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## Refining stratified reference

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**Abstract:** This is a reply to the comments by Corver, Doetjes, Link, Piñón, Schwarzschild, and Syrett on the target article in this volume, *Stratified reference: The common core of distributivity, aspect, and measurement*. Stratified reference is designed to capture semantic oppositions involving atelicity, plurality and mass reference, extensive measure functions, distributivity, and collectivity. Following suggestions by some of the commentators, stratified reference is refined here in two ways: it is restricted to the parts of the event or individual in question, and its granularity parameter is instantiated with a predicate built around mereological proper parthood and degree ordering.

**Keywords:** algebraic semantics, aspect, boundedness, collectivity, distributivity, mass, measurement, mereology, monotonicity, plural, partitives, telicity

### 1 Introduction

This paper continues the discussion about my target article, *Stratified reference: The common core of distributivity, aspect, and measurement* (Champollion, this volume). I am grateful and honored to receive the insightful comments by Norbert Corver, Jenny Doetjes, Godehard Link, Christopher Piñón, Roger Schwarzschild, and Kristen Syrett. I very much appreciate the contributions by Corver (this volume) on the bounded-unbounded opposition in syntax, and by Syrett (this volume) on the interpretation of *all* and *each* in child language. It is highly encouraging to see that stratified reference may help shed light on empirical domains quite distinct from those for which it was designed. However, I will limit myself to addressing those comments that I feel competent as a semanticist to address in print, namely the ones by Doetjes, Link, Piñón, and Schwarzschild.

After replying to these comments in Sections 2 through 5, I will refine the analysis described in the target article in Section 6. Building on proposals by Piñón and Schwarzschild, I will:

- restrict stratified reference to the parts of the event or individual in question, in order to prevent it from making universal claims affecting unrelated entities, and

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- instantiate its granularity parameter with a predicate built around mereological proper parthood and degree ordering instead of the predicate  $\varepsilon(K)$ .

These modifications preserve the explanatory power of stratified reference as a higher-order property that is parametrized for dimension and granularity, and that can be used to link theories across the empirical domains of distributivity, aspect, and measurement. I believe that the technical underpinnings of the theory have been strengthened as a result of the constructive criticism offered by the commentators. For this I am indebted to the commentators, and to the editors of this journal who provided a forum for this debate.

## 2 Reply to Doetjes

Doetjes (this volume) observes that stratified reference does not rule out incremental-theme verbs whose themes are downward-entailing modified numerals, such as (1a). It has this problem in common with the subinterval property, which it is meant to generalize. Cumulative reference does not fare any better because an analogous problem occurs with upward-entailing modified numerals (1b). She therefore proposes combining stratified reference with cumulative reference, following Landman and Rothstein (2012). This will rule out both types of examples out as desired, but unfortunately not (1c), discussed by Zucchi and White (2001).

- (1) a. #He drank at most thirty glasses of water for three hours.  
 b. #He finished at least three books for three hours.  
 c. #John drank {some/a quantity of} milk for an hour.

This kind of behavior is puzzling for most if not all algebraic theories of aspect, including mine. The noun phrases in (1) seem to behave for the purposes of these theories as if they were quantized. An early feature-based theory of aspectual composition, Verkuyl (1972), grouped modified and unmodified numerals together by assigning both of them a feature [+SPECIFIED QUANTITY], while bare plurals and mass nouns carried the feature [−SPECIFIED QUANTITY]. Algebraic notions like quantization, stratified reference, and the subinterval property are meant to make such features superfluous. But in noun phrases like the ones in (1), the effects of these two systems come apart (Verkuyl 2005, fn. 3). A similar issue is discussed by Schwarzschild (this volume) in connection with the word *line*. Other problematic predicates include *twig*, *rock*, and

*sequence*. A helpful but ultimately inconclusive discussion of possible ways to address this problem is found in Zucchi and White (2001).

Doetjes correctly observes that some examples involving measure phrases can be ruled out for reasons that are unrelated to the aspectual sensitivity of the *for*-adverbial. For example, we cannot use a measure phrase that is not large enough to include a minimal event:

- (2) #The recipe passed on from generation to generation for thirty years.

Doetjes suggests that *from generation to generation* entails that there are more than one or two generations, too much to fit into a thirty-year timespan (Zwarts 2013). If so, it is not the stratified-reference constraint of the *for*-phrase that makes (2) odd, but the mismatch between the measure phrase and the length of the shortest event that could be denoted by the predicate. I agree that this is a reasonable explanation for the oddness of (2). Similarly, (3a) (repeated from (48a) in the target article) not only violates stratified reference, we would also expect it to be infelicitous anyway because it would require the speaker to know that there is just a single twelve-pound weight. And Doetjes' example (3b) is not a felicitous way to describe a number of boxes that the speaker knows contain one twelve-pound weight each.

