Multiple Events and 'N Preposition N'

Sigrid Beck, Universität Tübingen

1. Introduction

1.1. The phenomenon

This chapter investigates data like (1).

(1) a. Dora published 'Henriette Potter' **chapter after chapter**.
 b. Anna piled **book upon book**.
 c. They looked **one by one**.
 d. Olivia climbed the mountain **meter by meter**.
 e. Olivia fell off **time after time**.

On the formal side, the sentences in (1) contain a reduplicative expression 'N Preposition N', for example 'book upon book' in (1b) (in bold-face). On the content side, their interpretation intuitively involves iteration, for example in (1b) a repetition of placing one book on top of another. That is, the examples in (1) talk about multiple events of publishing, piling, looking, climbing and falling. There is a formal similarity to data like (2) in that a central preposition is surrounded by two bare nouns which may be identical. But not all such examples are semantically parallel. In (2c) for example, there is no iteration of reading from one cover to another cover.

(2) a. She went **from door to door**.
 b. He was dressed in black **from head to toe**.
 c. I read the book (from) **cover to cover**.
 d. He repeated it **word for word**.

On the other hand, there are also semantically similar data like (3), which like (1) intuitively do involve iteration; for instance, (1a) and (3a) seem equivalent. But the adverbials in (3a,b) do not share the 'N Preposition N' form, and (3c,d) do not involve nouns.

(3) a. Dora published 'Henriette Potter' **one chapter after the other**.
 b. They looked **one at a time**.
 c. Olivia **climbed and climbed**.
 d. Olivia fell off **again and again**.

In this chapter, I focus on examples like (1), with some comments on non-iterative 'N Preposition N' structures like (2) on the one hand, and multiple event markers with a form other than 'N Preposition N' like (3) on the other. I refer to the core data like (1) as **pluractional 'N Preposition N'**. The chapter is structured as follows: In subsection 1.2 I explain in more detail the issues raised by pluractional 'N Preposition N' for semantic analysis. In subsection 1.3 I provide the background theory required. Section 2 analyses 'N Preposition N'. Section 3 concludes.

1.2. The issue

The questions raised by data like (1) are first, how to precisely capture the meaning of these sentences, and second, the matter of how form relates to meaning. Regarding the first question, the strategy in the literature (e.g. Stockall (2001), Zimmermann (2002), Beck & von Stechow (2007), Henderson (2013)) is to analyse (1) in terms of a plurality of events. The truth conditions of (1a), for example, entail (4). The overall event described by the sentence can be divided into multipe 'small' events.

(4) There is a plurality of events of Dora publishing a chapter of 'Henriette Potter'.

That is, the intuition that these data involve repetition - like multiple events of publishing a chapter - is modeled by making use of event pluralization. This connects English data like (1) to the crosslinguistic phenomenon of pluractionality. Pluractionality is understood as event pluralization, see e.g. Lasersohn (1995), Newman (2012); also chapter 2 of this volume (hence my term pluractional 'N Preposition N' for the data under investigation).
Many languages mark event pluralization morphologically on the verb, cf. (5) and (6), though not English and related languages. The form of the pluractional marker, glossed PLA below, is often reduplication. The example in (5a) can have the interpretations in (5b) and (5c), both of which involve multiple events. In (6) there is a contrast between the simple verb in (6a) which has an interpretation as a single event, and the PLA-marked verb in (6b) which leads to a multiple event interpretation. See the authors cited for details.

(5) a. cˇoy sa dedalcˇn'a [Klamath; Lasersohn (1995), p.259]
then they **PLA**-look
'Then they looked.'
b. The situation can be divided into relevant subevents each of which is an event of them looking.
c. The situation and "they" can be divided into parts so that in each subevent there is one part of them looking.

(6) a. kantooli-t taanapu i=toom-ay [Konso; Beck (2011), p.286]
kantooli-? taanapu 3=hit.with.fist[SG]-PF[3SGM]
'Kantoole (has) hit Taanapo with fist once.'
b. kantooli-t taanapu i=tot-toom-ay
kantooli-? taanapu 3=**PLA**-hit.with.fist[SG]-PF[3SGM]
'Kantoole (has) hit Taanapo with fist many times.'

The semantic analysis of pluractional data like (5) and (6) informs the analysis of (1): event pluralization as seen in (5), (6) is also involved in (1). To proceed with the analysis of (1), we thus need a semantic theory that answers the question in (7).

(7) Multiple event semantics:
What is responsible for event pluralization (in (1) as well as (5), (6))?

Turning to the second question raised by 'N Preposition N', the relation of syntax and semantics, we need to ask how the syntactic structure is mapped to the iterative, i.e. pluractional, meaning.

In order to answer this question, we first need an understanding of the syntax of the construction, that is, we need to answer the question in (8).

(8) Input to composition:
What is the syntax of 'N Preposition N' in (1)?

Once we understand how event pluralization comes about and what the syntactic structure of our data is, we can turn to the analysis of pluractional 'N Preposition N' proper:

(9) Compositional Analysis of pluractional 'N Preposition N':
a. What is the role of the 'N Preposition N' expression relative to event pluralization?
b. How is its semantics composed internally from its components?

The next subsection provides some background on questions (7) and (8). This will allow us to address the questions in (9) in section 2 and provide a compositional semantic analysis of (1). Before we proceed with the formal analysis, let me point out some of the specific properties of the data in (1) that will be addressed.
A first observation is that the preposition in 'N Preposition N' plays an interesting semantic role. The multiple events that (1a) talks about are ordered temporally, one occuring *after* the other. The multiple eventualities that (10) talks about are not ordered temporally. Instead, the order comes from the preposition *within*: one puzzle is contained inside another puzzle. Thus in (1a) and (10), the multiple 'small' events form a sequence which, taken together, gives us the 'big' event described by the sentence, and the ordering for the sequence relates to the preposition.

