Overt Distributivity in Algebraic Event Semantics*

Lucas Champollion

July 22, 2015

Abstract

This is the second in a pair of papers that aim to provide a comprehensive analysis of the semantic phenomenon of distributivity in natural language. This paper provides a unified analysis of observable cross-linguistic differences in overt distributivity operators in the framework of Neo-Davidsonian algebraic event semantics, drawing on previous work by Zimmermann (2002b,a). The previous paper postulated two covert distributivity operators, D and Part, in grammar, even though the semantic effects of D can be subsumed under the workings of Part. This paper motivates this split by arguing that D and Part are lexicalized as adverbial and adnominal distributivity operators in individual languages. For example, English *each* in its various forms lexicalizes D while the German distributive operator *jeweils* lexicalizes Part. For this reason, *jeweils* occurs in a wider range of distributive environments, including distribution over contextually given salient occasions. The proposed analysis explains why those distributive elements that can also used as distributive determiners, such as English *each*, never allow distribution over occasions.

Keywords: distance-distributivity, crosslinguistic semantics, algebraic semantics, adnominal *each*, adverbial *each*, quantifier float, covers

1 Introduction

This paper presents a surface-compositional theory of distance distributivity that relates adnominal and adverbial distributive elements, atomic and cover-based distri-

*For helpful discussions and comments, I am grateful to Chris Barker, Benjamin Bruening, Dylan Bumford, Seth Cable, Robert Henderson, Chris LaTerza, Anna Szabolcsi, Linmin Zhang, Malte Zimmermann and to the audiences of the Stuttgart 2011 workshop on distributivity, the Amsterdam Colloquium 2011, at the University of Potsdam, and to members of my 2013 NYU seminar on algebraic semantics, where earlier versions of this paper and its counterpart, Champollion (2014a), were presented. I thank Manuel Križ and Linmin Zhang for helping me with the surveys reported in this paper. For native speaker judgments on other languages, I thank my consultants Meike Baumann, Isaac Bleaman, Heather Burnett, Ivano Ciardelli, Tuğba Çolak-Champollion, Liz Coppock, Hana Filip, Daði Hafþór Helgason, Hildur Hrólfsdóttir, Gianina Iordăchioaia, Zack Jaggers, Songhee Kim, Sonia Kasyanenko, Sverrir Kristinsson, Jeremy Kuhn, Chigusa Kurumada, Yohei Oseki, Roumyana Pancheva, Floris Roelofsen, Kjell Johan Sæbø, and Gunnar Ingi Valdimarsson. This paper and Champollion (2014a) build in part on some earlier work of mine, for which I am indebted to many people and institutions as indicated there (Champollion, 2012, 2013).

butivity, and distributive determiners to each other. This is one of two self-contained papers that can be read individually but that form a coherent whole. This paper focuses on overt distributivity. Its counterpart, Champollion (2014a), focuses on covert distributivity. While this paper builds on results obtained in Champollion (2014a), the two papers can be read in either order.

Overt and covert distributivity are illustrated in the following examples:

(1) a. The girls each wore a black dress.
b. The girls wore a black dress.

In sentence (1a), the adverbial distributive element *each* distributes the predicate *wear a black dress* over the individual girls and leads to the entailment that each of the girls in question wears a black dress. Sentence (1b) is interpreted in the same way, even though there is no *each*. The ability of verb phrases to distribute in the absence of an overt distributive element has been attributed to what is traditionally called the D operator, a silent counterpart of adverbial *each* (Link, 1987; Roberts, 1987).

The purpose of this paper and of Champollion (2014a) is to bring together several strands of research on phenomena related to the semantics and pragmatics of distributivity in natural language. One of these strands deals with overt distributivity, which is crosslinguistically often expressed via adverbials and adnominals, such as English *each* and German *jeweils*. Such elements differ with respect to whether they are restricted to distribution over individuals mentioned in the same sentence, or whether they can also distribute over pragmatically salient occasions that need not have been explicitly mentioned. This strand is motivated by the properties of adverbial *each* and its adnominal and determiner counterparts both in English and other languages (Zimmermann, 2002b). As we will see, the meanings of these elements varies in ways that sometimes require them to distribute over individuals, such as in the case of *each*, and in other cases allow them to distribute over salient parts of spacetime, such as in the case of *jeweils*, as illustrated in the following example. The focus of this paper is on this strand.

(2) Hans hat jeweils zwei Affen gesehen. *(German)*
Hans has Dist two monkeys seen.
'Hans has seen two monkeys on each occasion.'

The other strand concerns the properties of silent distributivity operators such as the one arguably present in (1b). Covert phrasal distributivity has been at the center of a long debate as to whether it always involves distribution over atoms – singular individuals – or whether it can also involve distribution over nonatomic entities (Lasersohn, 1989; Gillon, 1990). This is the focus of Champollion (2014a). I reserve the term *D operator* for distributivity operators that always distribute over atoms. As for the nonatomic version of the operator, whose meaning may be paraphrased as *each salient part of*, I will refer to it as the *Part operator*, following Schwarzschild (1996).

As this sketch already suggests, overt and covert distributivity share many similarities. In both cases, some elements can only distribute to atoms (*each, D*) while others can distribute to salient nonatomic entities (*jeweils, Part*). And as we will see, in both cases, the former elements can only distribute over pluralities that have been explicitly mentioned while the latter elements can also distribute over salient domains that have not been explicitly mentioned, such as temporal occasions. These similarities give rise to analogous questions in the overt and in the covert case. Can a given distributive element (be it a covert operator or an overt lexical item) only distribute down to singular entities or also to plural entities? Do these entities need to be of a certain size or "granularity", and can this size vary from element to element? Must these entities have been overtly mentioned in the sentence and thereby contributed by semantic means, or can they also be supplied by the context via pragmatic means?

A unified semantic analysis of distributivity should make it apparent which aspects of the meanings of various distributivity operators are always the same, and along which dimensions these meanings can differ. The theory should capture the semantic variation across distributivity-related elements should be captured . The resulting system should be fully formalized and explicit.

This paper, together with Champollion (2014a), contributes towards these goals. By combining ideas from algebraic semantics and event semantics, the two papers provide a framework in which the split in overt distance-distributive elements can be related to the debate in the literature on covert distributivity. In this framework, the various uses of *each* in English are all lexically related to the distributivity operator, either in its semantic, atomic form as defined by Link (1987) or in its pragmatic, salience-related form as defined by Schwarzschild (1996). As we will see, these various uses of *each* and these silent operators share some part of their meanings with each other and with their counterparts across languages. This fact is captured by deriving them from related distributivity operators which differ only in possible settings of two parameters and the ranges of values they allow for them. One parameter indicates the dimension in which distributivity takes place. This can be a thematic role in some semantic instances of distributivity, or a spatial or temporal dimension in other instances. The other parameter indicates the size of the entities over which distributivity takes place, such as atoms or salient amounts of space or time. These parameters interact with each other against the background of assumptions about the metaphysics of natural language. For example, time is assumed to be either nonatomic or in any case to not make its atoms available to the semantics of natural language. As a result, when the first parameter is set to time, the second cannot be set to anything involving atoms, because time does not provide any atoms to distribute over. This simple idea turns out to explain and connect a range of superficially unrelated facts observed in various places in the literature. It is situated within a broader framework that connects it to aspect and measurement under the name of strata theory (Champollion, 2010b).

In this paper, I provide a view on the seemingly noncompositional behavior of distance-distributive elements on which they look much more well-behaved than might be expected. The analysis is surface-compositional, reuses many independently motivated assumptions, and avoids unusual semantic mechanisms such as index-driven and crosswise lambda abstraction (Zimmermann, 2002b). I also avoid nonstandard and otherwise unmotivated concepts such as distributive polarity items (Oh, 2001, 2006). The analysis is placed in the context of algebraic event semantics. This allows us to formally model the relations between distribution over individuals and over events, as well as those between distribution over atoms and over nonatomic parts. The paper provides a formal framework for algebraic event semantics and makes an explicit proposal for how the compositional process can be modeled.

When we move to algebraic event semantics, the theory of distributivity operators developed by Link (1987) and extended by Schwarzschild (1996) turns out to require adjustments for a number of reasons, as discussed in Champollion (2014a). As shown by the following examples, the Neo-Davidsonian event semantic setting gives us the ability to think of the D and Part operators as being coindexable with different thematic roles. This allows us to capture through a simple change in coindexation the kinds of configurations that have otherwise been taken to require type-shifting-based reformulations of these operators (Lasersohn, 1998):

(3) a. The first-year students D(took an exam). *Target: agent*
 b. John D(gave a pumpkin pie) to two girls. *Target: recipient*

The reformulation of the distributivity operators in Champollion (2014a) provides the groundwork on which I build in this paper in order to formally relate this ambiguity to the one observable in examples like the following:

(4) The boys told the girls two stories each. *Target: agent*
 (two stories per boy)

(5) The boys told the girls two stories each. *Target: recipient*
 (two stories per girl)

To capture this and other parallels between covert and overt distributivity, I will propose that distance-distributive elements across languages are in essence overt versions of the D and Part operators.

The theoretical picture that has been sketched so far, and that is developed below and in Champollion (2014a), provides us with a way to formulate commonalities and differences across instances of distributivity in natural language. Individual elements can be analyzed as being hard-wired for certain parameter values, so that, for example, the difference between Link's and Schwarzschild's operators, as well as that between *each* and *jeweils*, can be described in terms of whether the value of the granularity parameter is prespecified to *Atom* or can be filled in by context. In this way, overt and covert instances of distributivity fit together and into distributivity theory more generally.

To develop this picture, Section 2 starts by describing relevant facts and generalizations about overt instances of distributivity across languages, drawing largely on the crosslinguistic discussion in Zimmermann (2002b). The two strands – overt and covert distributivity – are brought together in Section 3, which develops a surface-compositional account of overt distance distributivity. Section 4 compares the present analysis with Zimmermann (2002b). Section 5 extends the analysis to the determiners *each* and *every*, and shows that it accounts for cumulative readings of the latter. The way in which meanings of overt distributive elements vary across languages is explained in Section 6. Section 7 deals with more complicated syntactic configurations, some of which previously lacked a surface-compositional analysis. Section 8 concludes.

2 Overt Distributivity Across Languages

Distributive elements have different syntactic uses and different meanings across languages. In English, the distributive quantifier *each* can be used in at least three ways, which I will refer to as adnominal, adverbial, and determiner *each* respectively:

(6) a. **Adnominal each:** Two men have carried three suitcases *each*.
    b. **Adverbial each:** Two men have *each* carried three suitcases.
    c. **Determiner each:** *Each* man has carried three suitcases.

There are many terms for these three uses. Adnominal *each* has also been called shifted (Postal, 1974), an anti-quantifier (Choe, 1987), binominal (Safir and Stowell, 1988), or ditransitive (Roberts, 1987). Adverbial *each* has also been called floated (Choe, 1987). Determiner *each* is also called prenominal (Safir and Stowell, 1988). For the purpose of this paper, I set aside the use of *each* in other constructions, notably the reciprocal *each other* and the partitive *each of the men*. On the connection between reciprocals and *each*, see for example LaTerza (2014b). (I have not been able to access LaTerza (2014a) in the preparation of this paper, but I understand from its author that it is likely to be relevant to this discussion.) I will refer to the noun phrase *two men* in (6a) and (6b) as the antecedent of *each*, and to the noun phrase *three suitcases* in (6a) as the host of adnominal *each*.

I will refer to adnominal and adverbial *each* and to similar elements across languages as distance-distributive elements. That term is taken from Zimmermann (2002b). There is a slight difference in terminology: Zimmermann reserves the term *distance distributivity* for adnominal elements while I use it both for adnominal and for adverbial elements. This seems appropriate because adverbial *each* can be separated from its antecedent, for example by an auxiliary as shown in (6b).

Adnominal *each* can be shown by movement tests to form a constituent with its host noun phrase (Burzio, 1986; Safir and Stowell, 1988). Distance-distributive elements like it are sometimes thought of as a challenge for compositional semantics, because their interpretations are similar to those of distributive determiners even though their surface syntactic structure appears to be fundamentally different (Oh, 2001, 2006). For example, adnominal *each* in the object of sentence (6b) is contained in the constituent over which it seems at first sight to distribute, namely the verb phrase *carried three suitcases each*. This is of course similar to the challenge represented by quantifiers in object position (*carried every suitcase*), and the standard solutions to that challenge are available in both cases. For example, one can lift the type of the quantifier or the verb in order to give the quantifier scope over the verb phrase (Hendriks, 1993; Barker, 2002). I will follow the same general strategy in the formal analysis below. In fact, I will assume that the scope of adnominal *each* is even more restricted than that of object quantifiers: it takes scope only over its host noun phrase (Dotlačil, 2011, 2012; LaTerza, 2014b). So there is no special challenge for compositionality.

As we have seen in the pair of examples in (4) and (5) above, adnominal *each* can target different antecedents. This dependency is generally regarded as a case of ambiguity rather than underspecification, and I will follow this view. There are syntactic constraints on the distribution of adnominal *each* with respect to its antecedent, such as c-command requirements and clausemate conditions. Accordingly, the dependency has been variously argued to be similar to that of reflexive pronouns with respect to their antecedents (Burzio, 1986; Safir and Stowell, 1988) or to that of traces of noun phrases that undergo raising with respect to these noun phrases (Sportiche, 1988). Similarly, adverbial *each* has been variously claimed to be related to its antecedent by movement, in the sense that it modifies the trace of its antecedent, or to be base-generated, in which case its relation to its antecedent can be taken to be anaphoric. For an overview of these conflicting claims and their implications, see Bobaljik (2001).

I will not have anything to add to the discussion on these syntactic constraints. Since the nature of the dependency between adnominal and adverbial *each* and their antecedents is not the focus of this paper, I will not take a strong position on it. In the formal theory to be developed below, I will represent it via coindexing of thematic relations, which is more in line with anaphora-based accounts than with movement-based ones. In this, I follow previous semantic analyses that interpret adnominal *each* without any movement, such as Zimmermann (2002b). My coindexing-based analysis is compatible with syntactic accounts because it treats *each* as an anaphoric element. I assume that coindexing of thematic relations is similar to other dependencies that are commonly formalized by coindexation, for example those between reflexive pronouns and their antecedents. These dependencies are subject to binding theory constraints, which can vary from language to language (Chomsky, 1981; Büring, 2005). Should the movement-based view turn out to be the correct one, the syntax-semantics interface may need to be modified accordingly, for example by incorporating elements from the theory of Cable (2014).

Turning now to other languages, adnominal and adverbial *each* are translated in German by one word, *jeweils* (Moltmann, 1997; Zimmermann, 2002b). Determiner *each*, however, is translated by another word, *jed-*. I gloss distance-distributive elements as Dist since, as we will see, they have a wider range of readings than *each.* Example (7a) is adnominal, example (7b) is adverbial, and example (7c) contains a determiner. Though adverbial and adnominal *jeweils* take the same surface position in (7a) and (7b), they can be teased apart syntactically, as discussed in Zimmermann (2002b).

(7) a. Die Jungen haben [*jeweils* [drei Koffer]] getragen.
The boys have Dist three suitcases carried.
b. Die Jungen haben [*jeweils* [drei Koffer getragen]].
The boys have Dist three suitcases carried.
c. *Jeder/*Jeweils* Junge hat drei Koffer getragen.
Each.sg.m/Dist boy has three suitcases carried.

As we will see, *each* and *jeweils* generalize to two classes of distance-distributive elements across languages. *Each*-type distance-distributive elements can also be used as determiners. *Jeweils*-type distance-distributive elements cannot double as determiners. Some languages have distance-distributive elements which can also function as distributive determiners, as in English, and others are like German in that they have no such elements (Zimmermann, 2002b). Across these languages, Zimmermann observes that distance-distributive elements which can also be used as determiners (e.g. *each*) always distribute over individuals, as determiners do. In contrast, many of those distance-distributive elements which are formally distinct from determiners (e.g. *jeweils*) can also distribute over salient occasions, that is, over chunks of time or space.