- (3) a. \*twelve pounds of twelve-pound weights  
b. Each of these boxes contains twelve pounds of weights.

Doetjes links this speaker-knowledge effect to a similar constraint on event-related readings of numerals.

A different problem for the account in the article arises because, as Doetjes notes, (3b) can be used to describe boxes that each contain one weight of ten pounds and two weights of one pound. The problem is that a ten-pound weight is not very small compared to twelve pounds, as we would expect due to the use of  $\varepsilon(K)$ . In response to this problem and similar considerations by other commentators, I will replace  $\varepsilon(K)$  by a weaker condition (see Section 6).

One might wonder if the only thing that *for*-adverbials require is that the measure phrase is large enough to contain a minimal entity described by the relevant predicate. The following examples show that aspectual sensitivity still plays a role, however.

- (4) a. John walked a mile in/\*for twenty minutes.  
b. The courier ran from Marathon to Athens in/\*for three hours.

Iterativity aside, any event described by a motion predicate with a quantized path will be minimal, so the minimal-entity constraint would not rule out them

out by itself. The stratified-reference constraint, by contrast, rules them out, and thereby makes sure that we cannot use *for-* and *in-*adverbials interchangeably.

### 3 Reply to Link

Stratified reference as originally formulated involves distributivity over events or individuals. Link (this volume)<sup>1</sup> shows that at least for the temporal case, its effect can also be achieved via universal quantification over subintervals.

Link and I share the same general outlook on the usefulness of mereology in natural language semantics, but he raises doubts about the way in which the value of the granularity parameter is determined in the target article. While I made it dependent on the measure phrase provided by the *for-*adverbial or pseudopartitive (e.g. *ten minutes*), he suggests that it should be governed by the predicate at issue (e.g. *waltz*). To this end, he associates every event property  $P$  with a temporal threshold  $\delta_P$ . This threshold supplies the minimum duration for an event to be meaningfully called a  $P$  event.

The purpose for which I used the granularity parameter was not to describe the length of the smallest events that count as waltzing, but to describe the requirements that *for-*adverbials impose on the properties they modify. If a *for-*adverbial is like a sieve and the waltzing events are like grains of sand, the system in the target article is not concerned with describing the size of the grains, but the size of the holes in the sieve. (The target article assumes that the holes of the sieve must be very small as compared with the measure phrase. Link notes that they can be of the same order of magnitude, as in his *The production of Airbus A380 at a rate of three per month has been going on for half a year now*. I come back to this point in Section 6.)

When we combine two *for-*adverbials with the same predicate, as shown in (5), the two *for-*adverbials correspond to sieves with different hole sizes (see also Doetjes' comment for related discussion).

- (5) The recipe was passed on from generation to generation...
- a. ...for thousands of years.
  - b. ...#for thirty years.

To capture this contrast, the granularity parameter cannot be determined exclusively with reference to the predicate, but must involve the time span described

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<sup>1</sup> Link's seminal work on algebraic semantics, compiled in Link (1998), has been one of the major influences for the target article and the dissertation on which it is based, Champollion (2010). It is a great honor for me to read and reply to his comments in these pages.

by the *for*-adverbial – either directly as I did it in the article, or indirectly via the temporal trace of the main event, as I will do in Section 6.

With that said, stratified reference can certainly also be used to describe the size of the grains of sand. For example, the size of a minimal waltzing event is not determined by any *for*-adverbials, although it will influence the ability of different *for*-adverbials to combine with *waltz*. If we were to formulate a meaning postulate stating that *waltz* has stratified reference down to a certain granularity, then indeed we might want to use a threshold function such as  $\delta_P$  to determine that granularity. In fact, I have tacitly assumed such meaning postulates at various places in the article. Wherever I state that a stratified-reference presupposition is satisfied by a verb phrase, a more complete formalization of the theory would derive that fact from meaning postulates and other means of capturing the formal properties of that verb phrase (cf. Krifka 1998).

For further discussion of the granularity parameter, see my reply to Piñón and Section 6. The remainder of this reply is concerned with Link's analysis of stratified reference.

Link approximates stratified reference in several steps. His first step, in (6), assumes a function  $\delta$  that maps events and intervals to degrees representing their durations, which are totally ordered by  $\leq$ . The parthood relation between events is written  $\sqsubseteq$ .