(10) This mystery offers **puzzle within puzzle.**

Secondly, the noun in 'N Preposition N' provides a description of parts of a plural or internally complex object. In (1a), a chapter is a part of a book, 'Henriette Potter' in the example. The multiple 'small' events are characterised by these parts of the plural or complex object being involved. (1a) differs from (the pragmatically less plausible) (11) in that in each relevant 'small' event in (11), a page rather than a chapter gets published. Thus the noun in 'N Preposition N' needs to denote an appropriate part of a plural or complex object in the sentence, and this part goes into the identification of the multiple events. The plural or complex object in (1a,b,c) is an entity (a book, a set of books, a group of people), but it is a path in (1d) and an event in (1e).

(11) Dora published 'Henriette Potter' **page after page**.

The three claims derived for pluractional 'N Preposition N' so far

(12) a. Pluractionality:
'N Preposition N' expressions characterize pluralities of events.
b. Ordered sequence:
The preposition in 'N Preposition N' may induce a sequence of events.
c. Part/whole structure:
The N in 'N Preposition N' provides the units by which a complex object participates in the multiple events.

allow us to understand some empirical limitations of the construction, cf. the ungrammatical examples in (13). In (13a) the verb *outnumber* precludes a pluractional interpretation. In (13b), the preposition *after* indicates a temporal sequence, but the predicate is not compatible with a step by step temporal unfolding ((13b) gets better if you imagine somebody leafing through a book of animal species; in that case, a derived temporal order may become available). In (13c), *chapter* is not a unit into which any complex object involved in the approaching event is plausibly divided. The data in (13) indicate that the verbal predicate, the N and the preposition all have to combine sensibly for a meaningful 'N Preposition N' structure.

(13) a. # The Smiths outnumber the Johnsons **person by person**.
b. # Whales are extinct **species after species**.
c. # Dora approached the walrus **chapter after chapter**.

There are some further interesting aspects of these constructions that we will come back to. The 'N Preposition N' constituent can be an adverbial or an argument, compare (1a) vs. (1b). While the core data in (1) involve the same noun, note that this is not always the case in the non-pluractional (or not necessarily pluractional) (2), cf. (2b). Finally, there is some interaction with Aktionsart, as seen in (14a), where the activity *wave* doesn't seem to take an 'N by N' modifier. The contrast to (14b) indicates possible crosslinguistic variation in this domain, which to my knowledge has not been systematically explored.

(14) a. * The graduating seniors waved **student by student**. (Henderson 2013, p.476)
b. Die Absolventen winkten **Student für Student**. [German]
the graduating students waved student for student
'The graduating students waved student by student.'

We will be better equipped to examine such facts when the formal theory is in place, to which we now turn.

1.3. Background Theory

1.3.1. Theory of plural operators

Semantics has established a general theory of covert plural operators that can apply to natural language predicates (prominently, Link (1983), Krifka (1986), Sternefeld (1998)). This theory has been extended to the event argument slot of predicates (e.g. Lasersohn (1995), Kratzer (2008), Beck (2011)). Below, I give a simplified version of such an overall theory of plural predication. A more extensive discussion of the version presented here can be found in Beck (2012) and Beck & von Stechow (2007).

Note first that if some predicate like 'run 20 miles' truthfully applies to two individuals, as in (15a), then it can be truthfully predicated of the two together. In addition to an interpretation according to which Dora and Anna together ran 20 miles (e.g. each ran 10 miles), (15b) can be judged true if each of Dora and Anna ran 20 miles.

(15) a. Dora ran 20 miles and Anna ran 20 miles.

b. Dora and Anna ran 20 miles.

Similarly, if a relation like 'marry' holds between one pair of individuals as well as a second pair, (16a), it also holds between the groups formed pairwise of the single individuals, (16b).

(16) a. Dora married Pat and Sandy married Shravan.
b. Dora and Sandy married Pat and Shravan.

It seems a general property of natural language predicates, then, that they can be truthfully claimed to hold of groups when they hold of the individuals that make up the groups. The definition in (17) summarises this insight by defining systematically for natural language predicates the corresponding pluralized predicate ('x+y' is the sum of x and y; e.g. Dora+Anna is the group individual consisting of Dora and Anna, and the book 'Henriette Potter' is the sum of all its chapters. I assume a mereological structure of the denotation domains, which generally reflects part/whole structures, cf. e.g. Beck & von Stechow (2007). An intuitive understanding is sufficient for our purposes).

(17) Cumulation operators *n (Sternefeld (1998))
Let R be an n-place relation. Then [*n R] is the smallest relation R' such that the conditions in (a) and (b) are satisfied.
(a) $R' \supseteq R$
(b) for all $<x_1,...x_n>$ and $<y_1,...y_n>$:
If $<x_1,...x_n> \in R'$ and $<y_1,...y_n> \in R'$, then $<x_1+y_1,...x_n+y_n> \in R'$

An analysis of (15) and (16) is presented in (18), (19). (18a) and (19a) are the Logical Forms (LFs). They are given in the format of Heim & Kratzer (1998), where e.g. the trace t1 is bound by the binding index 1, deriving a lambda abstraction as in (18b), (19b). The plural operator pluralizes a one-place predicate (type <e,t>, a function from individuals <e> to truth values <t>) in (18) and a two-place predicate (type <e,<e,t>>, a relation between individuals) in (19). (18b) and (19b) are formal representations of the truth conditions derived by compositional interpretation of the structures in (18a), (19a). In (18c), (19c), I give informal paraphrases of those truth conditions.