Let me illustrate this observation by using German *jeweils*, a distance-distributive element which cannot double as a distributive determiner. *Jeweils* can distribute over individuals like English *each*, but also over spatial or temporal occasions, as long as context provides a salient set of such occasions. I call this the occasion reading. It corresponds to what is also called the *spatial key reading* and the *temporal key reading* (Balusu, 2005; Balusu and Jayaseelan, 2013). I leave open the question of whether or not the spatial and temporal cases should be distinguished as two separate readings. The framework I will present can accommodate both possibilities. Another, less theory-neutral term for the occasion reading is *event-distributive reading* (Oh, 2001, 2006). Zimmermann (2002b) uses the term *adverbial reading* for it. This term is potentially misleading, because it suggests that only the adverbial use of *jeweils* can give rise to this reading. But adnominal *jeweils* can give rise to it as well (Zimmermann, 2002b, ch. 5). For example, in (8), *jeweils* is part of the subject noun phrase (we know this because German as a V2 language allows only one constituent before the tensed verb *standen*) and is therefore adnominal. However, as shown by the paraphrase, this instance of *jeweils* distributes over occasions, not over individuals.

(8) Jeweils zwei Jungen standen Wache.
DIST two boys stood watch.
'Each time, two boys kept watch.' (German)

The following examples illustrate the occasion reading. Sentence (9) is ambiguous between a reading that distributes over individuals – the ones of which their plural subject consists, (9a) – and one that distributes over occasions (9b).

(9) Die Jungen haben jeweils zwei Affen gesehen.
The boys have DIST two monkeys seen.
a. 'Each of the boys has seen two monkeys.'
b. 'The boys have seen two monkeys each time.' (German)

While the former reading is always available, the latter requires a supporting context. That is, when (9) is uttered out of the blue, it only has the reading (9a). The reading (9b), by contrast, is only available in contexts where there is a previously mentioned or otherwise salient set of occasions, such as contexts in which the boys have been to the zoo on several previous occasions.

Unlike *each*, *jeweils* can also occur with a singular subject, as in (10), repeated here from (2), which only has an occasion reading.

(10) Hans hat jeweils zwei Affen gesehen.
Hans has DIST two monkeys seen.
'Hans has seen two monkeys on each occasion.' (German)

This sentence is odd out of the blue, and it requires supporting context in the same way as reading (9b) does. Its other potential reading would involve vacuous distribution over only one individual, Hans. This is presumably blocked through the Gricean maxim of manner "Be brief" or a non-vacuity presupposition or implicature or whatever else prevents vacuous distributivity (Roberts, 1987, p. 219). For more discussion of this point, and for a fuller discussion of the kinds of noun phrases that can license adnominal *each* in English, see Champollion (2014b).

In the presence of contextual cues, *jeweils* is also able to distribute over nonatomic pluralities. Since this data point will be critical in the following development, I confirmed it through a large-scale web survey (300 participants) run in June 2015 on the online platform Ibex Farm (Drummond, 2013). Participants were recruited using the German online labor market platform Clickworker (http://www.clickworker.de). The survey contained the following target item and question:

(11) Dreißig Jungen wurden in Dreiergruppen aufgeteilt. Sie bekamen jeweils
Thirty boys were in triplet.groups divided. They received DIST
einen Ball.
one ball.
'Thirty boys were divided into groups of three. Each group (or: each boy) received one ball.'

(12) Wie viele Bälle wurden insgesamt verteilt?
How many balls were altogether distributed?
'How many balls were distributed in total?'

Participants were asked to type their answer to this question into a text field. A filler task and demographic questions were used to check whether subjects paid enough attention and whether they satisfied the criteria for the survey. The filler task consisted of a simple question:

(13) In wie viele Gruppen wurden die Jungen aufgeteilt?
In how many groups were the boys divided?

The target and filler tasks were displayed in random order, followed by the demographic questions. 30 participants responded to the filler with an answer distinct from ?10? (mostly ?3?) and were removed from the results. In addition, 36 participants were removed because they were nonnative speakers of German or did not spend all of their childhood in Germany. The remaining 234 data points are summarized in Table 1.

Choice	Raw frequency	Percentage
(i) 10	153	65%
(ii) 30	78	33%
(iii) 3	3	1%
(iv) other	0	0%
Total	234	100%

Table 1: Results of the survey on nonatomic readings with *jeweils*

These results suggest that about two thirds of the participants interpret *jeweils* as meaning "per group", while one third interprets it as meaning "per boy". For reasons discussed in Champollion (2014a), I model these pluralities of boys as salient nonatomic entities, rather than as "group atoms" in the sense of Landman (1989).

The previous example suggests that a contextually salient distribution over pluralities of individuals is sufficient for nonatomic interpretations of *jeweils*. In fact, it is a prerequisite. Out of the blue, that is in the absence of supporting context, *jeweils* is not able to distribute over nonatomic entities. This can be seen in the following sentence suggested by a reviewer, which is based on an example in Gillon (1987) (for discussion, see Champollion (2014a):

(14) Rodgers, Hammerstein und Hart haben jeweils ein Musical geschrieben.
Rodgers, Hammerstein and Hart have DIST a musical written.
Intended: 'There is a cover over Rodgers, Hammerstein and Hart such that each part of that cover wrote a musical.'

Out of the blue, (14) is false in the actual world, even though Rodgers and Hammerstein wrote a musical together and Rodgers and Hart wrote another musical together. The mere existence of a nonatomic cover is not sufficient to make a *jeweils* sentence true. Rather, its cells – the two nonatomic entities that each wrote a musical together – need to be made salient. Since (14) is uttered out of the blue, the relevant cover is not salient, and so the putative reading on which the sentence would be true does not arise.

While *jeweils* allows distribution both over individuals and over salient nonatomic entities, this is not the case for all distance-distributive elements (Zimmermann, 2002b). Across languages, many adnominal distance-distributive elements can only distribute over individuals. For example, English adnominal *each* lacks the occasion reading:

(15) The boys saw two monkeys each.
   a. *Available:* 'Each of the boys saw two monkeys.'
   b. *Unavailable:* 'The boys saw two monkeys on each occasion.'

When adnominal *each* is used in a sentence whose subject is singular, distribution over individuals is not possible, again presumably for pragmatic reasons:

(16) *John saw two monkeys each.

Unlike (10), this sentence lacks an occasion reading, even with supporting context. To make the occasion reading surface, one needs to add an overt noun like *time*:

(17) John saw two monkeys each time.

We have seen that English *each* also differs from German *jeweils* in that only the former can also be used as a determiner. Coming back to what I mentioned at the beginning of this section, Zimmermann reports the following generalization (Zimmermann, 2002b):

(18) **Zimmermann's generalization:** All *each*-type distance-distributive elements (i.e. those that can also be used as determiners) can only distribute over individuals. This contrasts with *jeweils*-type distance-distributive elements, many of which can also distribute over salient spatial or temporal occasions.

This generalization is based in part on the following examples, which show that distance-distributive elements in Dutch, French, Italian, Icelandic, Japanese, Norwegian, and Russian all behave like English *each* in two ways: They can also be used as distributive determiners, and they lack the occasion reading except when an extra noun *time* is added. Many of the following examples are taken from Zimmermann (2002b).

(19) De jongens hebben *elk* twee boeken gelezen.
the boys have DIST two books read
'The boys have read two books each.' (Dutch)[1]

(20) *Elk* jonge heeft twee boeken gelezen.
DIST boy has two books read
'Each boy has read two books' (Dutch)[2]

(21) Hans heeft *elke* *(keer) twee boeken gelezen..
Hans has DIST time two books read.
'Hans has read two books each time.' (Dutch)[3]

(22) Les professeurs ont lu deux livres *chacun/chaque*.
the professors have read two books DIST
'The professors have read two books each.' (French)[4]

(23) *Chaque* professeur a lu deux livres.
DIST professor has read two books
'Each professor has read two books.' (French)[5]

(24) Pierre a lu deux livres *chaque* *(fois) / **chac-un(e)*(fois).
Pierre has read two books DIST time
'Pierre read two books each time.' (French)[6]

(25) Strákarnir keyptu tvær pylsur hver.
the.boys bought two sausages DIST
'The boys bought two sausages each.' (Icelandic)[7]

(26) Hver strákur keypti tvær pylsur.
DIST boy bought two sausages.
'Each boy bought two sausages.' (Icelandic)[8]

(27) Pétur keypti tvær pylsur hvert *(sinn).
Peter bought two sausages DIST time.

---

[1] Zimmermann (2002b, p. 40)

[2] Zimmermann (2002b, p. 44)

[3] Floris Roelofsen, p.c. to the author

[4] Tellier and Valois (1993, p. 574, ex. 1a) quoted in Zimmermann (2002b, p. 41). *Chaque* is colloquial as an adnominal. While French adnominal *chacun* and determiner *chaque* are not exactly identical, they are historically related and can still be considered formally identical (Grevisse, 1980; Junker, 1995; Zimmermann, 2002b, p. 44, fn. 30).

[5] Zimmermann (2002b, p. 44)

[6] Author's judgment, adapted from Zimmermann (2002b, p. 47)

[7] Meike Baumann, Daði Hafþór Helgason, Hildur Hrólfsdóttir, Sverrir Kristinsson, Gunnar Ingi Valdimarsson (p.c.)

[8] Meike Baumann, Daði Hafþór Helgason, Hildur Hrólfsdóttir, Sverrir Kristinsson, Gunnar Ingi Valdimarsson (p.c.)

‘Peter bought two sausages each time.’ (Icelandic)[9]

(28) I ragazzi comprarono un libro *ciascuno*.
the boys bought a book Dist
‘The boys bought one book each.’ (Italian)[10]

(29) *Ciascun* ragazzo ha comprato due salsicce.
Dist boy has bought two sausages
‘Each boy has bought two sausages.’ (Italian)[11]

(30) *Peter ha comprato due salsicce *ciascun/-o/-e*.
Peter has bought two sausages Dist
Intended: ‘Peter has bought two sausages.’ (Italian)[12]

(31) Otoko=tati-ga *sorezore* huta=ri-no zyosei-o aisi teiru koto.
men=pl-nom Dist two=cl-gen women-acc love-asp fact
‘The men love two women each.’ (Japanese)[13]

(32) *Sorezore*-no gakusei-ga iti=dai-no piano-o motiage-ta.
Dist-gen student-nom one=cl-gen piano-acc lift-past
‘Each student lifted one piano.’ (Japanese)[14]

(33) Taroo-wa sorezore-?(de) iti-dai-no piano-o motiage-ta.
Taroo-top Dist(-loc) one-cl-gen piano-acc lift-past
‘Taroo lifted one piano on each occasion.’ (Japanese)[15]

(34) Guttene har kjøpt to pølser *hver*.
boys-the have bought two sausages Dist
‘The boys bought two sausages each.’ (Norwegian)[16]

(35) *Hver* gutt har kjøpt to pølser.
Dist boy has bought two sausages
‘Each boy has bought two sausages.’ (Norwegian)[17]

(36) Jon har kjøpt to pølser *hver* *(gang).
Jon have bought two sausages Dist
Intended: ‘Jon has bought two sausages each time.’ (Norwegian)[18]

(37) Mal’chiki kupili (po) dve sosiski *kazhdyj*.
boys.nom bought two sausage.gen.sg Dist
‘The boys bought two sausages each.’ (Russian)[19]

[9] Meike Baumann, Daði Hafþór Helgason, Hildur Hrólfsdóttir, Sverrir Kristinsson, Gunnar Ingi Valdimarsson (p.c.)
[10] Burzio (1986, p. 198, ex. 50b) quoted in Zimmermann (2002b, p. 41)
[11] Zimmermann (2002b, p. 44)
[12] Ivano Ciardelli, p.c. to the author
[13] Sakaguchi (1998, p. 115, ex. 1) quoted in Zimmermann (2002b, p. 41)
[14] Sakaguchi (1998, p. 4, ex. 7)
[15] Chigusa Kurumada, p.c. to the author. Kurumada comments that the sentence without *de* feels like an elliptical version of the sentence with *de*.
[16] Øystein Vangsnes, p.c. to Zimmermann (2002b, p. 40)
[17] Zimmermann (2002b, p. 44)
[18] Kjell Johan Sæbø, p.c. to the author
[19] Olga Borik, p.c. to Zimmermann (2002b, p. 41)

(38) *Kazhdyj* mal'chik kupil dve sosiski.
DIST boy bought two sausages
'Each boy bought two sausages' (Russian)[20]

(39) Petja pokupal dve sosiski *kazhdyj* *(raz).
Petja buy.perf two sausage DIST (time)
'Peter bought two sausages each time.' (Russian)[21]

Zimmermann's generalization states that every distance-distributive element that can be used as a determiner lacks the occasion reading. The opposite is not the case, however. For example, the Romanian distance-distributive element *cîte* lacks the occasion reading, but it cannot be used as a determiner. This is illustrated in the following:

(40) Doi oameni au cărat *cîte* trei valize.
two men have carried DIST three suitcases
'Two men have carried three suitcases each.' (Romanian)[22]

(41) **Cît(e)* student a plecat.
DIST student has left.
Intended: 'Each student has left.' (Romanian)[23]

(42) *Petru a cîștigat *cîtă/cîte* (dată).
Peter has won DIST.f/DIST.adv time.
Intended: 'Peter won each time.' (Romanian)[24]

Zimmermann considers Japanese as an example of the same phenomenon that I have illustrated with Romanian, but whether this is correct is not very clear. Zimmermann bases his view on the fact that the Japanese distance-distributive item *sorezore* differs formally from what he calls the Japanese distributive determiner-quantifier *wh... + mo*, which is illustrated in (43).

(43) *Dono* gakusei-mo sooseezi-o hutatu katta.
which student-MO sausage-acc two-cl bought
'Every student bought two sausages.' (Japanese)[25]

However, *sorezore* can also be used in the position of a determiner, as example (32) above shows. The syntactic status of *sorezore* in this example, and therefore the import of Japanese on Zimmermann's generalization, is debatable since Japanese is usually assumed to lack overt determiners.

While Romanian and possibly Japanese are counterexamples to the inverse of Zimmermann's generalization, that inverse direction still describes a tendency. That is, in many languages where adnominal distance-distributive elements have occasion readings, they cannot be used as determiners. In addition to German *jeweils*, adnominal

[20] Olga Borik, p.c. to Zimmermann (2002b, p. 44)
[21] Sonia Kasyanenko, p.c. to the author
[22] Gil (1982, p. 19, ex. 1f), Zimmermann (2002b, p. 41)
[23] Brasoveanu and Farkas (2011, p. 10), Gianina Iordăchioaia, p.c.
[24] Gianina Iordăchioaia, p.c. There is a related expression *cîte-o-dată* that means *from time to time.*
[25] Satoshi Tomioka, p.c. to Zimmermann (2002b, p. 45)

distance-distributive elements in Bulgarian, Czech, and Korean have occasion readings cannot be used as determiners, as is shown below. Most of these observations are due to Zimmermann (2002b). The Korean case is also discussed in depth by Choe (1987) and by Oh (2001, 2006).

(44) John i Mary kupiha *po* edna tetradka.
John and Mary bought DIST one notebook
'John and Mary bought one notebook each.' (Bulgarian)[26]

(45) *Vsjako/*Po* momche kupi dve jabulki.
DIST boy bought two sausages
'Each boy bought two sausages.' (Bulgarian)[27]

(46) Mary byaga *po* 5 mili predi zakuska.
Mary runs DIST 5 miles before breakfast
'Mary runs 5 miles before breakfast (every morning).' (Bulgarian)[28]

(47) Chlapci koupili *po* dvou párcích/párkách.
boys bought DIST two sausages.loc
'The boys bought two sausages each.' (Czech)[29]

(48) *Každý/*Po* chlapec koupil dva párky.
DIST boy bought two sausages
'Each boy bought two sausages.' (Czech)[30]

(49) *Po* třech ženách vstupovalo do místnosti.
DIST three.loc women.loc entered.3sg into room
'Three women entered the room [i.e., one triplet after another]' (Czech)[31]

(50) ai-tul-i phwungsen-hana-*ssik*-ul sa-ess-ta.
child-pl-nom balloon-one-DIST-acc bought
'The children bought one balloon each.' (Korean)[32]

(51) Sonyen-mata chayk-ul twu kwen-*ssik* sa-(a)t-ta.
boy-DIST book-acc two cl-dist buy-past-dec
'Every boy bought two books.' (Korean)[33]

(52) na-nun [phwungsen- hana-*ssik*-ul] sa-ess-ta.
I-top balloon one-DIST-acc bought
'I bought a balloon (each time / each day / at each store).' (Korean)[34]

Many languages express adnominal distance distributivity by a bound morpheme (either an affix or a reduplicative morpheme) that attaches to a numeral (Gil, 1982). In this category, on the one hand, we find cases where this process does not give rise

[26]Petrova (2000) quoted in Zimmermann (2002b, p. 41)
[27]Milena Petrova, p.c. to Zimmermann (2002b, p. 45); Roumyana Pancheva, p.c. to the author
[28]Petrova (2000, ex. 3b) quoted in Zimmermann (2002b, p. 41)
[29]Hana Filip, p.c. to Zimmermann (2002b, p. 41)
[30]Hana Filip, p.c. to Zimmermann (2002b, p. 45) and to the author
[31]Hana Filip, p.c. to Zimmermann (2002b, p. 47) and to the author
[32]Choe (1987, p. 49, ex. 13) quoted in Zimmermann (2002b, p. 41)
[33]Kim, p.c. to Zimmermann (2002b, p. 45)
[34]Choe (1987, p. 49, ex. 13) quoted in Zimmermann (2002b, p. 47)

to occasion readings, such as Hungarian (Farkas, 1997; Szabolcsi, 2010) and Turkish (Tuğba Çolak-Champollion, p.c.). On the other hand, we find cases where it does, such as Telugu (Balusu, 2005; Balusu and Jayaseelan, 2013) and Tlingit (Cable, 2014). All these cases are illustrated below. The import of these facts on Zimmermann's generalization is unclear, since bound morphemes are not expected to be able to act as determiners. I mention them here for completeness and because the compositional analysis given below extends to them.