- (6)  $\forall e \forall l (P(e) \wedge \delta_P \leq l \leq \delta(e) \rightarrow \exists e' \sqsubseteq e (P(e') \wedge \delta(e') = l))$  (SIP)  
 (Let  $e$  be a  $P$  event and  $l$  some duration at least as long as the temporal threshold associated with  $P$  but not longer than  $e$ . Then there is a subevent  $e'$  of  $e$  which is also a  $P$  and has duration  $l$ .)

While SIP avoids the minimal parts problem, Link notes that it requires the events in  $P$  have a dense structure. This is too strong an ontological assumption. Another problem, which Link does not mention, is that SIP applies not only to atelic predicates but also arguably to certain telic predicates. For example, if any sufficiently long final subinterval of the runtime of a *walk to the store* event qualifies as walking to the store, then *walk to the store* has SIP.

This problem is avoided by the formulation in (7), which exempts too-short subintervals from the universal quantifier. Here,  $\preceq$  stands for the inclusion relation between temporal intervals:

- (7)  $\forall e \forall t (P(e) \wedge t \preceq \tau(e) \wedge \delta(t) \geq \delta_P \rightarrow \exists e' \sqsubseteq e (P(e') \wedge \tau(e') = t))$  (SIP\*)  
 (Let  $e$  be a  $P$  event. Every time span  $t$  located within the trace of  $e$  whose duration is at least  $\delta_P$  is the trace of some subevent  $e'$  which is also a  $P$ .)

As Link notes, this runs into another problem. Take the atelic predicate *swim laps*. Suppose that John swims several laps in succession starting at 1 pm, one lap per minute. Then  $\delta_{[[\textit{swim laps}]]} = 1 \text{ min}$ , assuming that *laps* literally means *one or more laps*. Now if he starts each lap on the full minute, there will be no lap from 1:00:30 pm to 1:01:30 pm, and so there will be no event at that time that qualifies as *swim laps*. Therefore (7) does not hold of the property denoted by *swim laps*.

Note that by cumulativity, there is a *swim laps* event that takes from 1:00:00 pm to 1:02:00 pm. While its runtime is not equal to the time interval from 1:00:30 pm to 1:01:30 pm, it contains that interval and not much more. This leads to Link's final formulation, which I take to be (8).

- (8)  $\forall e \forall t [P(e) \wedge t \preceq \tau(e) \wedge \delta(t) \geq \delta_P \rightarrow$   
 $\exists e' \sqsubseteq e (P(e') \wedge t \preceq \tau(e') \wedge (\delta(\tau(e')) - \delta(t)) \leq 2\delta_P)]$  (SIP\*\*) (SIP\*\*)  
 (Let  $e$  be a  $P$  event. Every time span  $t$  which is located within the trace of  $e$  and whose duration is at least  $\delta_P$  is located within the trace of some subevent  $e'$  of  $e$  which is also a  $P$  and whose duration exceeds that of  $t$  by at most twice  $\delta_P$ .)

SIP\*\* quantifies over parts of an interval and then relates these parts to suitable events or entities, while stratified reference distributes down to parts of an event or entity and uses intervals or degrees to make sure that these parts are small enough. In the temporal domain, as Link shows, the two different routes lead essentially to the same result, and SIP\*\* comes very close in effect to stratified reference. Whether this means that SIP\*\* is as easily adaptable to other domains as stratified reference remains to be seen. Due to the way SIP\*\* relies on the specifics of time, generalizing it across domains is not straightforward. In (8), there is a distinction between temporal intervals such as  $t$  and their durations  $\delta(t)$ . Temporal intervals are individuated and more fine-grained than durations. Two events can have different runtimes but the same duration, as is the case for a one-hour-long event today and another one-hour-long event yesterday. There is no such distinction in degree-based domains like weight and temperature, and so it is not entirely clear how to reformulate SIP\*\* in a way that applies to pseudopartitives like *five pounds of cherries*—certainly not if weights and temperatures are degrees in the ordinary sense (totally ordered entities). The differences may become smaller, and a condition such as SIP\*\* more easily generalizable, if we adopt a nonstandard conception of weights and temperatures as partially ordered entities or tropes, so that they become more similar to temporal intervals (cf. Moltmann 2009).

## 4 Reply to Piñón

Stratified reference is designed to generate new hypotheses and predictions by supplying a common core that brings various theories and empirical domains together. Piñón (this volume) suggests that this common core “may be more illusory than real”. He sees stratified reference as neither sufficiently specified nor sufficiently motivated, and argues that it can and should be replaced by a combination of two properties built around proper parthood and extensive measure functions. Piñón’s position is informed by the hypothesis that the semantics of aspect, measurement, and distributivity does not make reference to smallness. Accordingly, one of his main concerns with stratified reference is its reliance on the formula  $\varepsilon(K)(x)$ , which I have paraphrased as “ $x$  is very small with respect to  $K$ ”.