(18) a. [[Dora and Anna] [*[1[t1 ran 20 miles]]]] (LF)
b. Dora+Anna $\in$ [*λx.x ran 20 miles] (interpretation)
c. The group Dora+Anna can be divided into parts that ran 20 miles. (paraphrase)

(19) a. [[Dora and Sandy][[Pat and Shravan][**[2[1[t1 married t2]]]]]]
b. <Dora+Sandy, Pat+Shravan> $\in$ [**λx. λy.x marrried y]
c. The groups Dora and Sandy, and Pat and Shravan, can be divided pairwise into subgroups that stand in the relation 'marry'.

The analysis of pluractionality shows that pluralization (17) is not just about individual argument slots of predicates, but also event argument slots. The two interpretations of the Klamath example (5) from above are analysed in terms of (17) in (20) and (21) below. (20) is an instance of one-place pluralization, here of a type <v,t> predicate (a property of events, where <v> is the type of events; I use the terms event, eventuality and situation interchangeably here). (21) is an instance of two-place pluralization, here of a type $<e,<v,t>>$ predicate (a relation between individuals and events). (The event argument E (for the 'big' event) presumably gets bound existentially higher up in the tree; I will ignore this point here for simplicity.)

(20) a. $E \in [{}^{*}\lambda e.$ they look in e]
b. The overall event/situation can be divided into subevents each of which is an event of them looking.

(21) a. $<E,\text{they}> \in [{}^{**}\lambda x.\lambda e.x$ look in e]
b. The overall situation and "they" can be divided into parts so that in each subevent there is a part of them looking.

The pluralization of argument slots of predicates in (17) is thus taken to be a fully general mechanism.
Here is an important addition to the theory: The specific interpretation of a plural predication depends on the **salient** parts that a given group is divided into. (22) illustrates (following Schwarzschild (1996)). Imagine as the context a charity running event in which teams try to cover a long distance. The teams have the property 'run 100 miles' in the example. Imagine further that the subjects in the three sentences in (22) refer to the same 10 persons, the ones in {a,b,c,d,e,f,g,h,i,j}. Still, you interpret the three sentences differently. A plausible interpretation of (22a) is one in which the semanticists form a team and so do the logicians. In (22b), it is more plausible that the five women form a team and so do the five men; similarly of (22c). Which teams are intuitively plausible depends on the way the 10 persons are introduced in the context.

(22) a. The semanticists and the logicians ran 100 miles.
- true e.g. if the semanticists ran 100 miles and the logicians ran 100 miles.
b. These five women and these five men ran 100 miles.
- true e.g. if these five women ran 100 miles and these five men ran 100 miles.
c. (You see two separate groups of people in running clothes, all panting.)
These people ran 100 miles.
- true e.g. if the people in the first group ran 100 miles, and so did the people in the second group.

This shows that the family of plural operators employed in natural language is sensitive to a contextually given division of the sums of all the things in the universe of discourse into salient parts. This division is a covert argument of the plural operator, the variable *Cov* below. The actual plural operators thus look like (23) (which pluralises $<e,t>$ predicates) and (24) (for $<e,<v,t>>$ predicates - the analysis generalises as required to further semantic types). (25), (26) analyse (22). In (22a), *Cov* would contain the semanticists as one group and the logicians as another, as indicated in (26a). It is these two salient groups to which the predicate *run 100 miles* applies. Similarly for (22b), (26b) and (22c), (26c).

(23) $[[\mathbf{PL}]] = \lambda Cov.\lambda P_{<e,t>}.\lambda X.\ X \in [{}^{*}\lambda x'.\ x' \in Cov \ \&\ P(x')]$

(24) $[[\mathbf{PL}]] = \lambda Cov.\lambda R_{<e,<v,t>>}.\lambda X.\lambda E.\ <X,E> \in [{}^{**}\lambda x'.\lambda e'.e' \in Cov \ \&\ x' \in Cov \ \&\ R(x')(e')]$

(25) a. These people ran 100 miles.

b. [[these people] [PL_{Cov} [ran 100 miles]]]
c. [[these people]] $\in$ [*λx. x$\in$Cov & x ran 100 miles]
d. 'these people' can be divided into **salient** subgroups each of which ran 100 miles.'

(26) a. Suppose a,b,c,d,e are the semanticists and f,g,h,i,j are the logicians.
{{a,b,c,d,e}, {f,g,h,i,j}}$\subseteq$Cov
Then, (25c) is true iff {a,b,c,d,e} ran 100 miles and {f,g,h,i,j} ran 100 miles.
b. Suppose a,b,c,f,g are the five women and d,e,h,i,j are the five men.
{{a,b,c,f,g}, {d,e,h,i,j}}$\subseteq$Cov
Then, (25c) is true iff {a,b,c,f,g} ran 100 miles and {d,e,h,i,j} ran 100 miles.
c. Suppose a,b,j,f,g are the first group and d,e,h,i,c are the second group, all panting.
{{a,b,j,f,g}, {d,e,h,i,c}}$\subseteq$Cov
Then, (25c) is true iff {a,b,j,f,g} ran 100 miles and {d,e,h,i,c} ran 100 miles.

The variable name *Cov* is chosen to invoke the notion of a cover, defined in (27a). Further concepts used below are defined in (27b,c).