(53) pilla-lu renDu renDu kootu-lu-ni cuus-ee-ru.
kid-pl two two monkey-pl-acc see-past-3pl
a. 'The kids each saw two monkeys.'
b. 'The kids saw two monkeys each time.'
c. 'The kids saw monkeys in groups of two.' (Telugu)[35]

(54) A gyerekek *két-két* majmot láttak.
The children two-two monkey.acc saw.3pl
a. *Available:* 'Each of the children saw two monkeys.'
b. *Unavailable:* 'The children saw two monkeys each time.' (Hungarian)[36]

(55) Çocuklar iki-ş-*er* sosis aldı.
The children two.Dist sausage bought.
'The children bought two sausages each.' (Turkish)[37]

(56) *Can iki-ş-*er* sosis aldı.
Can two.Dist sausage bought.
Intended: 'Can bought two sausages each time.' (Turkish)[38]

(57) *Nás'gigáa* xáat has aawasháat.
three.Dist fish 3pls.3o.caught
a. 'They caught three fish each.'
b. 'They caught three fish each time.' (Tlingit)[39]

The facts discussed so far suggest the following requirements for a semantic analysis of distance-distributivity. First, the synonymy of the determiner, adnominal and adverbial uses of *each* in English should be captured, ideally by essentially identical lexical entries. Second, the fact that distance-distributive elements across languages share some part of their meanings (namely their individual-distributive readings) should be represented, as well as the fact that some of them can also have occasion readings. Third, the analysis should clarify the connections between distance-distributive elements and distributivity theory more generally, and the semantic variation across distance-distributive elements should be captured. Finally, an explanation for Zimmermann's generalization should be readily available. The rest of the paper develops an analysis

[35] Balusu and Jayaseelan (2013, p. 67, ex. 15a)
[36] Szabolcsi (2010, p. 138, ex. 99)
[37] Tuğba Çolak-Champollion, p.c. to the author.
[38] Tuğba Çolak-Champollion, p.c. to the author. This sentence is unacceptable on the intended reading. According to my consultant, it may be thatăit is acceptable under the reading *Can bought two sausages of each kind.*
[39] Cable (2014, ex. 3b)

that fulfills these requirements.

The semantic analysis I will propose is semantic and not syntactic in nature. As such, it does not aim to explain every crosslinguistic difference there is. For example, I will not be able to shine additional light on why English-type languages are more reluctant to allow for the inverse distribution of subject over object denotations than some German-type languages are.

(58) *One journalist each interviewed the politicians.

(59) Jeweils ein Journalist interviewte die Politiker.
DIST one journalist interviewed the policitians.
'The politicians were interviewed by one journalist each.

See Zimmermann (2002b, Sect. 5.4.2 and 5.4.3) for extensive discussion and a syntactic account.

3 Relating Overt and Covert Distributivity

The connection between the D operator from Link (1987) and adverbial *each* that was illustrated in (1) has been noted many times. I take adverbial and adnominal *each* and related distance-distributive elements in Dutch, French, Italian, Japanese, Norwegian, and Russian to be essentially D operators. These are the languages mentioned in Section 2 as being English-type. As for *jeweils* and its relatives in German-type languages like Bulgarian, Czech and Korean, we have seen that they can distribute over spatial and temporal intervals – arguably nonatomic entities. Link's D operator always distributes down to individual atoms and can therefore not be extended to these cases. So I will connect them to the nonatomic distributivity operator Part from Schwarzschild (1996).

I now present a formally explicit, surface-compositional account of the overt distributive elements described in Section 2 in terms of the covert distributive operators D and Part discussed in Champollion (2014a) and in the literature on covert distributivity as summarized there. For the sake of brevity, I will only execute the analysis for English *each* and German *jeweils*, but it should be clear how to extend it to other distributive elements depending on which one of these two they pattern with. I will only show how to model the individual-distributive and the temporal occasion readings. The extension from the temporal to the spatial occasion reading is straightforward.

The guiding idea of the analysis is that overt distributive elements include two versions of the distributivity operator. *Each* includes the atomic distributivity operator D, which can only distribute over count domains because only those domains have atoms. *Jeweils* includes the nonatomic distributivity operator Part. I argue in Champollion (2014a) that the latter operator can also distribute over noncount domains like time. I adopt the strata-theoretic perspective from Champollion (2010b). According to this theory, distributivity is a property with two parameters: dimension and granularity. I will suggest that *each*, just like the D operator, comes prespecified for "granularity=atom". This blocks the setting "dimension=time", so distributivity over occasions is unavailable. By contrast, *jeweils* does not come prespecified for anything but is anaphoric on context, so it can distribute over salient covers, or salient stretches of time, just like the Part operator.

In claiming that *each* is an overt form of the D operator, I loosely follow proposals made for German *jeweils* and its short form *je* by Link (1998b, 1987) and for English *each* by Roberts (1987). While Link and Roberts did not give explicit compositional implementations and did not or not fully consider the crosslinguistic picture, this paper can be seen, in a way, as an update to these early ideas which benefits from later work on algebraic semantics, nonatomic distributivity, and compositional implementations. In particular, Link and Roberts did not have access to the theory that has been built around the commonalities and differences between the D and Part operators (Champollion, 2014a, and references therein).

Arriving at the meaning of *each* from the meaning of distributivity operators is somewhat of the reverse of the process by which Schwarzschild arrived at his Part operator, which "was based on a generalization of Dowty and Brodie's (1984) account of floated quantifiers as verb phrase modifiers" (Schwarzschild, 1996, p. 137). Schwarzschild himself notes that the history of Part should not be taken for an endorsement that floated quantifiers are related to it, and argues that floated quantifiers should be distinguished from Part operators because he takes reciprocals to be licensed by distributivity operators, but not by adverbial *each*. He gives the following examples to support this claim. These kinds of examples, as well as the idea that reciprocals are licensed by distributivity operators of some kind or other, go back to Heim, Lasnik, and May (1991).

(60) a. They$_j$ Part$_i$ [saw each other$_{j,i}$].
b. *They$_j$ each$_i$ saw each other$_{j,i}$.

While reciprocals are not the topic of this paper, let me briefly note that Schwarzschild's argument rests crucially on the assumption that reciprocals are licensed by VP-level distributivity operators. This has been argued to make wrong predictions, since not all VPs with reciprocals in them are interpreted distributively (see Dotlačil (2013) and references therein):

(61) a. John and Mary wrote to each other on two cold days.
?? under the reading 'John wrote to Mary on two cold days and Mary wrote to John on two other cold days' (Moltmann, 1992)
b. The doctors gave each other a new nose.
?? under the reading 'each doctor gave the other doctor a different new nose' (Williams, 1991)
c. The two children gave each other a Christmas present.
?? under the reading 'each child giving a different present' (Williams, 1991)

I conclude that neither overt and covert adverbial distributive operators seem to be able to license reciprocals, and therefore there is in principle no reason to avoid giving them a unified analysis.

I use the following typing conventions: t for propositions, e for ordinary objects, and v for events. I use the symbols x, y, z, x', y', z' and so on for variables that range over ordinary objects, and e, e', e'' for events. I use P for predicates of type $\langle et \rangle$, V

for predicates of type $\langle vt\rangle$, θ and Θ for functions of type $\langle ve\rangle$. I assume that ordinary objects and events are each closed under mereological sum formation (Link, 1998a). Intuitively, this means that these categories include plural entities. The lowercase variables just mentioned should therefore be taken to range over both singular and plural entities. In the literature on plurals, the distinction between singular and plural entities is often indicated by lowercase and uppercase variables. Since almost all the variables in my representations range over potentially plural entities, I do not follow this convention. I will adopt the framework of Champollion (2014a), including the following assumptions: atomicity of singular individuals, thematic uniqueness, cumulativity of thematic roles, verbs as pluralized event predicates.

I assume that noun phrases are interpreted in situ, because I do not consider quantifier raising in this paper. Silent theta role heads, which denote thematic roles of type ve (event to individual), are located between noun phrases and verbal projections. The one that denotes the agent role can be either thought of as a silent case-marker-like part of the noun phrase, or as little v or Voice, depending on whether it first combines with the subject noun phrase or with the verb phrase. The heads that denote the theme and recipient roles bear some conceptual similarity with applicative heads (Pylkkänen, 2008). I will occasionally omit or abbreviate these heads in my LFs but they should always be assumed to be there. The precise nature of the compositional process is not essential, but it affects the types of the lexical entries of distance-distributive elements so let me make it concrete. I assume that the following type shifters apply first to the theta role head, then to the noun phrase, and finally to the verbal projection. I will introduce a third type shifter in Section 7 below in order to accommodate the alternative theoretical assumption that the theta role head combines first with the verbal projection and then with the noun phrase it belongs to, as opposed to the other way round. The choice between these assumptions is immaterial for the theories in this paper, but it matters to theories of the syntax-semantics interface more generally.

(62) a. Type shifter for indefinites: $\lambda\theta_{ve}\lambda P_{et}\lambda e.P(\theta(e))$
b. Type shifter for definites: $\lambda\theta_{ve}\lambda x\lambda e.\theta(e) = x$

Each of these type shifters combines a noun phrase with its theta role head to build an event predicate of type $\langle vt\rangle$ which can combine with other predicates of the same type via intersection. For example, after the noun phrases *the boys* (definite) and *two monkeys* (indefinite) combine with the theta role heads [agent] and [theme] respectively, their denotations are as follows.

(63) ⟦[[agent] the boys]⟧ = $\lambda e[{}^*\text{agent}(e) = \bigoplus \text{boy}]$

(64) ⟦[[theme] two monkeys]⟧ = $\lambda e[|{}^*\text{theme}(e)| = 2 \wedge {}^*\text{monkey}({}^*\text{theme}(e))]$

After the verb has combined with all its arguments, the event variable is existentially bound if the sentence is uttered out of the blue. If the sentence is understood as referring to a specific event, the event variable is instead resolved to that event. If the noun phrases combine directly with the verb, we get a scopeless reading as in (65). Here and below, I write *2M* as a shorthand for $\lambda e[|{}^*\text{theme}(e)| = 2 \wedge {}^*\text{monkey}({}^*\text{theme}(e))]$.

(65) ⟦The boys saw two monkeys⟧ = $\exists e[{}^*\text{agent}(e) = \bigoplus \text{boy} \wedge {}^*\text{see}(e) \wedge \text{2M}(e)]$

To generate distributive readings, we use Link's D operator, reformulated in the counterpart of this paper and repeated here as (66). As in Champollion (2014a), I assume that the D operator is coindexed with the thematic role of its target.

(66) **Definition: Event-based D operator**
$[\![\mathrm{D}_\theta]\!] \stackrel{\mathrm{def}}{=} \lambda V_{\langle vt \rangle} \lambda e[e \in {}^*\lambda e'(V(e') \ \wedge \ \mathrm{Atom}(\theta(e')))]$

As an example, the distributive reading of (65) is derived like this:

(67) $[\![[[\mathrm{agent}]\ \mathrm{The\ boys}]\ [\mathrm{D}_{agent}\ [\mathrm{saw}\ [[\mathrm{theme}]\ \mathrm{two\ monkeys}]]]]]\!]$
$= \exists e[{}^*\mathrm{agent}(e) = \bigoplus \mathrm{boy} \ \wedge \ e \in [[\![D_{agent}]\!](\lambda e'[{}^*\mathrm{see}(e') \ \wedge \ 2\mathrm{M}(e')])]]$
$= \exists e[{}^*\mathrm{agent}(e) = \bigoplus \mathrm{boy} \wedge e \in {}^*\lambda e'[{}^*\mathrm{see}(e') \wedge 2\mathrm{M}(e') \wedge \mathrm{Atom}(\mathrm{agent}(e'))]]$

This formula is true just in case there is an event e whose agent is the boys, and which consists of seeing-two-monkeys events whose agents are atomic. As discussed in Champollion (2014a), the background assumptions of algebraic semantics ensure that the seeing-two-monkeys events have boys as agents even though the formula does not explicitly state this. I come back to this point at the end of this section.

Here are the entries for adverbial, adnominal, and determiner *each.* An explanation follows below. An illustration of the derivation of a basic sentence like *The boys saw two monkeys each* is shown in Figure 1. Adverbial and determiner *each* work similarly. Adverbial *each* is simply synonymous with the D operator. I come back to determiner *each* in Section 5.

(68) $[\![\mathrm{each}_\theta]\!]_{adverbial} = [\![\mathrm{D}_\theta]\!] =$ (66)

(69) $[\![\mathrm{each}_\theta]\!]_{adnominal} = \lambda P_{et} \lambda \Theta_{ve} \lambda e. e \in [\![D_\theta]\!](\lambda e'. P(\Theta(e')))$

I assume that adverbial *each*, as shown in (68), is a verb phrase modifier just like the D operator, and can therefore be given the same entry as that operator. I adopt for concreteness the assumption that adverbial *each* is an adverb adjoined to VP. This is similar what has been argued for floating quantifiers in general by Dowty and Brodie (1984), Bobaljik (1995) and Doetjes (1997). For another view that analyzes floating quantifiers as the remaining part of a noun phrase the rest of which has moved away from it, see for example Safir and Stowell (1988) and Sportiche (1988). The movement view makes a formal link between *each* and its antecedent available for independent reasons since there is a movement relation between them, while the adverbial view requires one to assume that the two are coindexed. Therefore the movement view, which I do not adopt here, would be likely to be at least as compatible with my approach than the adverbial view.

Adnominal *each*, as shown in (69), needs to be type-shifted, but like adverbial *each* it is defined in terms of the D operator. This captures the fact that they are essentially synonymous. As shown in (69), adnominal *each* carries an index. I assume that it is coindexed with the theta role θ of its antecedent. It first combines with its host predicate P (e.g. *two monkeys*), and then with the theta head Θ of the host (which is not to be confused with the theta role of its antecedent). Afterwards, it combines intersectively with the verbal projection to which its host attaches (e.g. the verb *see*). This means that adnominal *each* does not take scope over the verbal projection but

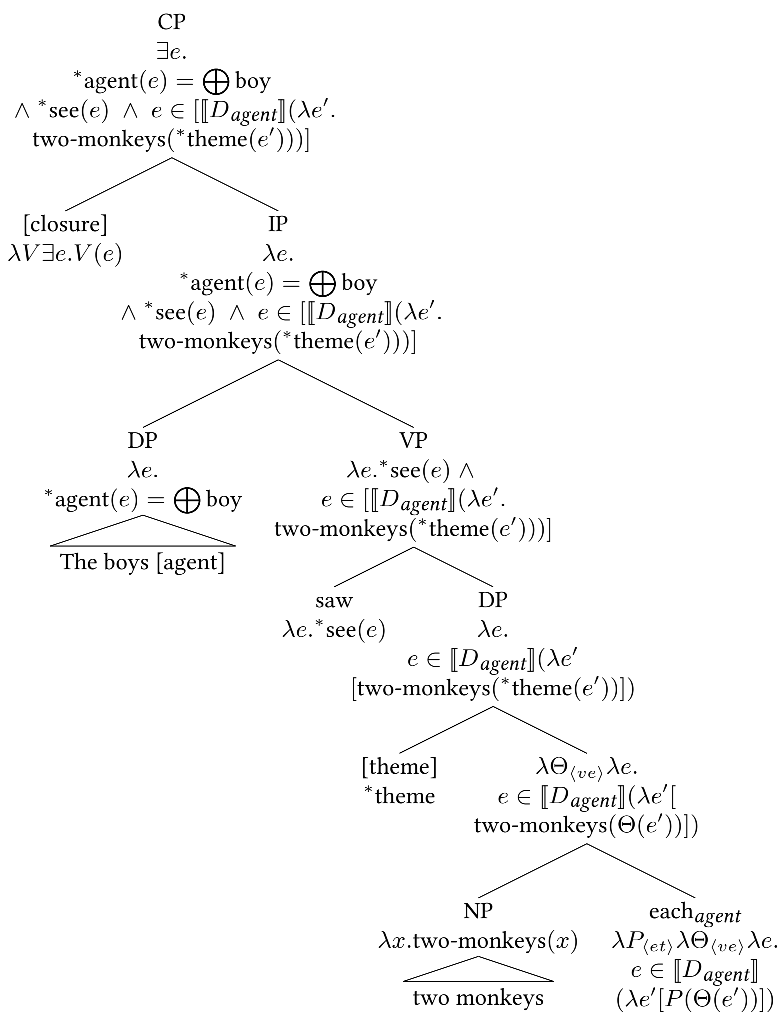

Figure 1: Deriving *The boys saw two monkeys each.*

only over its own complement (Dotlačil, 2012). By contrast, adverbial *each* takes scope over the verbal projection. In this, I follow LaTerza (2014b), who evidence the following minimal pair as evidence for this contrast:

(70) a. John and Bill served [four meals each] to (exactly) three judges.
b. John and Bill each [served four meals to (exactly) three judges].