It is not clear to me how to apply categories like reality and illusion to theoretical constructs. I agree that these constructs must be fully specified and well-motivated, though. In Section 6, I show how to reconcile Piñón’s no-smallness hypothesis with the proposal in the target article by adopting a version of stratified reference that does not rely on  $\varepsilon$ . Here, I critically review Piñón’s own proposal, which he describes as a simple and weak property that is meant to cover much of the same empirical ground as stratified reference.

Piñón defines this property, which he calls divided reference, as in (9). Here,  $y \upharpoonright z$  means that  $y$  and  $z$  are disjoint (that is, they do not have any part in common). The symbol  $\sqsubset$  stands for the mereological proper-part relation.

(9) **Divided reference**

$$DR(P)(x) \stackrel{\text{def}}{=} \exists y \exists z (y \sqsubset x \wedge z \sqsubset x \wedge y \upharpoonright z \wedge (y \oplus z) = x \wedge P(y) \wedge P(z))$$

( $x$  consists of two disjoint parts that are each in  $P$ .)

Given the axioms of classical extensional mereology, the subformula  $y \sqsubset x \wedge z \sqsubset x$  is entailed by  $y \upharpoonright z \wedge (y \oplus z) = x$ , so it can be dropped from the definition without changing its meaning. Alternatively, one could drop the disjointness condition  $y \upharpoonright z$  (it does not play a central role in Piñón’s account). Unlike the previous change, this does result in a different property, one that is even weaker than (9).

While stratified reference quantifies over all of the entities in the extension of the relevant predicate, divided reference is restricted to a single entity. I agree with Piñón that this is a useful move, and with the reasons he gives for it (it avoids making universal claims about unrelated entities). Schwarzschild makes some of the same observations as Piñón and shows how stratified reference can also be restricted to a single entity, while keeping its essential properties—the

dimension and granularity parameters and the ability to link domains—along with the explanatory power that they provide. See Section 6 for further discussion.

Divided reference cannot cover the same ground as stratified reference, mainly because it lacks dimension and granularity parameters. Section 4 of the target article shows that *all* and *each* behave differently with respect to distributive and collective predicates, and suggests that this is because their granularity parameters have different settings. *Each* accepts only distributive predicates because it requires distribution to events with atomic participants such as smiling events, while *all* also accepts certain collective predicates because it merely requires distribution to events with small but potentially nonatomic numbers of participants, such as gathering events. The same core idea can also be brought to bear on the difference between atomic and nonatomic covert distributivity operators and on the behavior of indefinites in the scope of *for*-adverbials (Champollion 2015a), as well as on the crosslinguistic difference between atomic and nonatomic adnominal distance-distributive items, such as English *each* and German *jeweils* (Champollion 2015b). Divided reference is not well-suited for any of these purposes because it lacks a granularity parameter.

All this is perhaps not problematic from Piñón's perspective given his doubts that stratified reference can shed light on issues raised by distributivity and collectivity. However, the lack of a dimension parameter also has consequences in the domains of aspect and measurement. Divided reference cannot account for differences between temporal and spatial aspect because it does not make reference to time or space (see the discussion around Figure 1 in the target article):

- (10) a. John pushed carts all the way to the store for fifty minutes.  
 b. John pushed carts all the way to the store for fifty meters.

Stratified reference provides a natural account of why these two sentences differ in meaning. The *for*-adverbials set the dimension parameter to two different values, namely  $\tau$  (temporal trace) for (10a) and  $\sigma$  (spatial extent) for (10b).

In the domain of measurement, Piñón admits that divided reference cannot be used to distinguish between pairs of pseudopartitives with the same substance noun:

- (11) a. three inches of water  
 b. \*three degrees Celsius of water

Stratified reference is satisfied in (11a) because every amount of water can be divided into amounts of water with smaller heights or diameters than the whole, but not in (11b) because the parts of any amount of water do not have a lower temperature than the whole. Divided reference is satisfied whenever the amount

of water in question is large enough to consist of two disjoint parts which are also water. This criterion does not distinguish between (11a) and (11b). Piñón recognizes the need for a separate constraint and suggests that pseudopartitives only accept extensive measure functions, following Krifka (1989). This is one of the notions that stratified reference is designed to formalize and subsume, so Piñón and I agree at some level. Still, there are differences between Krifka's formalization and mine. For presentational purposes, I have slightly condensed and adapted the following definition from Krifka (1989, 1998). Here,  $\leq$  is mereological parthood,  $+$  is arithmetic sum, and  $>$  is the arithmetic greater-than relation.