(27) a. A set X is a **cover** of Y if X is such that (i) for each x, x$\in$X: x$\leq$Y, and (ii) $\cup$X=Y.
(where '$\leq$' is the mereological part-of relation, e.g. a$\leq$a+b)
b. A cover X is a **partition** if no two members of X overlap.
c. A partition is a **sequence** if for each x_i, x_j in X: $x_i < x_j$.
(where '<' is the relevant ordering relation, e.g. e<e' if e' occured after e)

Finally, it is important for our purposes that languages have elements that constrain these invisible plural operators and thus in a sense make their presence visible. Such expressions add information on how the pluralities involved are divided up in order to make the plural predication true. In (28), *individually* adds the information that the parts of the plurality consist of singular individuals. In (29), the adverbial 'one at a time' tells us (i) that the relevant parts of 'they' are 'one' (i.e. a singular individual), and (ii) that the subevents form a temporal sequence. The pluractional modifier combines intersectively with the pluralised predicate.

(28) a. These people ran 20 miles **individually**.
b. [[these people] [[$_{<e,t>}$ individually$_{Cov}$] [$_{<e,t>}$$PL_{Cov}$ [ran 20 miles]]]
c. [[individually]] = [λCov.λX.$\forall$z[z$\leq$X & z$\in$Cov -> one(z)]]
d. [[these people]] $\in$ [*λx. x$\in$Cov & x ran 20 miles] &
$\forall$z[z$\leq$[[these people]] & z$\in$Cov -> one(z)]
e. These people can be divided into salient subgroups each of which ran 20 miles and which consist of singular individuals.

(29) a. They looked **one at a time**.
b. [E [they [[$_{<e,vt>}$ one at a time $_{Cov}$] [$_{<e,vt>}$ PL_{Cov} [1[2[t1 look in e2]]]]]]]
c. [[one at a time]] = [λCov.λX.λE.Cov partitions E into a temporal sequence
& $\forall$z[z$\leq$X & z$\in$Cov -> one(z)]]
d. <E,they> $\in$ [**λx.λe.x look in e & x$\in$Cov & e$\in$Cov] &
Cov partitions E into a temporal sequence & $\forall$z[z$\leq$[[they]] & z$\in$Cov -> one(z)]
e. The overall situation and "they" can be divided into parts such that each

relevant subsituation is some relevant part of them looking, and the parts of 'they' have one member and the parts of the overall situation form a temporal sequence.

Such expressions, which also include *all, each, piecewise, in pairs* etc. (Moltmann (1997), Brisson (1998), Zimmermann (2002)), can be understood as constraining what goes into the division of the pluralities into subparts. They are fed by the *Cov* variable introduced by the PL operator, and thus depend on the presence of a plural operator (Oh (2005), Beck & von Stechow (2007)). Clearly, the example in (29) sets us on the right path semantically for the analysis of pluractional 'N Preposition N'.

1.3.2. Travis (2003) on reduplication

Before we can examine the compositional semantics of pluractional 'N Preposition N', we need to adopt an analysis of their syntax. I rely on the proposal in Travis (2003) who assumes that a syntactic head is responsible for the reduplication shown by the data. I call this head RED. Below is an example. The syntax of (30a) is given in (30b). The RED head is joined by the preposition *after* in this example. It is responsible for copying material from its complement into its specifier position - in the example *cup*. (This example and our other data are Travis's case of iterative reduplication; see her paper for further syntactic discussion as well as comparison to other types of reduplication.) Remember that in the core data in (1), the same noun occurs twice, motivating an analysis in terms of syntactic reduplication.

(30) a. cup after cup of coffee
b. $[_{REDP}$ cup $[_{RED'}$ [RED after] $[_{NP}$ cup $[_{PP}$ of coffee]]]]

What is important for our purposes is that RED can be a meaningful element. In the compositional analysis below, it will be crucial for the derivation of the sequence interpretation of data like (30). The RED head is joined first by the preposition of 'N Preposition N' and then by the nominal category, which is only interpreted once (the copy is not semantically active).

We now have all the tools necessary to develop a compositional semantic analysis of 'N Preposition N'. The next section undertakes this task.

2. Varieties of 'N Preposition N'

The central goal of this section is to present a complete compositional analysis of data like (1). Subsection 2.1. introduces a version of the analysis of 'N after N' by Beck & von Stechow (2007). Subsection 2.2. discusses the range of the analysis and possible extensions to further pluractional 'N Preposition N' data, in particular 'N by N', guided by Henderson (2013). In subsection 2.3. we contrast our core data and analysis with 'N Preposition N' adverbials that are not, or not necessarily, pluractional (e.g. (2)), relying on Zwarts (2013).

2.1. N after N

The analysis sketched for 'one at a time' in (29) carries over to the external composition of 'N after N' fairly straightforwardly. Example (1a), repeated in (31), is analysed in (32). The resulting truth conditions for the sentence are described informally in (33). (34) exemplifies a situation in which (31) would be true. (HP in the semantic represenatation abbreviates 'Henriette Potter'. In the picture in (34), 'e1 chap1' represents that e1 is an event of Dora publishing chapter1, etc., in a temporal sequence according to the time line.)

(31) Dora published 'Henriette Potter' **chapter after chapter**.

(32) a. [E [HP [[$_{<e,vt>}$ chapter after chapter$_{Cov}$] [$_{<e,vt>}$ PL$_{Cov}$ [1[2[D. published t1 in e2]]]]]]]
b. <E,HP> ∈ [**λx.λe.Dora published x in e & x∈Cov & e∈Cov] & Cov partitions E into a temporal sequence & Cov partitions HP into chapters
c. [[chapter after chapter]] = λCov.λX.λE.Cov partitions E into a temporal sequence & Cov partitions X into chapters

(33) The overall situation and HP can be divided into parts such that in each relevant subevent, Dora published a successive chapter of HP, and the parts of the overall situation form a temporal sequence.