As LaTerza reports, speakers judge (70a) true of situations where there are at most three judges, while (70b) is true in situations which allow up to six different judges. As he notes, this is predicted by giving adnominal and adverbial *each* different scopes, as indicated by the square brackets in these examples. For example, sentence (70b) can be derived as in Figure 2.

My entry for adnominal *each* combines with its host in two steps, in order to give it access to both the predicate and the theta head. This is not essential, but it allows us to ensure that the type of the predicate is $\langle et \rangle$. I do so to provide a hook on which to build future accounts of the "counting quantifier requirement" that prevents such phrases as **most men each* (Safir and Stowell, 1988; Sutton, 1993; Szabolcsi, 2010, §10.5). The theory in this paper does not to provide an account of this requirement, since it will not rule out bare plurals as in **They saw monkeys each*, as pointed out in Cable (2014). If an independent account of these kinds of mismatches can be provided that does not need to have access to the host predicate and its theta role separately, then it may not be necessary to place *each* between the host predicate and the theta head after all. The choice is immaterial for the rest of this paper.

Let us now turn to *jeweils*. My reformulation of the Part operator in Champollion (2014a), repeated here as (71), is also the lexical entry of adverbial *jeweils*, as shown in (72). The same type shift as in (69) brings us from (72) to adnominal *jeweils*, as shown in (73).

(71) **Definition: Event-based Part operator**
$[\![\text{Part}_{\theta,\text{C}}]\!] \stackrel{\text{def}}{=} \lambda P_{\langle vt \rangle} \lambda e[\langle e, \theta(e)\rangle \in {}^*\lambda e'(P(e') \;\wedge\; C(\theta(e')))]$ (Takes an event predicate P and returns a predicate that holds of any event e which can be divided into events that are in P and whose θs satisfy the contextually salient predicate C.)

(72) $[\![\text{jeweils}_{\theta,C}]\!]_{\textit{adverbial}} = [\![\text{Part}_{\theta,C}]\!] =$ (71)

(73) $[\![\text{jeweils}_{\theta,C}]\!]_{\textit{adnominal}} = \lambda P \lambda \Theta \lambda e[[\![\text{Part}_{\theta,C}]\!](\lambda e'[P(\Theta(e'))])(e)]$

As in the case of the Part operator, the granularity parameter C of *jeweils* can be set to *Atom* so long as its dimension parameter θ is set to a function into a count domain, such as *agent*. In that case, Part distributes over individuals and is equivalent to the D operator, as explained in Champollion (2014a). This accounts for the fact that when *jeweils* distributes over individuals, it is equivalent to *each*. The following example illustrates this with sentence (7a); sentence (7b) is equivalent.

(74) Die Jungen haben jeweils$_{\textit{agent,Atom}}$ zwei Affen gesehen.
The boys have DIST two monkeys seen.
"The boys have each seen two monkeys."

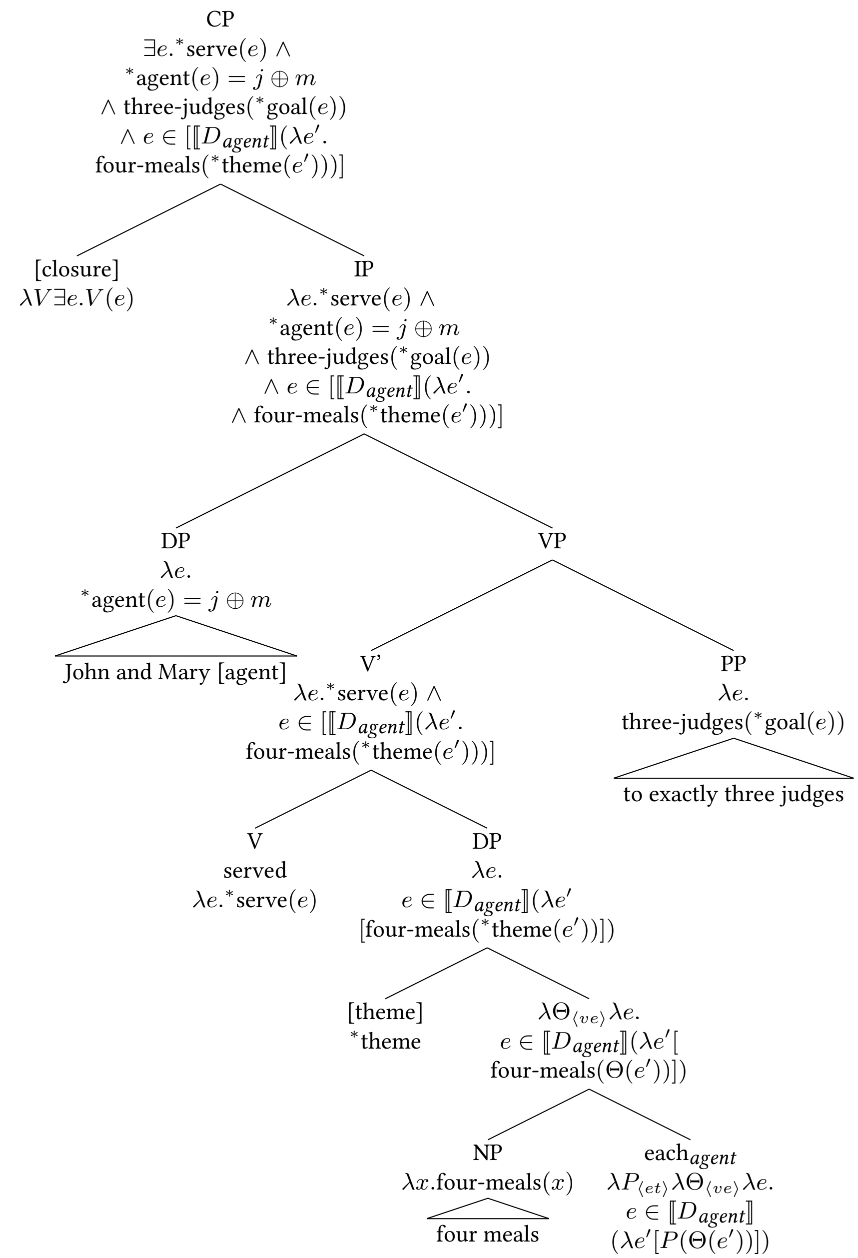

Figure 2: Deriving *John and Mary served four meals each to exactly three judges.*

If – and only if – there is a supporting context, the anaphoric predicate C can be set to a salient antecedent other than *Atom*, and in that case θ is free to adopt values such as τ (runtime). This leads to occasion readings. Suppose for example that it is in the common ground that the boys have been to the zoo to see animals last Monday, last Wednesday and last Friday, and that (7a) is uttered with reference to that state of affairs, or sum event. It is interpreted as follows.

(75) ⟦Die Jungen haben jeweils$_{\tau,\text{zoovisit}}$ zwei Affen gesehen.⟧ =
$^*\text{agent}(e_0) = \bigoplus\text{boy} \wedge {}^*\text{see}(e_0) \wedge e_0 \in {}^*\lambda e'\lambda t[|{}^*\text{theme}(e')| = 2 \wedge {}^*\text{monkey}({}^*\text{theme}(e')) \wedge \text{zoovisit}(\tau(e'))]$
"The boys have seen two monkeys on each occasion."

Since the sentence refers specifically to the sum e_0 of the three events in question, the event variable in (75) is resolved to e_0 rather than being existentially bound. The predicate that is true of any time interval at which a zoo visit takes place, call it *zoovisit*, is also salient in this context. So C can be resolved to *zoovisit* rather than to *Atom*. Since there are no atoms in time, it is only now that θ can be set to τ, rather than to *agent* as in (74). What (75) asserts is that e_0 has the boys as its agents; that it can be divided into subevents, each of whose runtimes is the time of a zoo visit; and that each of these subevents is an event whose theme are two monkeys. That these subevents are seeing events is entailed by the fact that *see* is lexically distributive on its theme argument, which in turn is formally represented as a meaning postulate, as discussed in Champollion (2014a). I assume that runtime is closed under sum just like other thematic roles ($\tau = {}^*\tau$), or in other words, it is a sum homomorphism. This means that any way of dividing e_0 must result in parts whose runtimes sum up to $\tau(e_0)$. Assuming that $\tau(e_0)$ is the (discontinuous) sum of the times of the three zoo visits in question, this entails that each of these zoo visits is the runtime of one of the seeing-two-monkeys events. This is the occasion reading.

4 Previous Work: Zimmermann (2002b)

The most detailed semantic account of *jeweils* and *each* is offered in Zimmermann (2002b). I summarize and critically review it here; other discussions of this account are found in a number of places (Zimmermann, 2002a; Blaheta, 2003; Dotlačil, 2012).

Zimmermann takes adnominal *each* and *jeweils* to be prepositional phrases that are only partially pronounced, but this aspect does not really influence the semantic composition. The meaning of *each*, or more precisely of the prepositional phrase that is supposed to contain it, is as follows (Zimmermann, 2002b, p. 210). While the relevant discussion is actually about adnominal *jeweils*, it carries over to adnominal *each* without changes, so I present it in terms of *each* for clarity.

(76) ⟦each⟧ (Zimmermann) = $\lambda P.\forall z[z \in Z_i \rightarrow \exists x[P(x) \wedge {}^*R_j(z,x)]]$

This meaning is a property of predicates that holds of a given predicate P iff every member of a certain plurality Z_i stands in the algebraic closure ${}^*R_j$ of a certain relation R_j to some entity of which P holds. In this definition, Z_i and R_j are free variables that are assumed to be coindexed, respectively, with the antecedent of *each* and with the relation that holds between the two, typically denoted by the verb. Take sentence (15), repeated here as (77) with the coindexation added. Here P is the denotation of *two monkeys*, Z is coindexed with *the boys*, and R is coindexed with *saw*.

(77) [The boys]$_i$ saw$_j$ two monkeys each$_{i,j}$.

Here is how this sentence would be represented by Zimmermann (2002b). First, the entry for *each* is applied to *two monkeys*, which is taken to denote a predicate of sum individuals that I will represent here by the shorthand *two-monkeys*. This results in an open proposition with two free variables:

(78) $[\![\text{two monkeys each}_{i,j}]\!] = \forall z[z \in Z_i \rightarrow \exists x[\text{two-monkeys}(x) \wedge {}^*R_j(z,x)]]$

The next steps involve lambda-abstracting over the free variables, via a rule that Zimmermann calls "index-triggered lambda abstraction", a variant of a rule which is taken to apply when a type mismatch makes function application impossible (Bittner, 1994, p. 69).

(79) **Index-triggered λ-abstraction (Zimmermann, 2002b, p. 217)**:
If the semantic types of a proposition-denoting expression α and its syntactic sister β do not match, and if $[\![\alpha]\!]$ contains a free variable u_i that shares an index 'i' with β, λ-abstraction in $[\![\alpha]\!]$ over index 'i' is licensed, and $\lambda u_i.[\![\alpha]\!]$ is a value for α.

This rule allows a constituent with a free variable in it to combine with another constituent that is coindexed with that variable. For example, in (77), the constituent *two monkeys each*$_{i,j}$ has the free variable j in it, which carries the same index as the constituent *saw*$_j$. Since the two constituents are sisters, index-triggered λ-abstraction applies, with the result as shown in (80), as discussed in Zimmermann (2002b, p. 226).

(80) $\lambda R_j.\forall z[z \in Z_i \rightarrow \exists x[\text{two-monkeys}(x) \wedge {}^*R_j(z,x)]]$

Zimmermann takes the classical Davidsonian view on verb meaning, under which n-ary verbs denote $n+1$-ary relations between arguments and events. He tentatively proposes that the event argument can "at least sometimes" (p. 226) be saturated inside the verb phrase by existential closure. This means that the verb *saw* can have the right type to combine with (80), as shown below in the derivation taken from Zimmermann (2002b, p. 227):

(81) $[\![\text{saw}_j]\!] = \lambda y \lambda x.\exists e[\text{see}(x,y,e)]$

(82) $[\![(80)]\!]([\![(81)]\!]) = \forall z[z \in Z_i \rightarrow \exists x[\text{two-monkeys}(x) \wedge \exists e[{}^*\text{see}(z,x,e)]]]$

In (82), the existential quantifier over events has ended up (somewhat mysteriously to me) outside the scope of the star operator, even though the star takes scope over R in (81). The result of the computation, in (82), is another open proposition. The last step in the derivation is to combine this with the antecedent, *the boys*$_i$, in another instance of index-triggered λ-abstraction. The result is as follows:

(83) $\forall z[(z \in \bigoplus \text{boy}) \rightarrow \exists x[\text{two-monkeys}(x) \wedge \exists e[{}^*\text{see}(z, x, e)]]]$

This formula says that for every boy there exists a sum of two monkeys such that the boy saw the monkeys. This is an accurate rendering of the truth conditions of sentence (77).

In Zimmermann's system, the denotation of the host phrase of adnominal *each*, given in (78), is of type t. This means that the only way it can combine with other constituents is via index-triggered lambda abstraction. The only two indices that can trigger this operation are the ones on Z and R. The values for these two variables will therefore always be provided by the two constituents which are closest to the host phrase. Put another way, the only thing that can intervene between the host phrase of *each* and its antecedent is the constituent that denotes R. Zimmermann's system requires the host phrase of adnominal *each* to be adjacent either to its antecedent or to the constituent that denotes the relation between the two.

As a point in favor of this adjacency requirement, Zimmermann (2002b, p. 240f.) notes that *jeweils* cannot distribute over individual-denoting noun phrases in a higher clause:

(84) *Die Verkäufer$_i$ sagen, dass Peter jeweils$_i$ einen Ballon gekauft hat.
the store.clerks say, that Peter Dɪsᴛ a balloon bought has.
*'The store clerks said that Peter had bought a balloon each.' (Zimmermann, 2002b, p. 241)

As mentioned earlier, this clausemate condition can also be explained by syntactic means, such as binding theory (e.g. Burzio, 1986) or LF movement (e.g. Safir and Stowell, 1988). As long as the syntactic locality requirement is sufficiently stringent, there is no need for an additional semantic adjacency requirement on top of it.

Zimmermann's adjacency requirement is not only redundant in those cases where it agrees with these syntactic constraints, it is also too strong in those cases where it goes beyond it. Establishing this requires us to think about the relationship between Z and R. The universal quantifier over parts of Z in (78) has scope over R. Therefore, if R contains a scope-taking element such as a numeral, this element cannot stand in a scopeless relation with Z, such as a cumulative relation (Scha, 1981; Beck and Sauerland, 2000). Either it should take scope below the universal quantifier, or else take above it due to scope displacement. Therefore if Zimmermann's account is right, the antecedent of adnominal *each* cannot stand in a cumulative relation with a noun phrase that intervenes between its antecedent and its host noun phrase. For example, if the indirect object in a ditransitive construction stands in a cumulative relation with the subject and if the direct object contains adnominal *each*, then only the indirect object can be its antecedent, the subject cannot:

(85) *Subject*$_i$ *Ditransitive-Verb Indirect-Object*$_j$ *Direct-Object* each$_{j/*i}$.

