubert and Clarke (1944).

7 Conclusion

This paper has presented a diagnostic for identifying distributive constructions and shown that it applies to pseudopartitives and *for*-adverbials. The restrictions on their constituents and on their measure functions both follow from a single general constraint on distributive constructions. Evidence for this constraint was claimed to come from distributive entailments. Informally, the explanation proposed for these restrictions is the following:

Why one can't say **run to the store for an hour*. Just like the distributive construction *Al, Bill, and Charles each wore a sweater* insists that any plural event denoted by *wore a sweater* should have some proper parts which are themselves sweater-wearing events and whose agents are proper parts of its own sum agent, the *for*-adverbial insists that any plural event denoted by *run to the store* should have some proper parts which are themselves running-to-the-store events and whose run-time include every proper part of its own runtime. But this is not the case since *run to the store* is telic and therefore does not have the subinterval property. (An analogous reasoning explains why one can't say **five pounds of book*.)

Why one can't say **thirty degrees Celsius of water*. Just like the distributive construction *Al, Bill, and Charles each wore a sweater* insists that any plural event denoted by *wore a sweater* should have some proper parts whose agents are proper parts of its own sum agent, the pseudopartitive insists that anything which is water should have some proper parts whose temperature is lower than its own.

The picture presented in this paper is idealized in several respects. For example, I have ignored the fact that distributive entailments do not always literally hold as far down as they can. *for*-adverbials are compatible with predicates like *waltz* and *sleep in the attic* that do not satisfy the subinterval property (Dowty, 1979). Similarly, pseudopartitives are compatible with heterogeneous mass nouns like *fruit cake* (Taylor, 1977). To “make room” for such predicates in distributive constructions, one would have to loosen the Distributivity Constraint a little bit so that very small parts of the Share are excluded from its requirement. I have abstracted away from this complication.

References

- Bach, E. (1986). The algebra of events. *Linguistics and Philosophy*, 15:5–16.
- Beavers, J. (2008). Multiple incremental themes and Figure/Path relations. In *Proceedings of SALT XVIII*.
- Bennett, M. and Partee, B. H. (1972). *Toward the logic of tense and aspect in English*. Indiana University Linguistics Club.
- Bunt, H. C. (1979). Ensembles and the formal semantic properties of mass terms. In Pelletier, F. J., editor, *Mass terms: Some philosophical problems*, pages 249–277. Springer.

- Champollion, L. (2009). *for*-adverbials quantify over subintervals, not subevents. Presentation at 9th International Conference on Tense, Aspect and Modality (CHRONOS 9).
- Cheng, C.-Y. (1973). Comments on Moravcsik's paper. In Hintikka, J., Moravcsik, J. M. E., and Suppes, P., editors, *Approaches to Natural Language*, pages 286–288. Reidel.
- Choe, J.-W. (1987). *Anti-quantifiers and a theory of distributivity*. PhD thesis, University of Massachusetts, Amherst.
- Choe, J.-W. (1991). Georgian reduplication and a relational theory of distributivity. In Ikeya, A., editor, *The Sixth Japanese-Korean Joint Conference on Formal Linguistics*, Tokyo. The Logico-Linguistic Society of Japan.
- Daubert, B. F. and Clarke, T. H. (1944). Unsaturated Synthetic Glycerides. VI.1 Polymorphism of Symmetrical Monoöleyldisaturated Triglycerides². *Journal of the American Chemical Society*, 66(5):690–691.
- Dotlačil, J. (2010). *Anaphora and distributivity: A study of same, different, reciprocals and others*. PhD thesis, Universiteit Utrecht.
- Dowty, D. (1979). *Word meaning and Montague grammar*. Dordrecht, Reidel.
- Dowty, D. R. (1987). Collective predicates, distributive predicates, and *All*. In *Proceedings of the 3rd ESCOL*, pages 97–115, Columbus, Ohio. The Ohio State University.
- Fox, D. and Hackl, M. (2006). The universal density of measurement. *Linguistics and Philosophy*, 29:537–586.
- Gawron, J. M. (2002). Two kinds of determiners in DP. Talk at LSA winter meeting.
- Gawron, J. M. (2005). Generalized paths. In *Proceedings from the Fifteenth Conference on Semantics and Linguistic Theory: SALT XV*.
- Krantz, D. H., Luce, R. D., Suppes, P., and Tversky, A. (1971). *Foundations of measurement*. New York: Academic Press.
- Kratzer, A. (2007). On the plurality of verbs. In Dölling, J., Heyde-Zybatow, T., and Schäfer, M., editors, *Event structures in linguistic form and interpretation*. Walter de Gruyter, Berlin.
- Krifka, M. (1989). Nominal reference, temporal constitution and quantification in event semantics. In Bartsch, R., van Benthem, J., and van Emde Boas, P., editors, *Semantics and contextual expression*, pages 75–115. Dordrecht, Foris.
- Krifka, M. (1998). The origins of telicity. In Rothstein, S., editor, *Events and grammar*, pages 197–235. Kluwer Academic Publishers, Dordrecht/Boston/London.

- Ladusaw, B. (1982). Semantic constraints on the English partitive construction. In Flickinger, D. P., Macken, M., and Wiegand, N., editors, *Proceedings of WCCFL 1*, pages 231–242, Stanford. CSLI.
- Landman, F. (1989). Groups, I. *Linguistics and Philosophy*, 12:559–605.
- Landman, F. (2000). *Events and plurality: The Jerusalem lectures*. Kluwer Academic Publishers.
- Link, G. (1987). Generalized quantifiers and plurals. pages 151–180. Reprinted in Link (1998).
- Link, G. (1998). *Algebraic semantics in language and philosophy*. Stanford: CSLI.
- Matthewson, L. (2001). Quantification and the nature of crosslinguistic variation. *Natural Language Semantics*, 9:145–189.
- Moltmann, F. (1991). Measure adverbials. *Linguistics and Philosophy*, 14:629–660.
- Parsons, T. (1990). *Events in the semantics of English*. MIT Press.
- Quine, W. v. O. (1960). *Word and Object*. MIT Press.
- Quine, W. v. O. (1985). Events and reification. In LePore, E. and McLaughlin, B. P., editors, *Actions and events: Perspectives on the philosophy of Donald Davidson*, pages 162–171. Blackwell.
- Roberts, C. (1987). *Modal subordination, anaphora, and distributivity*. PhD thesis, University of Massachusetts, Amherst.
- Schwarzschild, R. (2006). The role of dimensions in the syntax of noun phrases. *Syntax*, 9(1):67–110.
- Schwarzschild, R. and Wilkinson, K. (2002). Quantifiers in comparatives: A semantics of degree based on intervals. *Natural Language Semantics*, 10:1–41.
- Selkirk, L. (1977). Some remarks on noun phrase structure. In Culicover, P., Wasow, T., and Akmajian, A., editors, *Formal Syntax*, pages 285–316. Academic Press, New York.
- Taylor, B. (1977). Tense and continuity. *Linguistics and Philosophy*, 1:199–220.
- Verkuyl, H. J. (1972). *On the compositional nature of the aspects*. Dordrecht: Reidel.
- Williams, A. (2009). Themes, cumulativity, and resultatives: Comments on Kratzer 2003. *Linguistic Inquiry*, 40(4):686–700.
- Winter, Y. (2001). *Flexibility principles in Boolean semantics*. MIT Press.