(12) **Definition: Extensive measure function**

Let  $\wedge$  (a “concatenation”) be an associative and commutative but non-idempotent operation. A measure function  $\mu$  is extensive on  $\wedge$  iff for any  $a$  and  $b$  that are disjoint,  $\mu(a) + \mu(b) = \mu(a \wedge b)$ , and for any  $c$  and  $d$ , if  $c \leq d$  and  $\mu(d) > 0$  then  $\mu(c) > 0$ .

In order for this definition to work correctly, it is critical that the “right” concatenation be used. The issue is analogous to the one I illustrated with *five inches of snow* in the target article for a related proposal (Schwarzschild 2002, 2006). Suppose for example that we use mereological sum restricted to disjoint entities, as suggested by Krifka (1998). Height is not extensive on that concatenation. The five inches of snow  $s$  that fell on Berlin are the sum (and therefore the concatenation) of two disjoint parts, namely, the five inches of snow  $s_a$  that fell on West Berlin and the five inches of snow  $s_b$  that fell on East Berlin. The arithmetic sum of the heights of  $s_a$  and of  $s_b$  in inches is twice the height of  $s$  rather than equal to it. Height is only extensive on a concatenation that requires  $a$  and  $b$  in (12) to range over horizontal layers of snow, in which case  $s_a$  and  $s_b$  will be excluded. Krifka is not explicit on the way his system selects a concatenation before checking if the measure function of a given pseudopartitive is extensive on it, except that he requires the pseudopartitive to denote a quantized predicate (Krifka 1989: 82). But *five inches of snow* applies both to  $s$  and to its proper part  $s_a$ , so it is not quantized. This is not to say that it is impossible to formulate a more refined version of the definition in (12) or the ones on which it is based. Quite the opposite: It was among other things the attempt to do so that led me to stratified reference.

## 5 Reply to Schwarzschild

I focus here on just one of the many topics brought up in Schwarzschild (this volume): the significance of temporal parts. Section 6 discusses two more,

namely the restriction of stratified reference to the parts of the entity at hand and the status of  $\varepsilon(K)$ .

Concerning temporal parts, Schwarzschild observes that stratified reference does not explain why the following sentences sound odd in the scenarios he describes:

- (13) a. <sup>2</sup>Jack made pretzels for two feet. (i.e. a single two-foot peel)  
 b. <sup>3</sup>The water cooled for 5 degrees instantaneously.  
 c. <sup>3</sup>Jill crushed bamboo poles (instantaneously) for five square feet.

He suggests as a possible explanation that for the purpose of *for*-adverbials, the only parts that an event has are temporal parts. Schwarzschild writes  $<$  for mereological parthood and  $\prec$  for the inclusion relation between time intervals.

- (14)  $e' < e \rightarrow \text{duration}(e') \prec \text{duration}(e)$

This principle rules out the existence of two simultaneous events of which one is a part of the other. Schwarzschild hypothesizes that all *for*-adverbials are temporal and that what looks like non-temporal uses actually involves metaphoric uses or nonce temporal measure phrases. While I cannot explain what is wrong with the examples in (13), principle (14) is certainly too strong as stated. One class of examples that it would wrongly rule out involves events which are spatially extended across an area, similarly to (13c):

- (15) Snow fell throughout the area for two straight days.<sup>2</sup>
- (16) The flowering of the bamboo fascinated him. The bamboo flowers simultaneously for hundreds of miles. [...] The synchronicity of events fascinated him [...].<sup>3</sup>
- (17) The multiplicity of [a Chinese calligrapher's] horizontal and vertical brush strokes, and their unending possibilities may be likened to sudden thunder and lightning which instantaneously flash for thousands of miles.<sup>4</sup>
- (18) According to eyewitnesses, the ground was shaken for two miles around, and even the galleys tied up in the harbors felt the explosions through their wooden hulls.<sup>5</sup>

<sup>2</sup> Attested example (<http://community.lawyers.com/forums/t/17235.aspx>).

<sup>3</sup> Attested example (Seshadri and Visvanathan 2002: 2163).

<sup>4</sup> Attested example ([http://www.ngansiumui.com/about/about\\_pub\\_ebook-callig\\_en.html](http://www.ngansiumui.com/about/about_pub_ebook-callig_en.html)).

<sup>5</sup> Attested example (<http://www.historynet.com/the-guns-of-constantinople.htm>).

(19) [T]he police blocked streets for miles around [the museum].<sup>6</sup>

It is difficult to see the spatial *for*-adverbials in these examples as temporal *for*-adverbials in disguise. Areas cannot easily serve as metaphoric descriptions of temporal intervals, because a two-dimensional area cannot be mapped to a time interval in any obvious way. The principle (14) would also be difficult to uphold in any of these scenarios. For example, the event described by (15) may consist of various two-day-long subevents that correspond to different spatial parts of the area in question. By (14), these subevents would be required to have a shorter duration than the entire event rather than being simultaneous to it.