To test this prediction, I conducted a large-scale web survey using TurkTools (Erlewine and Kotek, to appear), which relies on the online labor market platform Amazon Mechanical Turk (http://www.mturk.com). The survey took place in June 2015 and contained the following target task:

(86) Imagine there is an election with two candidates. The day after, you read in the newspaper: "100 million voters gave two candidates one vote each." According to the newspaper, how many votes were cast in total?

Participants were asked to choose one of four answers: (i) 100 million, (ii) 200 million, (iii) 100 million or 200 million — it could be either one; (iv) none of the above. They were instructed to choose only one answer from the four choices. A filler task and demographic questions were used to check whether subjects paid enough attention and whether they satisfied the criteria for the survey. The filler task consisted of a simple question ("Imagine I have five coins in my pocket. Then I put ten more coins into my pocket. How many coins are in my pocket now?") and four answers: (i) ten; (ii) fifteen; (iii) ten or fifteen – it could be either one; (iv) none of the above. 200 participants were given the survey, with the target task preceding the filler task in one half of the cases and following it in the other half. Each participant was located in the United States and had an MTurk approval rate of at least 95%. Each was paid $0.02. Data were rejected from participants who worked on more than one group or did not finish the survey (10 rejected data points), who gave their native language as anything other than American English (9 rejected data points), and who answered the filler task with anything other than fifteen (6 data points). The remaining 175 data points are summarized in Table 2.

Choice	Raw frequency	Percentage
(i) 100 million	63	36%
(ii) 200 million	77	44%
(iii) 100 million or 200 million	30	17%
(iv) none of the above	5	3%
Total	175	100%

Table 2: Results of the survey on cumulative readings

Of interest are the 93 participants (53%) who answered (i) or (iii). It is likely that these participants understood the sentence to being able to describe a situation in which every one of the 100 million voters voted for only one of the candidates, with some of these votes going to the first candidates and the rest going to the second. In this reading, the word *each* can be paraphrased as *per voter* but not as *per candidate*, so its antecedent is the subject. The reading also involves a scopeless relation between the two noun phrases *100 million voters* and *two candidates*, since neither one distributes over the other. Since every voter is related by a giving event to one of the two candidates but not to the other one, that scopeless relation is cumulative. This is exactly the pattern that is unexpected on Zimmermann's account, which predicts that all participants should answer either (ii) or (iv).

As for those participants that were able to access the "200 million" reading, they presumably took the word *each* as taking the indirect object *two candidates* as its antecedent, and interpreted the vP *gave two candidates one vote each* as being in the scope of a D operator that distributes it over the 100 million voters. If the D operator is absent but *each* still targets the indirect object, the resulting reading should entail that a total of two votes were cast. Indeed, a small number of participants commented that the answer could also be "2 votes".

In Zimmermann's account, the universal quantifier introduced by *each* takes scope over whatever constituent provides the value for R, and that constituent must include everything between the host phrase of *each* and its antecedent. When his account is applied to (86), that constituent must be *give two candidates*, since it includes everything between the subject and the direct object. Zimmermann's entry for *each* then distributes this predicate over the voters. This prevents the candidates from cumulating with the voters. Therefore Zimmermann's account does not generate the relevant reading of (86).

On the account presented here, representing that reading is straightforward because adnominal *each* takes semantic scope only over its host argument (the noun phrase that contains it), and not over the verbal predicate. As discussed earlier, this insight is derived from Dotlačil (2012) and LaTerza (2014b). Zimmermann's account does not capture it because the relation between the voters and the votes corresponds to the variable R_j, which is in the scope of the universal quantifier contributed by adnominal *each*. On my account, the relationship of adnominal *each* with its antecedent is only subject to whatever (perhaps binding-theoretic) locality restrictions need to be imposed on theta-indexing. As long as these restrictions allow for theta-indexing of coarguments, the dependency in (86) can be modeled. Sentence (86) can be analyzed as in Figure 3, which gives the following result:

(87) $\exists e.[{}^*\text{give}(e)$
$\wedge$ 120-million-voters$({}^*\text{agent}(e))$
$\wedge$ two-candidates$({}^*\text{beneficiary}(e))$
$\wedge\ e \in {}^*\lambda e'[\text{vote}({}^*\text{theme}(e')) \wedge\ \text{Atom}(\text{agent}(e'))]]$

This representation states that there is a sum of giving events whose agents sum up to 100 million voters, whose beneficiaries sum up to two candidates, and which consist of subevents with atomic agents and individual votes as themes. The background assumptions of algebraic semantics ensure that this entails that there were 100 million such subevents.

A few comments on the derivation in Figure 3. The current consensus is that the syntax of ditransitives differs somewhat from their surface structure. Although nothing here hinges on this, I have chosen to make my analysis harmonize with the syntax proposed in Marantz (1993) and recently defended by Bruening (2010). For this purpose, I have assumed that the *Voice* and *Appl* heads introduce the thematic roles *agent* and *beneficiary* respectively, and I have type-shifted these heads accordingly. For reasons of clarity, I show the meanings of these heads only in their type-shifted form, but really they should be thought of as having the same meanings as above, that is, *agent and *beneficiary. The type-shifter I have used here is the following:

(88) $\lambda\theta_{ve}\lambda V_{vt}\lambda P_{et}\lambda e.V(e) \wedge P({}^*\theta(e))$

An alternative to this approach, if one prefers additional compositional operations to type-shifters, would be to use the event identification operation from Kratzer (1996).

For details on how this would work, see Harley (2012).

Another problem for Zimmermann's account, which is similar to the one discussed above, was noted by Blaheta (2003):

(89) Alex and Sasha lifted a piano with two jacks each.

In (89), it is possible for the piano-lifting event to be collective. As Blaheta puts it, the phrase *with two jacks each* "needs to distribute itself in some fashion over each member of the subject, *without* making the verb phrase itself distribute!" Indeed it is not obvious how to represent this kind of configuration in Zimmermann's system. Blaheta leaves (89) as an open problem for his own account, which is closely related to Zimmermann's, but notes he suspects that event semantics may hold the key to the solution. Indeed it does. The compositional derivation of (89) is similar to the one of (86). Each of the three arguments is intersected with the event predicate. This is the result:

(90)
$$\begin{aligned}&\exists e.[{}^{*}\text{lift}(e)\\&\wedge {}^{*}\text{agent}(e) = \text{alex} \oplus \text{sasha}\\&\wedge \text{piano}({}^{*}\text{theme}(e))\\&\wedge e \in {}^{*}\lambda e'[\text{two-jacks}({}^{*}\text{instrument}(e')) \wedge \text{ Atom}(\text{agent}(e'))]]\end{aligned}$$

This formula entails that Alex and Sasha together lifted a piano, and that each of them was the agent of a part of the lifting event which had two jacks as its instrument. I does not entail that the parts of the lifting events need to be lifting events themselves. This is as it should be, because *lift* is not distributive on its agent position.

Schwarzschild (2014) points out a potential problem for my line of analysis. Suppose that a group of artists build a wall of books on the sidewalk, with each artist putting one book down next to or on top of other books until a wall is built. In this scenario, each artist did something to one book. If we assume that all these events sum up to a building event, sentence (91) should be acceptable and true.

(91) #The artists built one book each.

The deviant status of (91) can be explained by assuming that the building event is not in fact the sum of the individual events in which artists put down books. For discussion of an analogous problem involving the collective planting of a rosebush, see Kratzer (2007), Williams (2009) and Champollion (2010b). An alternative line of analysis would be to assume that in some cases including (91), the scope of adnominal *each* includes the verb phrase after all. This would raise the question how to delineate the cases in which adnominal *each* does and does not take scope over the verb phrase. I have not adopted this analysis because I do not see an easy way to answer this question.

While the analysis so far has focused on adnominal and adverbial *each* and their counterparts across languages, it is possible to assimilate distributive determiners such as *each* and *every* to these items. I turn to them now.

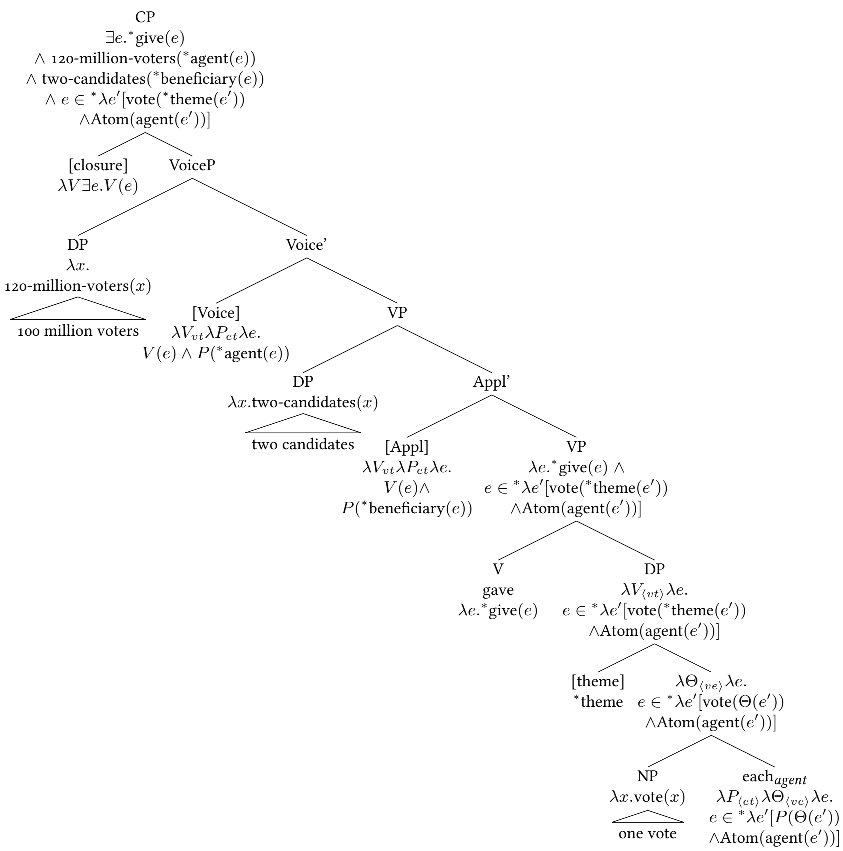

Figure 3: Deriving *100 million voters gave two candidates one vote each.*

5 Distributive Determiners

As we have seen, English *each* along with some of its crosslinguistic relatives can be used adnominally, adverbially, and as a determiner. I have suggested that the synonymy of these uses should be captured, ideally by essentially identical lexical entries. Another distributive determiner in English is *every*. As shown by their incompatibility with collective predicates, both *every* and *each* are distributive (92).

(92) a. #Every/#Each soldier surrounded the castle.
b. The soldiers surrounded the castle.

Traditionally, the determiners *every* and *each* are analyzed in terms of universal quantification (e.g. Montague, 1973):

(93) ⟦every boy⟧ *(traditional)*
$= \lambda P_{et} \forall x[\text{boy}(x) \rightarrow P(x)]$

This style of analysis is especially useful when one is interested in comparing them with other determiners from the perspective of generalized quantifier theory (e.g. Barwise and Cooper, 1981). This paper, however, focuses on the parallels between determiner *each* and its adnominal and adverbial counterparts. Therefore, instead of the traditional approach I will assimilate it, as far as it goes, to the analyses of adverbial and adnominal *each* that we have already encountered. Since the differences between *each* and *every* are not a core concern of this paper, I will adopt the same analysis for both determiners. This is not to deny that there are differences between *every* and determiner *each*. Determiner *each* has a strong preference for taking wide scope over its environment, more so than *every* (e.g. Ioup, 1975; Beghelli and Stowell, 1997). Moreover, *each* also appears to impose a condition of spatial or temporal separateness on its subevents, as shown in (94) (e.g. Tunstall, 1998; Brasoveanu and Dotlačil, 2015). There may be other differences as well.

(94) Jake photographed every/#each student in the class, but not separately.

The analysis I will adopt is couched in terms of the D operator (95). The determiner combines first with a nominal (of type $\langle et \rangle$) and then with a theta head. Unlike its adnominal and adverbial counterparts, determiner *each* is not coindexed with anything because it is not a distance-distributive element. The thematic relation is contributed by the theta head. The result is a phrase of VP modifier type $\langle vt, vt \rangle$, ready to combine with the verb phrase or other verbal projection V. A sample noun phrase denotation is shown in (96), and a sample sentence in (97).

(95) $[\![\text{each}]\!]_{\textit{determiner}} = [\![\text{every}]\!] = \lambda P_{et} \lambda \theta_{ve} \lambda V_{vt} \lambda e\ [\underline{\theta(e) = \bigoplus P} \wedge [\![D_\theta]\!](V)(e)]$
$= \lambda P_{et} \lambda \theta_{ve} \lambda V_{vt} \lambda e\ [\theta(e) = \bigoplus P \wedge e \in {}^*\lambda e'[V(e') \wedge \text{Atom}(\theta(e'))]]$

(96) ⟦[every boy [agent]]⟧
$= \lambda V_{vt} \lambda e[{}^*\text{agent}(e) = \bigoplus \text{dog} \wedge e \in {}^*\lambda e'[V(e') \wedge \text{Atom}(\text{agent}(e'))]]$
(Takes an event predicate V and returns a predicate that holds of any event e whose agent is all the boys and which consists entirely of events that are in V and whose agents are individual boys.)

(97) $[\![$[every boy [agent] carried three suitcases]$]\!]$
= $\exists e[{}^*\text{agent}(e) = \bigoplus \text{boy} \wedge e \in {}^*\lambda e'[{}^*\text{carry}(e') \wedge \text{Atom}(\text{agent}(e')) \wedge |{}^*\text{theme}(e')| = 3 \wedge {}^*\text{suitcase}({}^*\text{theme}(e'))]]$

This says that there is an event e whose agent is all the boys and which consists entirely of carrying events whose agents are individual boys and whose themes are sums of three suitcases. From this and from the assumption that the agent role is a sum homomorphism, we can conclude that every boy carried three suitcases.

The entry in (95) can be refined in various ways. For example, the underlined subformula could be replaced by a contextually supplied variable that specifies the domain of quantification. This variable can be dependent on another universal quantifier in the sentence (see e.g. Stanley and Szabó, 2000):

(98) Every child ate every apple. (Farkas, 1997)

In order to keep the system simple, I will refrain from adding these refinements here.

Treating universally quantified noun phrases as involving distributivity operators in the present event semantic framework avoids leakage, as discussed in Champollion (2011) in connection with examples like (99). Briefly, the event modifier *unharmoniously* needs access to the sum of the events whose agents are the individual students quantified over by *every* (Schein, 1993). The traditional account of *every* in terms of generalized quantifiers does not provide us with access to this sum event.

(99) Unharmoniously, every organ student sustained a note on the Wurlitzer. (Schein, 1993)

(100) $[\![(99)]\!] = \exists e[{}^*\text{agent}(e) = \bigoplus \text{organ.student}$
$\wedge e \in {}^*\lambda e'[\text{sustain}(e') \wedge \text{note}(\text{theme}(e') \wedge \text{Atom}(\text{agent}(e'))]]$
(There is an unharmonious event e whose agent is all the students and which consists entirely of note-sustaining events whose agents are individual students.)

Another advantage relates to cumulative readings of *every* such as the ones available in (101a) and (101b), from Schein (1993) and Kratzer (2000) respectively.

(101) a. Three video games taught every quarterback two new plays.
b. Three copy editors caught every mistake in the manuscript.

Such configurations cause problems for the traditional analysis of *every* in (93). Just like the adverbial modifier *unharmoniously* needs access to the sum of all the individual events in (99), so does the subject noun phrase in (101a) and in (101b). For example, the cumulative reading of (101b) can be paraphrased roughly as "There is a sum of mistake-catching events, whose agents sum up to three copy editors, and every mistake was caught in at least one of these events" (Schein, 1993; Kratzer, 2000; Champollion, 2010a). In this reading, the relationship between the two verbal arguments is cumulative and symmetric. There is no entailment that any mistake was caught by more than one copy editor, as would be expected if *every mistake* took scope either above or below *three copy editors*. My analysis of this reading is as follows.

(102) ⟦(101b)⟧
$= \exists e[|{}^*\text{agent}(e)| = 3 \wedge {}^*\text{copy-editor}({}^*\text{agent}(e)) \wedge {}^*\text{theme}(e) = \bigoplus \text{mistake} \wedge e \in {}^*\lambda e'[{}^*\text{catch}(e') \wedge \text{Atom}(\text{theme}(e'))]]$

This formula says that there is an event whose agents sum up to three copy editors, whose themes sum up to all the mistakes, and which consists of catching events with atomic themes. That these themes are individual mistakes follows from cumulativity of thematic roles.