(34)
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                         E
-----|------------|------------|------------|-----------|------------------>
        e1           e2            e3          e4

      chap1      chap2         chap3   chap4
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This analysis says that 'N after N' is a pluractional modifier, which adds to the pluractional operator PL <e,<v,t>> the information that the division of the event is into a sequence of temporally ordered subevents, and that the parts of the nominal plurality have the property expressed by N. The pluractional modifier 'N after N' in (32c) has a very similar semantics to 'one at a time' in (29c). This formalises the claim from (12a) above, repeated in (35). Next, we ask how the interpretation in (32c), which is the desired contribution of the adverbial to the overall truth conditions, can be composed from its component parts. To approach this question of the internal composition of the 'N after N' modifier, we come back to (35b,c).

(35) a. Pluractionality:
'N Preposition N' expressions characterize pluralities of events.
b. Ordered sequence:
The preposition in 'N Preposition N' may induce a sequence of events.
c. Part/whole structure:
The N in 'N Preposition N' provides the units by which a complex object participates in the multiple events.

First, the preposition in 'N Preposition N' induces the ordering that the sequence is based on. In the case of *after*, the sequence is temporal, as seen in (31). Comparing *after* to *upon*, a spatial sequence seems possible here instead. (38) sketches a paraphrase of (36a) in parallel to the paraphrase in (33) of example (31) (*upon* seems to be compatible with a range of orderings, so nothing more specific will be said). Yet another order is at work for *within*, (37).

(36) a. The dandelion wine stood there **row upon row**.

b. The books stood there **shelf upon shelf**.
c. **Row upon row**, tomato plants stand in formation inside the greenhouse.
d. The wall was built **stone upon stone**.

(37) a. This mystery offers **puzzle within puzzle**.
b. They are arranged **box within box**.

(38) The overall situation and dandelion wine can be divided into parts such that in each relevant subsituation, a row of dandelion wine stands there, and the parts of the overall situation form a spatial sequence.

Secondly, the noun in 'N-Preposition-N' provides the units of the cover of the individual argument of the plural operator - chapters, shelves, rows, stones. Now this information needs to be put together.

As anticipated in section 1, I adopt a structure for the adverbial as in (39), drawing from Travis (2003) and others on reduplicative syntax. The semantically central element of the adverbial is the RED head, enriched here by a cover variable. RED gets an ordering from the preposition. 'Prep$_<$' indicates that the preposition in this construction provides an ordering relation, e.g. temporal precedence in the case of *after* (40). The sequence is based on this order, as indicated by the subscript on ' sequence$_<$'; the two '<' are the same ordering relation. The RED head moreover gets a unit for the elements of the nominal cover from the noun. Its semantics is given in (41). The copy of the noun is not represented because it doesn't contribute to interpretation.

(39) $[[\ \text{RED}_{\text{Cov}}]\ \text{Prep}_<\ ]\ \text{N}]$

(40) $[[\text{after}]] = [\lambda a.\lambda b.b \text{ is after } a] = [\lambda a.\lambda b.a<b]$

(41) $[[\text{RED}]] = \lambda \text{Cov}.\lambda \text{Prep}_<.\lambda \text{N}.\lambda \text{X}.\lambda \text{E}.\text{Cov partitions E into a sequence}_<$
$\quad\quad\quad\quad \&\ \text{Cov partitions X into Ns}$

(42) applies the analysis to the internal composition of 'chapter after chapter'. Given that the ordering relation < provided by *after* is temporal, this is the desired result (32c).

(42) $[[\text{chapter after chapter}_{\text{Cov}}]] = [[\ [[\ \text{RED}_{\text{Cov}}]\ \text{after}_<\ ]\ \text{chapter}]\ ]]$
$= [[\text{RED}_{\text{Cov}}]]([[\text{after}_<]])([[\text{chapter}]])$
$= \lambda \text{X}.\lambda \text{E}.\text{Cov partitions E into a sequence}_<\ \&$
$\quad\quad \text{Cov partitions X into chapters}$

There is an obvious extension of the analysis, which can be exemplified by (1e) repeated in (43a). The paraphrase (43b) indicates pluralization of a <v,t> predicate (in contrast to the <e,<v,t>> predicates discussed so far). The analysis is worked out in (44).

(43) a. Olivia fell off **time after time**.
b. The overall event can be divided into a sequence of subevents ('times') of Olivia falling off.

(44) a. [E [[$_{<v,t>}$ time after time$_{Cov}$] [$_{<v,t>}$ PL$_{Cov}$ [2[Olivia fell off in e2]]]]]

b. E ∈ [*λe.Olivia fell off in e & e∈Cov] & Cov partitions E into a sequence$_<$ of 'times'

c. [[time after time]] = λCov.λE.Cov partitions E into a sequence$_<$ of 'times'

This instance of 'N Preposition N' makes visible very nicely the generality of the analysis in terms of pluralization operators of various semantic types, upon which the adverbials depend.

This concludes the core compositional analysis of 'N after N' and its closest relatives like 'N upon N'. Let me mention a couple of closely related issues briefly.

Reduplicative and non-reduplicative pluractional modifiers: The first is the obvious semantic similarity between (45a) and (45b), and similarly for (46) (remember also the data in (3) from the introduction).