Given these examples, it seems plausible that either time or space can be encoded in a *for*-adverbial and that not all *for*-adverbials are temporal. In line with the broader discussion on spatial aspect in Moltmann (1991) and Gawron (2005), this provides motivation for the dimension parameter of stratified reference.

## 6 Restricting stratified reference

Both Schwarzschild and Piñón make observations that relate to the universal quantifier in stratified reference. Schwarzschild proposes a modification that drops this quantifier while staying within the spirit of the original approach.

In the target article, I suggested that stratified reference rules out (20a) because it generates the presupposition in (20b), which I took to be a presupposition failure.

- (20) a. \*five pounds of book  
 b. Every book can be divided into one or more parts, each of which is a book that weighs a lot less than five pounds.

I said that this presupposition fails for two reasons: (i) typically, a book's weight is not very small compared with five pounds, so we cannot read the "one or more parts" as "one part"; (ii) based on the assumption that entities in the denotation of singular count nouns are atoms, a book does not consist of proper parts which are themselves books, so we cannot read the "one or more parts" as

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<sup>6</sup> Attested example (*Iraq museum that was looted reopens, far from whole*, by Steven Lee Myers, New York Times, February 24, 2009). With thanks to Cleo Condoravdi (p.c.)

“two or more parts”. Schwarzschild and Piñón both note a problem in connection with (21).

(21) five pounds of books

My account predicts that (21) presupposes that every sum of one or more books (and in particular, every book) can be divided into one or more parts, each of which is a book or sum of books  $x$  that weighs a lot less than five pounds. Now whenever  $x$  is a sum of several books that weighs a lot less than five pounds, each of these books will also weigh less than five pounds. As Piñón and Schwarzschild note, this means that the presupposition of (21) boils down to (20b). In other words, my account generates the same presuppositions for (20a) and (21). Now since (21) is acceptable, if my stratified-reference account is correct then (20b) cannot be a presupposition failure. But this means that either (i) or (ii) must be false. Indeed I was wrong about (i). Five pounds are 80 ounces. The average book weighs 12 ounces, and over 75% weigh under 24 ounces (Weatherford and Manley 2002), which means that a book’s weight is typically much smaller than 80 ounces. Now suppose that (ii) is true, and therefore (20b) is true in the “two or more parts” sense. This amounts to (22):

(22) All books weigh a lot less than with five pounds.

If (22) is true, then (20a) will be ruled out because the intersection of the set of books with the set of objects whose weight is five pounds is empty (see the discussion around example (42) in the article, *\*five tons of book*).

Although we can explain the difference between (20a) and (21), stratified reference plays no role in explaining it. This should give us pause. There is also another problem. As Schwarzschild puts it, “I can felicitously report that I’ve bought 5 pounds of books without committing to something as strong as [(22)]. It is sufficient that each of the books I’ve bought weighs less than 5 pounds.”

This problem arises from the way stratified reference incorporates a higher-order property without relativizing it to a single individual or event. Schwarzschild suggests addressing this problem by restricting stratified reference to the parts of the individual or event in question. As he notes, this also simplifies my account of examples (11a) and (11b) in the article involving John pushing carts to the store because I no longer need to appeal to contextual restriction for this purpose. This modification preserves what I take to be the central features of my approach, namely the dimension and granularity parameters and the ability to link empirical domains. Therefore I am happy to endorse it here. I repeat Schwarzschild’s definition (4) here in slightly modified form in (23).

(23) **Restricted stratified reference**

$$\text{SR}_{f,g} \stackrel{\text{def}}{=} \lambda P \lambda x \left[ x \in {}^* \lambda y \left( \begin{array}{l} P(y) \wedge \\ g(f(y)) \end{array} \right) \right]$$

( $x$  consists of one or more parts in  $P$  that are each mapped by  $f$  to something in  $g$ .)

We may read  $\text{SR}_{f,g}(P)(x)$  as “ $P$  stratifies  $x$  along dimension  $f$  with granularity  $g$ ”. The type of (23) is  $\langle at, at \rangle$  where  $a$  is either  $e$  for individuals or  $v$  for events. This gives it the type of a modifier. In Champollion (2015a), I use slight variations of (23) to redefine the atomic and nonatomic distributivity operators originally introduced in Link (1987) and Schwarzschild (1996). I argue there that they are modifiers as well, just like adverbial *each* and similar items in other languages, which can be analyzed in terms of these operators (Champollion 2015b). It is encouraging that the reformulation in (23) brings stratified reference even closer to these operators and items.