It has been suggested that *every* can never enter a cumulative relation with arguments in its syntactic scope (Champollion, 2010a, cf. Kratzer, 2000). For example, Kratzer (2000) notes that (103) does not have a cumulative reading, in contrast to (101b). Bayer (1997) judges (104a) to be "clearly bizarre" because scripts cannot be written more than once, but reports that (104b) has a reading where every screenwriter in Hollywood contributed to the writing of the movie. Assuming that *Gone with the Wind* denotes a sum entity, we can represent (104b) as a cumulative reading. Similarly, Zweig (2008) reports that (105a) entails that each game was won by both teams at once, but (105b) has a cumulative reading, in which either team won games and every game was won by only one of the teams.

(103) Every copy editor caught 500 mistakes.

(104) a. Every screenwriter in Hollywood wrote *Gone with the Wind*.
b. *Gone with the Wind* was written by every screenwriter in Hollywood.

(105) a. Every game was won by the Fijians and the Peruvians.
b. The Fijians and the Peruvians won every game.

These facts are in line with what we would expect, since *every* distributes over its syntactic scope but makes the large event available for arguments or adverbs further up the tree. In (104a) and (105a), the syntactic scope of the argument headed by *every* is the entire verb phrase. The verb phrase includes the other argument, which is then related as a whole to each of the individual screenwriters or games. As a result, the *every*-phrase takes scope over its coargument and a cumulative reading is ruled out.

(106) ⟦(104a)⟧
$= \exists e[{}^*\text{agent}(e) = \bigoplus \text{screenwriter} \wedge e \in {}^*\lambda e'[{}^*\text{write}(e') \wedge \text{Atom}(\text{agent}(e')) \wedge {}^*\text{theme}(e) = [\![\text{Gone with the wind}]\!]]]$

(107) ⟦(105a)⟧
$= \exists e[{}^*\text{theme}(e) = \bigoplus \text{game} \wedge e \in {}^*\lambda e'[{}^*\text{win}(e') \wedge \text{Atom}(\text{theme}(e')) \wedge {}^*\text{agent}(e) = [\![\text{the fijians and the peruvians}]\!]]]$

By contrast, in (104b) and (105b), the syntactic scope of the *every*-phrase only includes the verb. For this reason, it does not distribute over the other argument, and a cumulative reading is possible. Distributing over the verb does not amount to anything much in (105b) since *win* is already distributive on its theme.

(108) ⟦(104b)⟧
$= \exists e[{}^*\text{theme}(e) = [\![\text{Gone with the wind}]\!] \wedge {}^*\text{agent}(e) = \bigoplus \text{screenwriter} \wedge e \in {}^*\lambda e'[{}^*\text{write}(e') \wedge \text{Atom}(\text{agent}(e'))]]$

(109) ⟦(105b)⟧
$= \exists e[{}^*\text{agent}(e) = ⟦\text{the fijians and the peruvians}⟧ \wedge {}^*\text{theme}(e) = \bigoplus \text{game} \wedge e \in {}^*\lambda e'[{}^*\text{win}(e') \wedge \text{Atom}(\text{theme}(e'))]]$

Kratzer (2000) claims that the availability of cumulative readings depends on the thematic role of the coargument of the *every*-phrase. According to her, cumulativity is only possible when the coargument plays the agent role. Champollion (2010a) points out that (104b), where the role of the coargument is theme, is a counterexample.

6 Zimmermann's Generalization Explained

How can we capture the correlation expressed in Zimmermann's generalization (18)? That is to say, why does a distance-distributive element which can also be used as a distributive determiner lack the occasion reading? Zimmermann himself proposes a syntactic explanation: Determiners must agree with their complement; adnominal or adverbial *each* also has a complement, a proform that must acquire its agreement features from its antecedent, which is the antecedent of *each*; only overt antecedents have agreement features; so adnominal/adverbial *each* cannot have a covert antecedent; so it cannot refer to a contextually supplied but not overtly mentioned antecedent such as a salient set of occasions.

This explanation is compatible with the present framework, and it makes the right predictions given the assumption that covert antecedents cannot have agreement. However, this assumption is problematic. To mention a simple example, German has grammatical gender, so for example, the gender of *Tisch* 'table' is feminine. Knowing this, a German speaker can point to a table and say with reference to it:

(110) Den hab ich gebraucht gekauft.
This.m have I used bought.
'I have bought this used.' (German)

But the same speaker cannot point to it and say:

(111) *Die hab ich gebraucht gekauft.
This.f. have I used bought.
Intended: 'I have bought this used.' (German)

As this example shows, a deictic pronoun in German has to agree in grammatical gender with the gender of the noun phrase that would most aptly describe this antecedent, even though the antecedent has not been mentioned explicitly.

A similar phenomenon was pointed out for English by Tasmowski-De Ryck and Verluyten (1982). English pronouns agree with their antecedents based on syntactic rather semantic grounds, as is shown by *pluralia tantum* such as *pants* and *scissors* which are syntactically plural but semantically singular. Pronouns show syntactic agreement with their antecedents even when these antecedents are not overtly mentioned:

(112) a. (John wants his pants that are on a chair and he says to Mary:)
Could you hand them/*it to me, please?

b. (Same situation but with a shirt:)
Could you hand *them/it to me, please?

For a recent discussion of these facts, and an explanation in terms of covert syntactic antecedents that are included in the syntactic structure and c-command the entire sentence in question, see Collins and Postal (2012, ch. 4). In the following I will remain neutral on whether the covert syntactic antecedent should be thought of as being included in the syntactic structure or not.

While Zimmermann's account seems problematic, its difficulties can perhaps be overcome, and it is by itself not incompatible with the present framework. But in the context of the general theory adopted here, a more straightforward explanation suggests itself. Distributive determiners like English *each* are only compatible with count nouns, not with mass nouns. We know this since, for example, **each mud* is ungrammatical. Formally, this amounts to an atomicity requirement of the kind the Link's D operator provides, as discussed in Champollion (2014a). This requirement can be seen as independent evidence of the atomic distributivity hard-coded in the entry (95) via the D operator. In other words, the distance-distributive element inherits the atomicity requirement of the determiner. This explanation is in line with the notion of parameter settings imported from strata theory and described above. That is, in English, adnominal, adverbial and determiner *each* have identical meanings up to type-shifting. Determiner *each* is only compatible with count domains because its granularity parameter is hardwired to the value "Atom". Adnominal *each* is formally identical to determiner *each*, so it inherits this property.

Zimmermann's generalization is not about languages but about items. As such, it can even be observed within one language. The German distributive determiner that corresponds to *each* and *every* is *jed-*. The distance-distributive item *jeweils* cannot be used in this position. This is illustrated in sentence (7c), repeated here:

(113) *Jeder/*Jeweils* Junge hat drei Koffer getragen.
Each.sg.m/Dist boy has three suitcases carried.
'Every boy has carried three suitcases.'

This determiner can in turn also be used as an adverbial distance-distributive item. Like English *each*, and unlike German *jeweils*, it can only distribute over individuals, but not over salient occasions.

(114) Die Jungen haben jeder zweimal geniest.
The boys have each.sg.m sneezed.
Available: 'The boys have each twice sneezed.'
Unavailable: 'The boys have sneezed twice on each occasion.'

(115) *Hans hat jeder zweimal geniest.
Hans has each.sg.m twice sneezed.
Intended: 'Hans has sneezed twice on each occasion.'

As we see, the distance-distributive element *jeder* can also be used as a distributive determiner, and it lacks the occasion reading. The distance-distributive element *jeweils* cannot be used as a distributive determiner, and as we have seen before, it has the occasion reading. All this is in line with Zimmermann's generalization. As I have suggested, we can account for it by assuming that *jed-*, like *each*, corresponds to the D operator (its granularity parameter can only be *Atom*), while *jeweils* corresponds to the Part operator (its granularity can be set to a nonatomic predicate if it is salient is context). Concretely, I propose the following denotations for adverbial and determiner *jed-*. They are identical with adverbial and determiner *each* respectively. As for *jeweils*, we have already seen its entry in (72).

(116) $[\![\text{jed-}_\theta]\!]_{adverbial} = [\![\text{D}_\theta]\!]$ = (66)

(117) $[\![\text{jed-}]\!]_{determiner} = [\![\text{every}]\!] = \lambda P_{et}\lambda\theta_{ve}\lambda V_{vt}\lambda e\ [\theta(e) = \bigoplus P \wedge e \in {}^*\lambda e'[V(e')\wedge \text{Atom}(\theta(e'))]]$ = (95)

The derivation of (113) is exactly analogous to (97) above. Let me show a derivation of (114). For convenience, and to avoid getting into the difficult question of how to count events, I represent *zweimal* ("twice") as an unanalyzed intersective predicate of sum events.

(118) $[\![[\text{agent}]\ \text{Die Jungen}]\!] = \lambda e[{}^*\text{agent}(e) = \bigoplus \text{boy}]$ = (63)

(119) $[\![\text{zweimal geniest}]\!] = \lambda e[\wedge \text{twice}(e) \wedge {}^*\text{sneeze}(e)]$

(120) $[\![\text{jeder}_{agent}\ \text{zweimal geniest}]\!]$ = (117)((119)) $= \lambda e[e \in {}^*\lambda e'(\text{twice}(e')\wedge{}^*\text{sneeze}(e') \wedge \text{Atom}(\text{agent}(e')))]$

(121) $[\![(114)]\!] = \exists e.e \in [\![(118)]\!] \cap [\![(120)]\!]$
$= \exists e[{}^*\text{agent}(e) = \bigoplus \text{boy} \wedge e \in {}^*\lambda e'(\text{twice}(e')\wedge{}^*\text{sneeze}(e') \wedge \text{Atom}(\text{agent}(e')))]$

This says that there is a sum event whose agents sum up to the boys, and which consists of sneezing-twice events with atomic agents.

As a reviewer notes, *jeweils* and *jed-* are morphologically related. They are both built around the distributive element *je*, which also occurs as a free morpheme; in that case it is an *each*-type distance-distributive item (Link, 1998b). On the present account that the underlying semantics of *jed-* and *jeweils* is related via the common core of the D and Part operators, discussed in Champollion (2014a). An interesting question is whether we can explain the two of them denote related different distributivity operators. A starting point might be the observation that the morpheme *weil* in *jeweils* is related to the noun *Weile* 'timespan, while'. However, the reviewer notes that the morpheme *je* is also found in words with quite distinct meanings, such as *nie* 'never', *jeglich* 'any kind', *je* ... *je* 'the ... the' and others. As we can see, a common morphological core implies related but not necessarily identical meanings. On these questions see also Zimmermann (2002b), who argues that *weil* is a proform; in terms of the present account, it might be the part of *jeweils* that is anaphoric on the variable C.

7 Some More Complicated Cases

I will now go through a few configurations that are more complicated than those I have discussed so far and demonstrate the versatility of my analysis of adnominal distance-distributive items.

7.1 *Each* as a PP Modifier

Each can occur as the modifier of a prepositional phrase. Example (123) is a simple case. Example (122) plays an important role in Schein (1993) and has not received a compositional semantic analysis so far.

(122) 300 quilt patches covered two workbenches each with two bedspreads. (Schein, 1993)

(123) Mary put the books each back on the bookshelf.
(Maling, 1976)

To analyze these sentences, I assume that *each* modifies the prepositional phrase to its right, similarly to the adverb *back* in *back at the farm*, rather than the noun phrase to its left. (As in (123) shows, these modifiers can be stacked.) My assumption is plausible because adnominal *each* cannot modify definite plurals like *the books*. I assume for concreteness that the syntactic structure of these sentences is [[V DP] PP] rather than [V [DP PP]]; for discussion on the choice between these two analyses, see Janke and Neeleman (2012).

Example (122) has a reading according to which there are a total of two workbenches and a total of four bedspreads that cover them. The workbenches stand in a cumulative relation with the 300 quilt patches. The following formula captures this reading:

(124) $\exists e.{}^*\text{cover}(e)$
$\wedge\ {}^*\text{quilt-patch}({}^*\text{agent}(e)) \wedge |{}^*\text{agent}(e)| = 300$
$\wedge\ {}^*\text{workbench}({}^*\text{theme}(e)) \wedge |{}^*\text{theme}(e)| = 2$
$\wedge\ e \in {}^*\lambda e'[{}^*\text{bedspread}({}^*\text{instrument}(e'))$
$\wedge |{}^*\text{instrument}(e')| = 2 \wedge \text{Atom}(\text{theme}(e'))]$
(There is a sum of covering events whose agents sum up to 300 quilt patches, whose themes sum up to two workbenches, and which can be divided into two smaller sum events, each of which involves two bedspreads and one of the workbenches.)

Formula (124) is derived as follows. I have used shortcuts like *300-quilt-patches* for better readability. The derivation is straightforward and does not make use of any new ingredients. The entry for *each* is the same as the adverbial one, even though it modifies a prepositional phrase and not a verb phrase. This works because the prepositional phrase is represented as an event predicate, in the same way as a verb phrase.

(125) $[\![\text{each}_{theme}]\!] = \lambda V_{vt} \lambda e.e \in {}^*\lambda e'[V(e') \wedge \text{Atom}(\text{theme}(e'))]$

(126) $[\![\text{with two bedspreads}]\!] = \lambda e.\text{two-bedspreads}({}^*\text{instrument}(e))$

(127) $[\![\text{each with two bedspreads}]\!] = \lambda e.e \in {}^*\lambda e'[\text{two-bedspreads}({}^*\text{instrument}(e')) \wedge \text{Atom}(\text{theme}(e'))]$

(128) $[\![\text{covered two workbenches [theme]}]\!]$
$= \lambda e.{}^*\text{cover}(e) \wedge \text{two-workbenches}({}^*\text{theme}(e))$

(129) $[\![\text{300 quilt patches [agent]}]\!] = \lambda e.\text{300-quilt-patches}({}^*\text{agent}(e))$

(130) $[\![(122)]\!] = \exists e.e \in (129) \cap (128) \cap (127) = (124)$

7.2 *Jeweils* Distributing over a Conjunction of Verbs

German *jeweils* can take a conjunction of verbs as its antecedent and distribute over the two events described by the conjuncts, which results in a meaning for which English uses the word *respectively*.

(131) Peter kritisierte und lobte Maria aus jeweils zwei Gründen.
Peter criticized and praised Mary for DIST two reasons.
'Peter criticized and praised Mary for two reasons respectively.'
(Zimmermann, 2002b, p. 46)

(132) Der Professor hat jeweils drei Studenten gelobt und kritisiert.
The professor has DIST three students praised and criticized.
'The professor praised three students and criticized three students.'

As for English *each*, it cannot be used for that purpose:

(133) *Peter criticized and praised Mary for two reasons each. (Zimmermann, 2002b, p. 134)

According to Zimmermann (2002b, p. 143f.), other languages that pattern with English in this respect include Bulgarian, Czech, Dutch, French, Italian, Norwegian and Russian. As we have seen in Section 2, this list includes many languages whose distance-distributive items can also be used as determiners and lack the occasion reading. I have suggested earlier that the occasion reading is only possible if the granularity parameter can be set to a nonatomic value. Therefore, distributivity over conjunctsăis predicted to be impossible as long as the events described by the two conjuncts are nonatomic, contra Zimmermann (2002a). There is ample reason to assume that they are indeed nonatomic. For example, in (131), the praising event could be imagined to possibly consist of two subevents corresponding to the two reasons that caused it. Sentence (132) entails that each of the six students was either praised or criticized, which means that the two verbs are distributive on their themes. This in turn means that the praising event in (132) consists of three praising subevents, and similarly for the criticizing event. More generally, *praise* and *criticize* are atelic predicates, so any praising event that goes on for five minutes will have parts that take less than five minutes.

This explanation will work for most of the languages just mentioned, but not for all of them. As we have seen in Section 2, in Bulgarian and Czech the distance-distributive item *po* can be used to distribute over salient occasions and cannot be used as a distributive determiner. We would therefore expect that this item allows distribution over conjuncts, but it does not. Like Zimmermann, I have no explanation for this fact.

To derive (131) compositionally, I assume that the dimension parameter θ of *jeweils* is resolved to the identity function id rather than to a thematic role. I also assume that the cover variable C is resolved to the pragmatically salient cover $\{e_c, e_p\}$ where e_c

is the salient criticizing-for-two-reasons event and e_p is the salient praising-for-two-reasons event.