(45) a. Dora published 'Henriette Potter' **chapter after chapter**.

b. Dora published 'Henriette Potter' **one chapter after the other**.

(46) a. Anna piled **book upon book**.

b. Anna piled the books **one on top of the other/ on top of one another**.

Beck & von Stechow (2007) concentrate on the (b)-sentences for the internal composition of the adverbial. They interpret 'the other' to be the preceding N in terms of the ordering relation provided by the preposition. That is, in addition to ordering the events, the preposition induces a derived order of the individuals (something I have left out in the above discussion). Beck & von Stechow leave open the precise connection between (45a) and (45b). With the proposal made in this chapter, we have two independent analyses for the adverbials in place which lead to the same overall sentence interpretation. Future research will show whether this is the right way to think about these data.

Argument and modifier uses: The second issue is illustrated by (46a) and (47a) (and also (37)). Many uses of 'N Preposition N' are as arguments, not as adverbials. Beck & von Stechow propose that an existential type shift derives the argument use from the adverbial. This is illustrated in (47): the shift gets us from the adverbial meaning in (47b) to the existential quantifier in (47c), deriving the meaning in (47d) for (47a). (48) offers a paraphrase. Exploring the consequences of the proposal is again left for future investigation.

(47) a. Dora published **chapter after chapter**.

b. [[[$_{Adv}$ chapter after chapter $_{Cov}$]]] = λX.λE.Cov partitions E into a sequence$_<$ & Cov partitions X into chapters

c. [[[$_{NP}$ chapter after chapter $_{Cov}$]]] = λP.λE.∃X[Cov partitions E into a sequence$_<$ & Cov partitions X into chapters & P(X)(E)]

d. ∃X[Cov partitions E into a sequence$_<$ & Cov partitions X into chapters & <E,X> ∈ [**λx.λe.Dora published x in e & x∈Cov & e∈Cov]]

(48) **There is an X** such that the overall situation and X can be divided into parts such that in each relevant subevent, Dora published a successive chapter of X, and the parts of the

overall situation form a temporal sequence.

2.2. N by N

We now turn to the remaining data from (1), (1c,d) repeated in (49) below. They differ from the data discussed in the last subsection in terms of the preposition. The examples in (49) contain *by*, which in contrast to *after, upon* or *within* does not make available an ordering relation. It is tempting to consider in this context also (50) with *for* and *and*, where the preposition/particle similarly doesn't offer enough content to derive an ordering.

(49) a. They looked **one by one**.
b. Olivia climbed the mountain **meter by meter**.

(50) a. The teams are **dog for dog** as fast as their open class counterparts.
b. The children went into the room **two by/and two**.

Beck & von Stechow claimed that these 'N Preposition N' adverbials do not lead to a sequence interpretation, which Henderson (2013) shows to be wrong. A particularly clear case is provided by Henderson's example (51). In order for (51) to be true there have to be successive widening events, in each of which the crack becomes wider by one inch.[1] This is depicted informally in (52).

(51) a. The crack widened **inch by inch**. (Henderson 2013, p. 475)
b. The overall event can be divided into a sequence of subevents in each of which the crack widened by one inch.

(52)
```
                           E
-----|------------|------------|-------------|------------|----------------->
          e1          e2           e3          e4

        1 inch     1 inch        1 inch     1 inch
```

The analysis from the preceding subsection can be extended to (51) as in (53). (53) differs in some specifics from Henderson's analysis (in particular, he puts the content of the PL operator in the adverbial modifier), but the essentials are the same. The adverbial 'inch by inch' is analysed parallel to 'N after N' above: it provides additional content for the division into subevents - a temporal sequence -, and the unit into which the other plurality is divided - inches. The other plurality in this example is a plurality of degrees D (type <d>), not individuals, and accordingly the example involves <d,<v,t>> pluralization. The degrees are measured by the noun *inch*; see (53c). The verb *widen* is analysed according to von Stechow (1996), Kennedy & Levin (2008): a widening event is an event such that the width of the individual argument (here: the crack C) at the end of the event exceeds its width at the beginning of the event by a difference degree d, cf.

[1] A spatial reading is also possible, see e.g. Deo et al. (2013). This is fully compatible with our general approach (see also Beck & von Stechow (2007), Beck (2012)) but will not be discussed further in this chapter.

(53d). (Let's assume that D, like E, is in the end existentially bound; this is again not represented here).

(53) a. [E [D [[$_{\langle d,\langle v,t\rangle\rangle}$ inch by inch$_{Cov}$] [$_{\langle d,\langle v,t\rangle\rangle}$ PL$_{Cov}$ [1[2[C widened d1 in e2]]]]]
b. <E,D> ∈ [**λd.λe.C widened by d in e & e∈Cov & d∈Cov] & Cov partitions E into a temporal sequence & Cov partitions D into one inch intervals
c. [[inch by inch]] = [[[[RED$_{Cov}$] by] inch]]] = λCov.λD.λE.Cov partitions E into a temporal sequence & Cov partitions D into one inch intervals
d. [[the crack widened]] = λd.λe.Width(C)(end(e)) ≥ Width(C)(begin(e)) + d
'the crack widened by d in e'

The examples in (54) similarly combine a temporal sequence with a change of degree.

(54) a. What happens when the planet gets warmer **degree by degree**?
b. Lose weight **pound by pound**!

(49a) is parallel to (29), i.e. *one by one* is parallel to *one at a time*, with <e,<v,t>> pluralization, and analysed below.