The original formulation, which we may call universal stratified reference, will still be useful for various purposes, such as the formulation of meaning postulates like (52) in the target article. We can retrieve it from the definition in (23) as follows:

(24) **Universal stratified reference**

$$\text{SR}_{f,g} \stackrel{\text{def}}{=} \lambda P \forall x [P(x) \rightarrow \text{SR}_{f,g}(P)(x)]$$

( $P$  has stratified reference with dimension  $f$  and granularity  $g$  iff  $P$  stratifies everything in  $P$ .)

In (23) and (24), I have written the granularity parameter simply as  $g$ . We could instantiate it as  $\varepsilon(K)$  to obtain the original formulation in the article. But Schwarzschild and Piñón suggest that it may be that all that is required for a *for*-adverbial to be felicitous is that there be at least two distinct, or perhaps disjoint, subevents (cf. Kratzer 2007). One of the examples Schwarzschild uses to illustrate his claim involves a slow-walking robot who “walks for four minutes” by starting with a *two-minute* step followed by two minutes of normal walking. This is analogous to Doetjes’ example (3b), in which *twelve pounds of weights* describes boxes that each contain a ten-pound weight and two one-pound weights, and to Link’s example (8), in which two airplanes are produced during a six-month span.

Schwarzschild’s restricted formulation of stratified reference can be used to capture this if we instantiate  $g$  in (23) with  $\lambda h.h < f(x)$ , where  $<$  is overloaded to denote the proper-part relation over individuals or events as well as the less-than relation over degrees.

$$(25) \quad \lambda P \lambda x \left[ x \in {}^* \lambda y \left( \frac{P(y) \wedge}{f(y) < f(x)} \right) \right]$$

( $x$  consists of one or more parts in  $P$  that are each less than  $x$  on the scale determined by  $f$ .)

There is a price to pay for swapping  $\varepsilon(K)$  for  $<$  in this way, as Schwarzschild notes: We no longer account for the gradual decrease in acceptability shown in Bale's and Zweig's squishes, reported as (46) and (48) in the article. Perhaps a different account can be given in terms of speaker knowledge along the lines of Doetjes' suggestion, as I discussed in Section 2. I leave this problem open for future investigation, and turn to revising the entries for the words *for*, *each*, and *all* provided in the target article.

$$(26) \quad \llbracket \text{for} \rrbracket = \lambda \tau_{(vt)} \lambda M_{(it)} \lambda P_{(vt)} \lambda e : \text{SR}_{\tau, \lambda h. h < \tau(e)}(P)(e) \cdot P(e) \wedge M(\tau(e))$$

$$(27) \quad \llbracket \text{[each (of the) NP]} \rrbracket = \lambda P \lambda e : \text{SR}_{\text{agent, Atom}}(P)(e) \cdot [P(e) \wedge {}^* \text{agent}(e) = \oplus \text{NP}]$$

$$(28) \quad \llbracket \text{[all the NP]} \rrbracket = \lambda P \lambda e : \text{SR}_{\text{agent, } \lambda x. x < \text{agent}(e)}(P)(e) \cdot [P(e) \wedge {}^* \text{agent}(e) = \oplus \text{NP}]$$

The article did not suggest an explicit lexical entry that checks stratified reference in pseudopartitives. I assume that the presuppositions of pseudopartitives are contributed by *of*, which combines with a silent measure function  $\mu$ , then with the substance noun  $N$  and finally with the measure phrase  $M$ . For clarity, I have labeled the entry in (29) with the types that are appropriate for ordinary pseudopartitives. The actual entry must be type-polymorphic in order to accommodate event-based pseudopartitives, for which the types would be as in (26).

$$(29) \quad \llbracket \text{of} \rrbracket = \lambda \mu_{(ed)} \lambda N_{(et)} \lambda M_{(dt)} \lambda x : \text{SR}_{\mu, \lambda d. d < \mu(x)}(P)(x) \cdot N(x) \wedge M(\mu(x))$$

The following formulas describe in schematic form some sample presuppositions generated by these entries. All of them concern a single event or individual—informally speaking, the one that the construction is about—rather than every entity in the denotation of the relevant predicate:

(30) **Presupposition of a temporal *for*-adverbial:**

$$e \in {}^* \lambda e' \left( \frac{\text{VP}(e') \wedge}{\tau(e') < \tau(e)} \right)$$

(The event  $e$  in question can be divided into VPing events whose runtime is shorter than its own.)