(134) $[\![\text{jeweils}_{\theta,C}]\!]_{adnominal}$
$= \lambda P \lambda \Theta \lambda e. e \in {}^*(P(\Theta(e')) \ \wedge \ C(\theta(e')))$

(135) $[\![\text{jeweils}_{id,\{e_c,e_p\}} \text{ zwei Gründen}]\!] = \lambda \Theta \lambda e. e \in {}^*\lambda e'.\text{2-reasons}(\Theta(e')) \wedge e' \in \{e_c, e_p\}$

I assume that *aus* (in this context) denotes a function from events to their causes (or whatever is the relation between a praising/criticizing event and its reason).

(136) $[\![\text{aus}]\!] = \lambda e.{}^*\text{cause}(e)$

(137) $[\![\text{aus jeweils}_{id,\{e_c,e_p\}} \text{ zwei Gründen}]\!] = \lambda e. e \in {}^*\lambda e'.\text{2-reasons}({}^*\text{cause}(e')) \wedge e' \in \{e_c, e_p\}$

I represent the denotation of the verbal conjunction using sum formation as in (138). I remain noncommittal about the compositional derivation of this conjunction. For present purposes, we do not need to choose between a sum-based denotation of *and*, as in (Lasersohn, 1995), and an intersective denotation that involves lifting of verb phrases as in Winter (2001) and Champollion (2015, to appear).

(138) $[\![\text{kritisierte und lobte}]\!] = \lambda e. \exists e_1 \exists e_2 [{}^*\text{criticize}(e_1) \wedge {}^*\text{praise}(e_2) \wedge e = e_1 \oplus e_2]$

Once all these building blocks have been put together and conjoined with the agent and theme, the result is as follows:

(139) $[\![(131)]\!] = \exists e.\text{agent}(e) = \text{peter} \ \wedge \ \text{theme}(e) = \text{maria} \wedge$
$\exists e_1 \exists e_2 [{}^*\text{criticize}(e_1) \wedge {}^*\text{praise}(e_2) \wedge e = e_1 \oplus e_2 \wedge$
$e \in {}^*\lambda e'.\text{2-reasons}({}^*\text{cause}(e')) \ \wedge \ e' \in \{e_c, e_p\}]$

This is true iff there is an event whose agent is Peter, whose theme is Maria, and which consists of two events e_c and e_p such that one of them is a criticizing event, the other one is a praising event, and each of them is caused by two reasons. By thematic uniqueness, each of these two events has Peter as agent and Maria as theme.

7.3 *Jeweils* in Subject Position

German adnominal *jeweils* can occur as part of the subject of a clause (Zimmermann, 2002b, p. 27). When the subject is at the beginning of the clause, one may speak of "backwards distributivity" since the antecedent of *jeweils* occurs to its right:

(140) Jeweils zwei Offiziere begleiteten die Ballerinen nach Hause.
Dist two officers accompanied the ballerinas to home.
'The ballerinas were accompanied home by two officers each.'

It has been claimed that backwards distribution is not possible in English, perhaps except for passives and unaccusatives (Burzio, 1986; Safir and Stowell, 1988):

(141) *One officer each accompanied the ballerinas home. (Zimmermann, 2002b)

(142) ?One interpreter each was assigned to the visitors. (Burzio, 1986, p. 200)

(143) Table 3 shows the dissertation topics for those holding earned doctorates. [...] Three dissertations each dealt with assessment, transfer, trustees, and technical education. Two dissertations each were on accreditation, counseling, effectiveness, and mission. One dissertation each focused on economic development, learning resources, performing arts, and strategic planning.[40]

(144) Indeed, Mr. Mitsotakis commanded only 144 seats [...] The Socialists won 125 seats [...] and one seat each went to a conservative independent and to an ethnic Turk from Thrace, near the Turkish border.[41]

I do not have a semantic explanation for the restriction against backwards distributivity in English. As in the case of locality restrictions, I assume that this restriction can be dealt with by syntactic accounts such as the ones already proposed, for example by Safir and Stowell (1988). I come back to this point in Section 8. For the German case, where there is no restriction, my account can easily be used to derive the meaning of (140) if we assume that the dimension paramter of *jeweils* is provided by the theta role of *die Ballerinen*. Here are the core elements of the derivation:

(145) $[\![\text{jeweils}_{theme,Atom}]\!]$ *(adnominal)* $= \lambda P \lambda \Theta \lambda e.e \in {}^*\lambda e'.P(\Theta(e')) \wedge \text{Atom}(\text{theme}(e'))$

(146) $[\![\text{jeweils}_{theme,Atom} \text{ zwei Offiziere [agent]}]\!] = \lambda e.e \in {}^*\lambda e'.\text{2-officers}({}^*\text{agent}(e')) \wedge \text{Atom}(\text{theme}(e'))$

(147) $[\![\text{begleiten die Ballerinen [theme]}]\!] = \lambda e.{}^*\text{accompany}(e) \wedge {}^*\text{theme}(e) = \bigoplus \text{ballerina}$

(148) $[\![\text{jeweils}_{theme,Atom} \text{ zwei Offiziere [agent] begleiten die Ballerinen [theme]}]\!]$
$\exists e.{}^*\text{accompany}(e) \wedge {}^*\text{theme}(e) = \bigoplus \text{ballerina} \wedge e \in {}^*\lambda e'.\text{2-officers}({}^*\text{agent}(e')) \wedge \text{Atom}(\text{theme}(e')))$

What (148) says is that there is a sum of accompanying events whose themes sum up to the ballerinas and which consists of parts e' such that each e' has an atomic theme and two officers as its sum agent.

7.4 Reverse DP-internal distributivity

Finally, here is an example of how the analysis can be extended to a use of a distance-distributive item which is halfway between the adverbial and adnominal case: backwards distributivity cases within a noun phrase like the following. I illustrate this case with a German example; a reviewer notes that parallel constructions are available with Polish distributive *po*.

[40] Attested example. Keim and Murray (2008, p. 125f.)

[41] Attested example. The New York Times, *Greek Conservative Is Seeking Coalition.* June 20, 1989.

(149) Das Parlament hat jeweils zwei Abgeordnete aus den drei baltischen
The parliament has DIST two representatives from the three Baltic
Staaten eingeladen.
states invited.
'From each of the three Baltic states, two representatives were invited by the parliament.'

The analysis proceeds as follows. I write $es \oplus la \oplus li$ for the sum of the three Baltic states Estonia, Latvia and Lithuania.

(150) $[\![$den drei baltischen Staaten$]\!]$ = $es \oplus la \oplus li$

I assume that in this context, *aus* ("from") denotes a function that maps individuals to their origins:

(151) $[\![$aus$]\!]$ = $\lambda y \lambda x.^{*}\text{origin}(x) = y$

The prepositional phrase then denotes the set of all plural individuals whose origins are the three Baltic states:

(152) $[\![$aus den drei baltischen Staaten$]\!]$ = $\lambda x.^{*}\text{origin}(x) = es \oplus la \oplus li$

The complex noun phrase denotes a sum of six representatives consisting of three pairs, with each pair coming from one of the three Baltic states. I will assume that *jeweils* here has the same denotation as adverbial *jeweils* in (71) except that it ranges over individuals instead of events. In the sentence at hand, its dimension parameter is set to the *origin* function I used as the denotation of *aus*, and its granularity parameter to *Atom* (since each pair of representatives comes from a single Baltic state:

(153) $[\![\text{jeweils}_{\textit{origin,Atom}}]\!]$ = $\lambda P_{et} \lambda x.x \in {}^{*}\lambda y.P(y) \wedge \text{Atom}(\text{origin}(x))$

(154) $[\![\text{jeweils}_{\textit{origin,Atom}}$ zwei Abgeordnete$]\!]$ = $\lambda x.x \in {}^{*}\lambda y.|y| = 2 \wedge {}^{*}\text{rep}(y) \wedge \text{Atom}(\text{origin}(y))$

The denotation of the complex noun phrase is the intersection of (154) and (152). After it combines with the *theme* theta head via the appropriate type shifter in (62a), the result is this:

(155) $[\![$[theme] jeweils zwei Abgeordnete aus den drei baltischen Staaten$]\!]$
= $\lambda e.^{*}\text{origin}(^{*}\text{theme}(e)) = es \oplus la \oplus li \wedge {}^{*}\text{theme}(e) \in {}^{*}\lambda y.|y| = 2 \wedge {}^{*}\text{rep}(y) \wedge \text{Atom}(\text{origin}(y))$

After combining with the main verb *eingeladen* and with the subject *Das Parlament*, the final result is as follows:

(156) $[\![$(149)$]\!]$
= $\exists e.^{*}\text{agent}(e) = \iota x[\text{parliament}(x)] \wedge mystar\text{invite}(e) \wedge {}^{*}\text{origin}(^{*}\text{theme}(e)) = es \oplus la \oplus li \wedge {}^{*}\text{theme}(e) \in {}^{*}\lambda y.|y| = 2 \wedge {}^{*}\text{rep}(y) \wedge \text{Atom}(\text{origin}(y))$

This says that there is an inviting event whose agent is the parliament, and whose theme has the following properties: its origins sum up to the three Baltic states, and it consists of sums of two representatives, each of which has an atomic origin.

8 Summary and Discussion

At the end of Section 2, I had suggested that the facts reviewed in that section suggest the following requirements for a theory of distributivity. First, the synonymy of the determiner, adnominal and adverbial uses of *each* in English should be captured, ideally by essentially identical lexical entries. Second, the fact that distance-distributive elements across languages share some part of their meanings (namely their individual-distributive readings) should be represented, as well as the fact that some of them can also have occasion readings. Third, the analysis should clarify the connections between distance-distributive elements and distributivity theory more generally, and the semantic variation across distance-distributive elements should be captured. Finally, an explanation should be readily available for the crosslinguistic observation that distance-distributive elements that can also be used as determiners can only distribute over individuals (Zimmermann's generalization).

Let me briefly summarize how the theory presented in this paper addresses these issues. The synonymy of the determiner, adnominal and adverbial uses of *each* in English is captured by the fact that they are all derived from Link's D operator. I have represent the fact that distance-distributive elements across languages share some part of their meanings by derived them from related distributivity operators (Link's or Schwarzschild's) which differ from each other only in their parameter settings. On the theory presented here, distance-distributive items display the same parametric variation as covert distributivity operators do, not only insofar as nonatomic distributivity is concerned, but also insofar as the ability is concerned to target different thematic roles or time. The semantic variation among distance-distributive elements is captured by restriction on parameter settings. One type of element, exemplified by English *each*, is hard-wired for distribution over atoms and the other one, exemplified by German *jeweils* also allows distribution over nonatomic contexts. Zimmermann's generalization is explained by the natural assumption that distance-distributive elements are formally identical to distributive determiners and therefore inherit their inability to distribute over nonatomic domains, no matter if these domains are mass or temporal.

The theory in this paper, while surface-compositional, is semantic and pragmatic. In this, it contrasts with some previous accounts discussed here. For example, Zimmermann (2002b) is an integrated syntactic and semantic approach. I have not specified the syntactic constraints that govern the theta-indexing of distributivity operators. While it would not be in the scope of this paper to do so, clearly a theory of theta-indexing eventually needs to supplement the proposed analysis in order to account for the locality conditions on binominal *each* constructions. These conditions have been studied in detail in the syntactic literature (e.g. Burzio, 1986; Safir and Stowell, 1988; Zimmermann, 2002b, ch. 3). Other examples of coindexation that are subject to syntactic locality constraints are familiar from binding theory (Chomsky, 1981; Büring, 2005). As one reviewer suggests, one might expect θ-indexing to turn out to obey a hierarchy comparable to the hierarchies of thematic roles that are sometimes claimed to be at work in binding theory (Jackendoff (1972, p. 148), see also Büring (2005, p. 16)).

If correct, this may help explain why attested cases of inverse distribution in English, such as the ones we have seen in (143) and (144), tend to involve nonagent subjects.

One possibility is that there are language specific constraints on θ-indexing. This may seem necessary in the light of differences in distribution of distance-distributive items in subject position that we have seen in (140). Another possibility is that θ-indexing is subject to language-universal constraints, but that distance-distributive items differ across languages in whether they require θ-indexing in order to distribute over another element in the sentence. For example, one might speculate that *jeweils* in (140) is not actually coindexed with the θ-role of the ballerinas. Rather, it distributes over a set of occasions which stand in a one-to-one relation with the ballerinas and which are made salient by the fact that the ballerinas are mentioned in the sentence. Thus, on this option there is no formal link between *jeweils* and the ballerinas. This makes an interesting prediction: The languages that allow distance-distributive items in subject position might turn out to be just the ones that allow distribution over salient entities that need not be overtly mentioned and need not be atomic. This prediction indeed appears to be borne out, as discussed in Zimmermann (2002b, p. 48-50). Besides German, Korean, Bulgarian and Czech have distance-distributive items that can occur in subject position. We have seen in Section 2 that these languages are in the group that allow distribution over salient entities.

Taken together, this paper and its counterpart, Champollion (2014a), suggest the following general picture of distributivity. No matter whether distributivity is introduced by an overt or by a covert element, it always involves a certain domain that contains the individuals or the material to be distributed over, and a certain size or granularity that specifies how finely the relevant predicates are distributed. When the domain question is a count domain, for example when we distribute over people or objects, then it is always possible to distribute over these objects one by one. When the domain in question does not make such atomic units available, as in the case of time or space, two things can happen. Either the element in question does not allow distribution over such nonatomic domains, for example because it is incompatible with non count domains to begin with, or else it looks for a salient cover or set in the context, such as a salient set of temporal locations. Those distributive elements that can do this in principle can also do this in count domains even though atoms are available.

References

Balusu, Rahul (2005). Distributive reduplication in Telugu. In: *Proceedings of the 36th Annual Meeting of the North East Linguistic Society (NELS 36)*. Ed. by Christopher Davis, Amy Rose Deal, and Youri Zabbal. Amherst, MA: University of Massachusetts GLSA Publications, pp. 39–53. URL: semanticsarchive.net/Archive/mEoYTZkZ/.

Balusu, Rahul and Karattuparambil A. Jayaseelan (2013). Distributive quantification by reduplication in Dravidian. In: *Strategies of quantification*. Oxford, UK: Oxford University Press, pp. 60–86. DOI: 10.1093/acprof:oso/9780199692439.003.0004.

Barker, Chris (2002). Continuations and the nature of quantification. *Natural Language Semantics* 10(3), 211–242. DOI: 10.1023/A:1022183511876.

Barwise, Jon and Robin Cooper (1981). Generalized quantifiers and natural language. *Linguistics and Philosophy* 4(2), 159–219. DOI: 10.1007/bf00350139.

Bayer, Samuel L. (1997). *Confessions of a lapsed neo-Davidsonian: Events and arguments in compositional semantics*. New York, NY: Garland. DOI: 10.4324/9780203055106.

Beck, Sigrid and Uli Sauerland (2000). Cumulation is needed: A reply to Winter 2000. *Natural Language Semantics* 8(4), 349–371. DOI: 10.1023/A:1011240827230.

Beghelli, Filippo and Tim Stowell (1997). Distributivity and negation: The syntax of *each* and *every*. In: *Ways of scope taking*. Ed. by Anna Szabolcsi. Vol. 65. Dordrecht, Netherlands: Kluwer, pp. 71–107. DOI: 10.1007/978-94-011-5814-5_3.

Bittner, Maria (1994). Cross-linguistic semantics. *Linguistics and Philosophy* 17(1), 53–108. DOI: 10.1007/bf00985041.

Blaheta, Don (2003). Binominal *each*: Evidence for a modified type system. MA thesis. Providence, RI: Brown University. URL: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.10.7455&rep=rep1&type=pdf.

Bobaljik, Jonathan D. (1995). Morphosyntax: The syntax of verbal inflection. PhD thesis. Cambridge, MA: Massachusetts Institute of Technology. URL: http://www.ai.mit.edu/projects/dm/theses/bobaljik95.pdf.

Bobaljik, Jonathan D. (2001). Floating quantifiers: Handle with care. In: *The second state-of-the-article book*. Ed. by Lisa Cheng and Rynt Sybesma. 45-68. Berlin, Germany: de Gruyter. DOI: 10.1515/9783110890952.107.

Brasoveanu, Adrian and Jakub Dotlačil (2015). Strategies for scope taking. *Natural Language Semantics* 23, 1–19. DOI: 10.1007/s11050-014-9109-1.

Brasoveanu, Adrian and Donka Farkas (2011). How indefinites choose their scope. *Linguistics and philosophy* 34(1), 1–55. DOI: 10.1007/s10988-011-9092-7.