(55) a. They looked **one by one**.
b. [E [they [[$_{\langle e,vt\rangle}$ one by one $_{Cov}$] [$_{\langle e,vt\rangle}$ PL$_{Cov}$ [1[2[t1 look in e2]]]]]]
c. [[one by one]] = [[[[RED$_{Cov}$] by] one]]] = [λCov.λX.λE.Cov partitions E into a temporal sequence & ∀z[z≤X & z∈Cov -> one(z)]]
d. <E,they> ∈ [**λx.λe.x look in e & x∈Cov & e∈Cov] &
Cov partitions E into a temporal sequence & ∀z[z≤[[they]] & z∈Cov -> one(z)]
e. The overall situation and "they" can be divided into parts such that each relevant subsituation is some relevant part of them looking, and the parts of 'they' have one member and the parts of the overall situation form a temporal sequence.

In related data, it seems plausible that paths replace degrees as the plural object for which a unit is provided in 'N by N'. (56) extends the analysis to (49b). This example involves paths (type <l>) instead of degrees or individuals, and once more demonstrates the generality of the analysis for the various semantic types. Some further examples are given in (57). The three semantic types correspond to the three predicate types incremental theme, directed motion and change of state identified by Henderson as taking pluractional 'N by N' modifiers in English.

(56) a. Olivia climbed the mountain **meter by meter**.
b. [E [P [[$_{\langle l,\langle v,t\rangle\rangle}$ meter by meter$_{Cov}$] [$_{\langle l,\langle v,t\rangle\rangle}$ PL$_{Cov}$ [1[2[O climbed M p1 in e2]]]]]
c. <E,P> ∈ [**λp.λe.O climbed M along p in e & e∈Cov & p∈Cov] & Cov partitions E into a temporal sequence & Cov partitions P into 1m long path segments
d. [[meter by meter]] = [[[[RED$_{Cov}$] by] meter]]] = λCov.λP.λE.Cov partitions E into a temporal sequence & Cov partitions P into 1m long path segments
e. [[Olivia climbed the mountain]] = λp.λe.O climbed M along p in e

(56') The overall event and its path can be divided into parts such that each subevent is Olivia climbing the mountain along a part of the path, and the subevents form a temporal sequence, and the path segments measure one meter.

(57) a. Sandy crawled across the beach **meter by meter**.
b. They lowered the barrel **inch by inch**.

Henderson (2013) enriches the empirical picture to include further semantic types of plural operators and pluractional adverbials, and corrects Beck & von Stechow's view of 'N by N' adverbials by pointing out their sequence interpretation. His findings raise interesting further issues. Let's take as our starting point the origin of the ordering relation for the sequence. Beck & von Stechow held the preposition responsible for providing the order for the sequence (and clearly couldn't resort to that in the case of *by*). But Henderson's data show that a temporal ordering is given in 'N by N' nonetheless. This leads to two sets of questions: (i) what is the role of the preposition? What is the range of interpretive possibilities and how are they correlated with the preposition in 'N Preposition N'? (ii) what is the role of the predicate? How does the predicate interact with the sequence interpretation of 'N by N'?

Re (i): We have seen that the sequence in 'N Preposition N' does not have to be temporal: *upon* and *within* open the possibility of spatial orderings. But this does not seem to be available in full generality, cf. the problemantic data in (58). Moreover, not all pluractional 'N Preposition N' adverbials seem to involve a sequence interpretation. An example that seems, after all, to have the simpler semantics that Beck & von Stechow had in mind, and an analysis without the sequence component is sketched in (59). Future research has to provide a clearer empirical picture and a better understanding of the role of the preposition.

(58) a. * Dora published 'Henriette Potter' **chapter before chapter**.
a. ?? Anna pushed **paper under paper**.
b. ?? They are arranged **box around box**.

(59) a. The teams are **dog for dog** as fast as their open class counterparts.
b. The overall situation/event and the teams can be divided into subevents such that each part of the team is a dog, and in each subevent, a dog is as fast as its counterpart.
c. $\langle E,T\rangle \in [{}^{**}\lambda x.\lambda e.x$ is as fast as x's counterpart in e & $x \in Cov$ & $e \in Cov]$ &
Cov is a **cover** of E & $\forall z[z \leq T \;\&\; z \in Cov \rightarrow dog(z)]$

Re (ii): Henderson's observations highlight the role of the predicate in the interaction of pluractional adverb, plural operator and predicate. English 'N by N' appears to require some kind of telic component in the predicate. Some impossibilities involving non-telic predicates are illustrated below.

(60) a. * John exercised **step by step**. (Henderson 2013, p.476)
b. * George shuddered **extremity by extremity**. (Henderson 2013, p.476)

This observation suggests that a temporal order of multiple events is available for pluractional sentences that include a predicate with such a telic component. The order that the RED head works with should come from that.
Constraints on the Aktionsart of the pluralized predicate are pointed out by Beck & von Stechow, (61); while such constraints can be stated, it is not really clear how they follow from the general theory.

(61) a. John ran and ran.
b. * Sally was sick and sick. (Beck & von Stechow 2007, p. 243)

(62) shows that pluractional adverbials need to be examined individually: though English and German look quite parallel, the judgements come out differently (we may speculate that this lead Beck & von Stechow astray in their discussion of 'N by N'). The German counterpart of 'N by N' does not require a telic component.

(62) a. * The graduating seniors waved **student by student**. (Henderson 2013, p476)
b. Die Absolventen winkten **Student für Student**. [German]
the graduating students waved student for student
'The graduating students waved student by student.'

So while the theory presented here provides a general framework for the analysis of pluractional modifiers, it doesn't include an analysis of the constraints and crosslinguistic differences we have observed in this section. A systematic investigation of the constraints on 'N Preposition N' adverbials is an interesting perspective for future research.