(31) **Presupposition of an ordinary pseudopartitive:**

$$x \in {}^*\lambda y \left( \text{SN}(y) \wedge \mu(y) < \mu(x) \right)$$

(The substance amount  $x$  in question can be divided into parts in the denotation of the substance noun (SN) which are smaller than the whole as measured by the appropriate measure function  $\mu$ .)

(32) **Presupposition of *each* in agent position:**

$$e \in {}^*\lambda e' \left( \text{VP}(e') \wedge \text{Atom}(\text{agent}(e')) \right)$$

(The event  $e$  in question can be divided into VPing events whose agents are atoms.)

(33) **Presupposition of *all* in agent position:**

$$e \in {}^*\lambda e' \left( \text{VP}(e') \wedge \text{agent}(e') < \text{agent}(e) \right)$$

(The event  $e$  in question can be divided into VPing events whose agents are proper parts of its own.)

Predicates like *numerous* and *heavy* are incompatible with *all*, setting aside distributive interpretations that may arise from silent distributivity operators (see Champollion 2010: Ch. 9):

- (34) a. \*All the students who came to the rally are numerous. (Kroch 1974)  
 b. \*All the water is heavy. (Dobrovie-Sorin 2014)

This can be explained by the presupposition in (33), if these predicates are analyzed formally as quantized predicates. As I discussed in my reply to Doetjes, a similar analysis is needed for predicates like *line*, *twig*, *some milk*, and *quantity of milk*. How exactly to ensure this, while preventing other predicates like *milk*, *towards the store*, and *gather* from being treated as quantized, is an important open problem (cf. Zucchi and White 2001).

As Piñón notes, the target article does not explicitly spell out how to apply stratified reference to examples involving mass quantification such as (34b) and (35).

- (35) All the milk is sour. (Dobrovie-Sorin 2014)

As with the other examples in this section I use Schwarzschild's restricted version of stratified reference. One of the advantages of this version is that

there is no need to invoke cardinality in the definition of count-based *all*, and consequently there is no need to decide what measure function should substitute for cardinality in the case of mass-based *all*. As is already the case for other stative examples like *the children are numerous*, I assume that  $e$  ranges over states as well as events. I assume that lexical cumulativity applies to *sour*, that is, it denotes a set of sour states that is closed under sum. Somewhat arbitrarily, I write *theme* for the function that maps a state of an entity's being sour to that entity.

(36) All the milk is sour.

**Satisfied presupposition:**  $SR_{\text{theme}, \lambda x. x < \text{theme}(e)}(\lambda e'. \text{sour}(e'))(e) \Leftrightarrow$

$$e \in * \lambda e' \left( \begin{array}{l} \text{sour}(e') \wedge \\ \text{theme}(e') < \text{theme}(e) \end{array} \right)$$

(The sourness state in question can be divided into sourness states whose themes are proper parts of its own.)

This constraint is presumably what requires the predicate in the nuclear scope of mass quantification with *all* to be homogeneous (see Dobrovie-Sorin (2014) and references therein):

(37) \*All the water weighs one ton.

**Failed presupposition:**  $SR_{\text{theme}, \lambda x. x < \text{theme}(e)}(\lambda e'. e' \in \llbracket \text{weighs one ton} \rrbracket)(e) \Leftrightarrow$

$$e \in * \lambda e' \left( \begin{array}{l} e' \in \llbracket \text{weighs one ton} \rrbracket \wedge \\ \text{theme}(e') < \text{theme}(e) \end{array} \right)$$

(The weighing-one-ton state in question can be divided into weighing-one-ton states whose themes are proper parts of its own.)

## 7 Conclusion

My target article proposed stratified reference as a formalization of unboundedness in natural language, and as a way to characterize various semantic oppositions involving atelicity, plurality and mass reference, extensive measure functions, distributivity, and collectivity. I suggested that several constructions impose analogous stratified-reference constraints, instantiated with different parameter values. The comments on my article have changed my thinking about the best way to formalize stratified reference. I have followed some of Piñón's and Schwarzschild's suggestions and relativized it to the parts of the event or individual in question. This takes stratified reference a step away from, and perhaps ahead of, well-known properties such as cumulative or divisive

reference. I have also followed another suggestion to replace the predicate  $\varepsilon(K)$ , which I had never fully defined in the first place, by a simpler one based on  $<$ , and I instantiated the granularity parameter of stratified reference accordingly. The commentators deserve credit for suggesting these modifications and I am grateful to them for engaging in this debate. I am sure that not all of them will agree with the conclusions I have drawn from it. Still, I hope that the result is a useful synthesis of the debate in this volume and a stable basis for future theory-building.

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**Electronic supplementary material:** A 60-minute video exposition of the original proposal in the target article is available at the following URL: <https://www.youtube.com/watch?v=gNTL17Qf2IU>