Bruening, Benjamin (2010). Ditransitive asymmetries and a theory of idiom formation. *Linguistic Inquiry* 41(4), 519–562. DOI: 10.1162/ling_a_00012.

Büring, Daniel (2005). *Binding theory*. Cambridge, UK: Cambridge University Press. DOI: 10.1017/cbo9780511802669.

Burzio, Luigi (1986). *Italian syntax: A government-binding approach*. Berlin, Germany: Springer. DOI: 10.1007/978-94-009-4522-7.

Cable, Seth (2014). Distributive numerals and distance distributivity in Tlingit (and beyond). *Language* 90(3), 562–606. URL: https://muse.jhu.edu/journals/language/v090/90.3.cable.html.

Champollion, Lucas (2010a). Cumulative readings of *every* do not provide evidence for events and thematic roles. *Logic, Language and Meaning* 6042, 213–222. DOI: 10.1007/978-3-642-14287-1_22.

Champollion, Lucas (2010b). Parts of a whole: Distributivity as a bridge between aspect and measurement. PhD thesis. Philadelphia, PA: University of Pennsylvania. URL: repository.upenn.edu/cgi/viewcontent.cgi?article=2117&context=edissertations.

Champollion, Lucas (2011). Quantification and negation in event semantics. *The Baltic International Yearbook of Cognition, Logic and Communication* 6, 1–23. DOI: 10.4148/biyclc.v6i0.1563.

Champollion, Lucas (2012). Each vs. Jeweils: A cover-based view on distance distributivity. *Logic, Language and Meaning* 7218, 251–260. DOI: 10.1007/978-3-642-31482-7_26.

Champollion, Lucas (2013). Man and woman: The last obstacle to boolean coordination. In: *Proceedings of the 19th Amsterdam Colloquium*. Ed. by Maria Aloni, Michael Franke, and Floris Roelofsen. Amsterdam, Netherlands: ILLC Publications, pp. 83–90. DOI: 10.13140/2.1.4779.1045.

Champollion, Lucas (2014a). Covert distributivity in algebraic event semantics. Ms. New York University. URL: ling.auf.net/lingbuzz/002097.

Champollion, Lucas (2014b). Every boy bought two sausages each: Distributivity and dependent numerals. In: *Proceedings of the 32nd West Coast Conference on Formal Linguistics (WCCFL 32)*. Ed. by Ulrike Steindl et al. Somerville, MA: Cascadilla Proceedings Project, pp. 103–110. URL: lingbuzz/002232.

Champollion, Lucas (2015). The interaction of compositional semantics and event semantics. *Linguistics and Philosophy* 38(1), 31–66. DOI: 10.1007/s10988-014-9162-8.

Champollion, Lucas (to appear). Ten men and women got married today. In press at *Journal of Semantics*. URL: ling.auf.net/lingbuzz/002025.

Choe, Jae-Woong (1987). Anti-quantifiers and a theory of distributivity. PhD thesis. Amherst, MA: University of Massachusetts. URL: http://scholarworks.umass.edu/dissertations/AAI8727027/.

Chomsky, Noam (1981). *Lectures on government and binding: the Pisa lectures*. Dordrecht, Netherlands: Foris. DOI: 10.1515/9783110884166.

Collins, Chris and Paul Martin Postal (2012). *Imposters: a study of pronominal agreement*. MIT Press. DOI: 10.7551/mitpress/9780262016889.001.0001.

Doetjes, Jenny (1997). Quantifiers and selection: On the distribution of quantifying expressions in French, Dutch and English. PhD thesis. The Hague, Netherlands: Holland Institute of Generative Linguistics. URL: https://openaccess.leidenuniv.nl/bitstream/handle/1887/19731/doetjes_geheel%5B1%5D.pdf?sequence=1.

Dotlačil, Jakub (2013). Reciprocals distribute over information states. *Journal of Semantics* 30(4), 423–477. DOI: 10.1093/jos/ffs016.

Dotlačil, Jakub (2011). Fastidious distributivity. In: *Proceedings of the 21st Semantics and Linguistic Theory Conference (SALT 21)*. Ed. by Neil Ashton, Anca Chereches, and David Lutz. Ithaca, NY: Cornell University CLC Publications, pp. 313–332. URL: http://elanguage.net/journals/salt/article/download/21.313/2538.

Dotlačil, Jakub (2012). Binominal *each* as an anaphoric determiner: Compositional analysis. In: *Proceedings of Sinn und Bedeutung 16*. Ed. by Ana Aguilar Guevara, Anna Chernilovskaya, and Rick Nouwen. Cambridge, MA: MIT Working Papers in Linguistics, pp. 211–224. URL: http://mitwpl.mit.edu/open/sub16/Dotlacil.pdf.

Dowty, David R. and Belinda Brodie (1984). The semantics of "floated" quantifiers in a transformationless grammar. In: *Proceedings of the 3rd West Coast Conference on Formal Linguistics (WCCFL 3)*. Ed. by Mark Cobler, Susannah McKaye, and Michael T. Westcoat. CSLI Publications. Stanford, CA, pp. 75–90.

Drummond, Alex (2013). *Ibex Farm*. Online server. URL: http://spellout.net/ibexfarm.

Erlewine, Michael Yoshitaka and Hadas Kotek (to appear). A streamlined approach to online linguistic surveys. *Natural Language and Linguistic Theory*.

Farkas, Donka F. (1997). Dependent indefinites. In: *Empirical issues in formal syntax and semantics*. Ed. by Francis Corblin, Danièle Godard, and Jean-Marie Marandin. Bern, Switzerland: Peter Lang, pp. 243–268. URL: semanticsarchive.net/Archive/GUyODE1M/.

Gil, David (1982). Distributive numerals. PhD thesis. Los Angeles, CA: University of California.

Gillon, Brendan S. (1987). The readings of plural noun phrases in English. *Linguistics and Philosophy* 10(2), 199–219. DOI: 10.1007/bf00584318.

Gillon, Brendan S. (1990). Plural noun phrases and their readings: A reply to Lasersohn. *Linguistics and Philosophy* 13(4), 477–485. DOI: 10.1007/bf00630751.

Grevisse, Maurice (1980). *Le bon usage: grammaire française, avec des remarques sur la langue française d'aujourd'hui*. Paris, France: Duculot.

Groenendijk, Jeroen, Theo Janssen, and Martin Stokhof, eds. (1984). *Truth, interpretation and information: Selected papers from the Third Amsterdam Colloquium*. Dordrecht, Netherlands: Foris. DOI: 10.1515/9783110867602.

Harley, Heidi (2012). Semantics in distributed morphology. In: *Semantics: An International Handbook of Natural Language Meaning*. Ed. by Claudia Maienborn, Klaus von Heusinger, and Paul Portner. Vol. 3. de Gruyter, pp. 2151–2172. DOI: 10.1515/9783110253382.2151.

Heim, Irene, Howard Lasnik, and Robert May (1991). Reciprocity and plurality. *Linguistic Inquiry* 22(1), 63–101. URL: http://www.jstor.org/stable/4178708.

Hendriks, Herman (1993). Studied flexibility. PhD thesis. Amsterdam, Netherlands: University of Amsterdam.

Ioup, Georgette (1975). Some universals for quantifier scope. *Syntax and semantics* 4, 37–58.

Jackendoff, Ray S. (1972). *Semantic interpretation in generative grammar*. Cambridge, MA: MIT Press.

Janke, Vikki and Ad Neeleman (2012). Ascending and descending VPs in English. *Linguistic Inquiry* 43(1), 151–190. DOI: 10.1162/ling_a_00082.

Junker, Marie-Odile (1995). *Syntaxe et sémantique des quantifieurs flottants* tous *et* chacun*: distributivité en sémantique conceptuelle*. Vol. 28. Geneva, Switzerland: Librairie Droz.

Keim, Marybelle C. and John P. Murray (2008). Chief academic officers' demographics and educational backgrounds. *Community College Review* 36(2), 116–132. DOI: 10.1177/0091552108324657.

Kratzer, Angelika (1996). Severing the external argument from its verb. In: *Phrase structure and the lexicon*. Ed. by J. Rooryck and L. Zaring. Dordrecht, Netherlands: Kluwer, pp. 109–137. DOI: 10.1007/978-94-015-8617-7_5.

Kratzer, Angelika (2000). The event argument and the semantics of verbs, chapter 2. Ms. University of Massachusetts, Amherst. URL: semanticsarchive.net/Archive/GU1NWM4Z/.

Kratzer, Angelika (2007). On the plurality of verbs. In: *Event structures in linguistic form and interpretation*. Ed. by Johannes Dölling, Tatjana Heyde-Zybatow, and Martin Schäfer. Berlin, Germany: de Gruyter, pp. 269–300. DOI: 10.1515/9783110925449.269.

Landman, Fred (1989). Groups, I. *Linguistics and Philosophy* 12(5), 559–605. DOI: 10.1007/BF00627774.

Lasersohn, Peter (1989). On the readings of plural noun phrases. *Linguistic Inquiry* 20(1), 130–134. URL: http://www.jstor.org/stable/4178619.

Lasersohn, Peter (1995). *Plurality, conjunction and events*. Dordrecht, Netherlands: Kluwer. DOI: 10.1007/978-94-015-8581-1.

Lasersohn, Peter (1998). Generalized distributivity operators. *Linguistics and Philosophy* 21(1), 83–93. DOI: 10.1023/A:1005317815339.

LaTerza, Chris (2014a). Distributivity and plural anaphora. PhD thesis. College Park, MD: University of Maryland. URL: http://drum.lib.umd.edu/bitstream/1903/15826/1/LaTerza_umd_0117E_15588.pdf.

LaTerza, Chris (2014b). Local plural anaphora as sub-event distributivity. In: *Proceedings of the 32nd West Coast Conference on Formal Linguistics (WCCFL 32)*. Ed. by Ulrike Steindl et al. Somerville, MA: Cascadilla Proceedings Project, pp. 141–148. URL: http://www.lingref.com/cpp/wccfl/32/paper3165.pdf.

Link, Godehard (1987). Generalized quantifiers and plurals. In: *Generalized quantifiers*. Ed. by Peter Gärdenfors. Reprinted in Link, 1998a, Chapter 4. Berlin, Germany: Springer, pp. 151–180. DOI: 10.1007/978-94-009-3381-1_6.

Link, Godehard (1998a). *Algebraic semantics in language and philosophy*. Stanford, CA: CSLI Publications.

Link, Godehard (1998b). Je drei Äpfel - three apples each: Quantification and the German 'je'. In: *Algebraic semantics in language and philosophy*. Ed. by Godehard Link. Stanford, CA: CSLI Publications, pp. 117–132.

Maling, Joan M. (1976). Notes on quantifier-postposing. *Linguistic Inquiry* 7(4), 708–718. URL: http://www.jstor.org/stable/4177962.

Marantz, Alec (1993). Implications of asymmetries in double object constructions. *Theoretical aspects of Bantu grammar* 1, 113–151.

Moltmann, Friederike (1992). Reciprocals and *same/different*: Towards a semantic analysis. *Linguistics and Philosophy* 15(4), 411–462. DOI: 10.1007/bf00627683.

Moltmann, Friederike (1997). *Parts and wholes in semantics*. Oxford, UK: Oxford University Press. URL: http://ukcatalogue.oup.com/product/9780195154931.do.

Montague, Richard (1973). The proper treatment of quantification in ordinary English. In: *Approaches to Natural Language: Proceedings of the 1970 Stanford Workshop on Grammar and Semantics*. Ed. by Jaakko Hintikka, Julius Moravcsik, and Patrick Suppes. Dordrecht, Netherlands: Springer, pp. 221–242. DOI: 10.1007/978-94-010-2506-5_10.

Oh, Sei-Rang (2001). Distributivity in an event semantics. In: *Proceedings of the 11th Semantics and Linguistic Theory Conference (SALT 11)*. Ed. by Rachel Hastings, Brendan Jackson, and Zsófia Zvolensky. Ithaca, NY: Cornell University CLC Publications, pp. 326–345. URL: http://elanguage.net/journals/index.php/salt/article/download/11.326/1717.

Oh, Sei-Rang (2006). Plurality markers across languages. PhD thesis. Amherst, MA: University of Massachusetts. URL: http://digitalcommons.uconn.edu/dissertations/AAI3236140.

Petrova, Milena (2000). The distributive marker *po* in Bulgarian. Ms. University of Southern California.

Postal, Paul (1974). *On raising*. Cambridge, MA: MIT Press.

Pylkkänen, Liina (2008). *Introducing arguments*. Cambridge, MA: MIT Press. DOI: 10.7551/mitpress/9780262162548.001.0001.

Roberts, Craige (1987). Modal subordination, anaphora, and distributivity. PhD thesis. Amherst, MA: University of Massachusetts. URL: http://scholarworks.umass.edu/dissertations/AAI8710499/.

Safir, Ken and Tim Stowell (1988). Binominal each. In: *Proceedings of the 18th Annual Meeting of the North East Linguistic Society (NELS 18)*. Amherst, MA: University of Massachusetts GLSA Publications, pp. 426–450. URL: http://www.linguistics.ucla.edu/people/stowell/Safir-Stowell_-_Binominal_Each_-_NELS_1988_ocr.pdf.

Sakaguchi, Mari (1998). Distributivity in English and Japanese. PhD thesis. Los Angeles, CA: University of California.

Scha, Remko (1981). Distributive, collective and cumulative quantification. In: *Formal methods in the study of language*. Ed. by Jeroen Groenendijk, Theo Janssen, and Martin Stokhof. Reprinted in Groenendijk, Janssen, and Stokhof, 1984. Amsterdam, Netherlands: Mathematical Center Tracts, pp. 483–512. DOI: 10.1515/9783110867602.131.

Schein, Barry (1993). *Plurals and events*. Cambridge, MA: MIT Press.

Schwarzschild, Roger (1996). *Pluralities*. Dordrecht, Netherlands: Kluwer. DOI: 10.1007/978-94-017-2704-4.

Schwarzschild, Roger (2014). Distributivity, negation and quantification in event semantics: Recent work by L. Champollion. Ms. Massachusetts Institute of Technology.

Sportiche, Dominique (1988). A theory of floating quantifiers and its corollaries for constituent structure. *Linguistic Inquiry* 19(3), 425–449. URL: http://www.jstor.org/stable/25164903.

Stanley, Jason and Zoltán Gendler Szabó (2000). On Quantifier Domain Restriction. *Mind and Language* 15(2&3), 219–261. DOI: 10.1111/1468-0017.00130.

Sutton, Melody (1993). Binominal "each". MA thesis. Los Angeles, CA: University of California.

Szabolcsi, Anna (2010). *Quantification*. Cambridge, UK: Cambridge University Press. DOI: 10.1017/cbo9780511781681.

Tasmowski-De Ryck, Liliane and S. Paul Verluyten (1982). Linguistic control of pronouns. *Journal of Semantics* 1(4), 323–346. DOI: 10.1093/jos/1.3-4.323.

Tellier, Christine and Daniel Valois (1993). Binominal *chacun* and pseudo-opacity. *Linguistic Inquiry* 24(3), 399–589. URL: http://www.jstor.org/stable/4178830.

Tunstall, Susanne Lynn (1998). The interpretation of quantifiers: semantics & processing. PhD thesis. University of Massachusetts, Amherst.

Williams, Alexander (2009). Themes, cumulativity, and resultatives: Comments on Kratzer 2003. *Linguistic Inquiry* 40(4), 686–700. DOI: 10.1162/ling.2009.40.4.686.

Williams, Edwin (1991). Reciprocal scope. *Linguistic Inquiry* 22(1), 159–173. URL: http://www.jstor.org/stable/4178711.

Winter, Yoad (2001). *Flexibility principles in Boolean semantics: The interpretation of coordination, plurality, and scope in natural language*. Cambridge, MA: MIT Press.

Zimmermann, Malte (2002a). A compositional analysis of anti-quantifiers as quantifiers. In: *Proceedings of the 12th Semantics and Linguistic Theory Conference (SALT 12)*. Ed. by Brendan Jackson. Ithaca, NY: Cornell University CLC Publications, pp. 322–338. URL: http://elanguage.net/journals/salt/article/download/12.322/1789.

Zimmermann, Malte (2002b). Boys buying two sausages each: On the syntax and semantics of distance-distributivity. PhD thesis. Amsterdam, Netherlands: University of Amsterdam. URL: http://www.lotpublications.nl/Documents/62_fulltext.pdf.

Zweig, Eytan (2008). Dependent plurals and plural meaning. PhD thesis. New York, NY: New York University. URL: semanticsarchive.net/Archive/GJhMzhhZ/.