2.3. From N to N

Finally, let's take a look at the examples in (2), in distinction to our core data set. We concentrate on (2a,b,c), repeated in (63), and Zwarts' (2013) discussion of these data.

(63) a. She went **from door to door**.
b. He was dressed in black **from head to toe**.
c. I read the book (from) **cover to cover**.

'From N to N' adverbials may be iterative, like (63a), but they need not be, cf. (63b,c). They may involve the same noun, but they don't have to, cf. (63b), also (64). This indicates that they have an analysis different from the one sketched in the preceding subsections.

(64) The whole thing was nonsense **from start to finish**. (Zwarts 2013, p.65)

Zwarts (2013) offers an analysis in which the meaning of a 'From N to N' PP is composed systematically from a set of familiar ingredients. I can only offer a rough sketch here. (65a) below analyses 'from-to' as a complex preposition that combines with two nouns and returns the set of paths that start at an object meeting the description provided by the first noun, and end at an object meeting the description provided by the second. This complex preposition is combined to 'from door to door' in (65b). The example (63a) has an iterative interpretation, hence this property of paths is pluralized. I render this as in (65c). Finally, the PP is a modifier of a predicate of events and adds information about the path of the event, yielding the semantics in (65d).

(65) a. [[from-to]] =
$\lambda P.\lambda Q.\lambda p\exists x,y[P(x)$ & $Q(y)$ & $\exists p1,p2[from(x)(p1)$ & $to(y)(p2)$&$p=p1+p2]]$

b. [[from door to door]] =
$\lambda p\exists x,y[door(x)$ & $door(y)$ & $\exists p1,p2[from(x)(p1)$ & $to(y)(p2)$&$p=p1+p2]]$
set of paths that begin at a door and end at a door

c. $[[[PL_{Cov}$ [from door to door]]]] = [*$\lambda p.p\in Cov$ & $\exists x,y[door(x)$ & $door(y)$ &
$\exists p1,p2[from(x)(p1)$ & $to(y)(p2)$&$p=p1+p2]]]$
paths that can be divided into sub-paths from a door to a door

d. [[She went from door to door]] =
$\lambda e.$ go(e)(she) & path(e) $\in$ [*$\lambda p.p\in Cov$ & $\exists x,y[door(x)$ & $door(y)$ &
$\exists p1,p2[from(x)(p1)$ & $to(y)(p2)$&$p=p1+p2]]]$
events that are going events by her whose paths can be divided into sub-paths from a door to a door

'From N to N' can interact with (further) plural operators, as analysed by Zwarts (2013). A relevant example is given in (66).

(66) a. The squirrel jumped **from tree to tree**.

b. The squirrel jumped **from tree to tree again and again**.
'The overall event can be divided into a sequence of subevents which are jumpings by the squirrel, and the overall path of the event can be divided into sub-paths from a tree to a tree.'

Non-iterative examples work without the pluralization in (65c) and thus only state the beginning and end of one path. This would happen e.g. in (64) (with abstract, i.e. non-spatial paths). For such examples, the existential interpretation in (65) is not plausible. (64) and (63c) are more likely instances of a definite interpretation of the starting and end point of the relevant path. A version of the complex preposition with a shift to a definite interpretation of the nouns is given in (67a) and the meaning of the resulting PP for (63b) in (67b), following Zwarts' analysis. Note that 'From N to N' adverbials do not contain the RED head (no syntactic reduplication) and hence do not require a cooccuring PL operator (no pluractionality).

(67) a. [[from-to]] =
$\lambda P. \lambda Q.\lambda p.\exists p1,p2[from(the\ x:P(x))(p1)$ & $to(the\ y:Q(y))(p2)$&$p=p1+p2]]$

b. [[from head to toe]] =
$\lambda p.\exists p1,p2[from(the\ x:head(x))(p1)$ & $to(the\ y:toe(y))(p2)$&$p=p1+p2]]$
set of paths that begin at the head and end at the toe

Zwarts (2013) thus shows that 'From N to N' adverbials are not by themselves pluractional adverbials. His analysis makes it clear that not all appearances of 'N Preposition N' are about multiple events.
No detailed discussion is offered here of further interesting 'N Preposition N' data like (68); see also Jackendoff (2008). Zwarts's case study suffices to show that they have to be examined individually, and that not all such structures involve multiple events.

(68) a. The houses stand **side by side**. (Beck & von Stechow, p.245)
b. The lovers walked **hand in hand** to the river. (Beck & von Stechow, p.245)
d. He repeated it **word for word**.

3. Conclusions

I have focused in this chapter on pluractional 'N Preposition N' adverbials. They highlight the systematic nature of plural predication in languages that do not systematically mark semantic event pluralization morphologically. The analysis presented is centered around plural operators available at Logical Form. Pluractional adverbials are elements that are dependent on these operators. They make visible that a plural operator is there, by constraining the division into parts that is expressed by the operator (the Cover variable in the framework adopted here). Pluractional adverbials including 'N Preposition N' show that pluractionality is more pervasive than morphology suggests, perhaps even universal.
The analysis assumes operators of various semantic types. The content of the adverbials mirrors that. I have pointed out that we have not yet fully developed a theory of how the connection between plural operator, predicate and adverbial is constrained. While we have the foundations of a theory of 'N Preposition N' pluractionals, both the repercussions for the general crosslinguistic theory of plural predication and a fine-grained study of syntactic and semantic variation remain to be explored. We will get there step by step.

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