Each vs. *Jeweils*: A Cover-Based View on Distance Distributivity

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Abstract. Zimmermann [2002] identifies two kinds of distance-distributive items across languages. The first kind (e.g. *each*) is restricted to distribution over individuals; the second kind (e.g. German *jeweils*) can also be interpreted as distributing over salient occasions. I explain this behavior by formally relating this split to the two distributivity operators proposed in the work of Link (atomic operator) and Schwarzschild (cover-based operator), which I reformulate in a Neo-Davidsonian framework.

Keywords: distributivity, crosslinguistic semantics, algebraic semantics.

1 Introduction

Across languages, distributive items have different syntactic uses and different meanings. In English, *each* can be used in three essentially synonymous ways:

(1) a. **Adnominal:** The children saw two monkeys *each*.
b. **Adverbial:** The children *each* saw two monkeys.
c. **Determiner:** *Each* child saw two monkeys.

There are many terms for these three uses. Adnominal *each* is also called binominal or shifted; adverbial *each* is also called floated; and determiner *each* is also called prenominal. Following Zimmermann [2002], I will refer to adnominal and adverbial *each* as distance-distributive items, or DD items for short.

In German, adnominal and adverbial *each* are translated by one word, *jeweils*. Determiner *each*, however, is translated by another one, *jed-*. I gloss DD items as DIST since, as we will see, they have a wider range of readings than *each*.

(2) a. **Adnominal:** Die Kinder haben [*jeweils* [zwei Affen]] gesehen.
The children have DIST two monkeys seen.
b. **Adverbial:** Die Kinder haben [*jeweils* [zwei Affen gesehen]].
The children have DIST two monkeys seen.
c. **Determiner:** *Jedes/*Jeweils* Kind hat zwei Affen gesehen.
Each.sg.n/DIST child has two monkeys seen.

Though adverbial and adnominal *jeweils* take the same surface position in (2a) and (2b), they can be teased apart syntactically, as shown in Zimmermann [2002]. However, this distinction will play no role in this paper.

M. Aloni et al. (Eds.): Amsterdam Colloquium 2011, LNCS 7218, pp. 251–260, 2012.

2 Crosslinguistic Variation

Zimmermann [2002] classifies about a dozen languages depending on whether the DD item can also function as a distributive determiner, as in English, or not, as in German. Across these languages, he observes that DD items which can also be used as determiners (e.g. *each*) always distribute over individuals, as determiners do. In contrast, many of those DD items which are formally distinct from determiners (e.g. *jeweils*) can also distribute over salient occasions, that is, over chunks of time or space. See also Moltmann [1997] for an earlier discussion of *each* vs. *jeweils*, and Zimmermann [2002] for a critique of Moltmann's analysis.

The best way to illustrate Zimmermann's observation is to start by considering German *jeweils*, a DD item 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.[1] The following examples illustrate this. Sentence (3) is ambiguous between a reading that distributes over individuals – the ones of which their plural subject consists, (3a) – and one that distributes over occasions (3b).

(3) Die Kinder haben jeweils zwei Affen gesehen. *(German)*
The children have DIST two monkeys seen.
a. 'Each of the children has seen two monkeys.'
b. 'The children have seen two monkeys each time.'

While the former reading is always available, the latter requires a supporting context. That is, when (3) is uttered out of the blue, it only has the reading (3a). The reading (3b), 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 children have been to the zoo on several previous occasions.

Unlike *each*, *jeweils* can also occur with a singular subject, as in (4), which only has an occasion reading, 'Hans has seen two monkeys on each occasion.'

(4) Hans hat jeweils zwei Affen gesehen. *(German)*
Hans has DIST two monkeys seen.

[1] The occasion reading corresponds to what Balusu [2005] calls the *spatial key* and *temporal key* readings. I leave open the question of whether the spatial and temporal cases should be distinguished as two separate readings. Another, less theory-neutral term for it is *event-distributive reading* [Oh, 2001]. Zimmermann [2002] uses the term *adverbial reading* for it. This term is misleading, because it suggests that only the adverbial use of *jeweils* can give rise to this reading. But as he documents in his Chapter 5, adnominal *jeweils* can give rise to it as well. For example, in (i), *jeweils* is part of the subject DP and is therefore adnominal. However, as shown by the paraphrase, this instance of *jeweils* distributes over occasions, not over individuals.

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

This sentence is odd out of the blue, and it requires supporting context in the same way as reading (3b) does. Its other potential reading would involve vacuous distribution over only one individual, Hans, and is presumably blocked through the Gricean maxim of manner "Be brief".

While *jeweils* allows distribution both over individuals and over salient occasions, this is not the case for all DD items, as Zimmermann reports. Crosslinguistically, many adnominal DD items can only distribute over individuals. For example, English adnominal *each* lacks the occasion reading:

(5) The children have seen two monkeys each.
   a. *Available:* 'Each of the children has seen two monkeys.'
   b. *Unavailable:* 'The children have seen 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 Gricean reasons:

(6) *John has seen two monkeys each.

Unlike (4), this sentence lacks an occasion reading, even with supporting context. Why does *each* lack the occasion reading? We have seen in Section 1 that *each* also differs from *jeweils* in that only the former can also be used as a determiner. Adnominal DD items in Dutch, Norwegian, Italian, Russian, and French [Zimmermann, 2002] and in Turkish (Tuğba Çolak, p.c.) all behave like adnominal *each* in two ways: They can also be used as distributive determiners, and they lack the occasion reading.[2] Following Zimmermann [2002], we can generalize:

(7) **Zimmermann's Generalization:** If a DD item can also be used as a distributive determiner, it lacks the occasion reading.

This generalization goes only one way, that is, the "if" cannot be strengthened to "if and only if". This is because, as Zimmermann shows, the Japanese DD item *sorezore* cannot be used as a determiner but lacks the occasion reading. But "if and only if" may still be true as a tendency. Zimmermann reports that in addition to German *jeweils*, adnominal DD items in Czech, Bulgarian, and Korean have occasion readings and cannot be used as determiners.[3]

The following requirements for a semantic analysis of distance-distributivity emerge. First, the synonymy of the determiner, adnominal and adverbial uses

[2] The French case is somewhat controversial. Adnominal *chacun* and determiner/adnominal *chaque* are not exactly identical, but Zimmermann [2002] argues (p. 44) that they are historically related and can still be considered formally identical.

[3] Many languages express adnominal distance distributivity by reduplicating a numeral [Gil, 1982]. In this category, we both find cases where reduplication does not give rise to occasion readings, such as Hungarian [Farkas, 1997; Szabolcsi, 2010], and cases where it does, such as Telugu [Balusu, 2005]. The import of these cases on Zimmermann's generalization is unclear, as reduplication is not usually thought of as a free morpheme and is therefore not expected to be able to act as a determiner.

of *each* in English should be captured, ideally by essentially identical lexical entries. Second, the fact that DD items 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 DD items and distributivity theory. Finally, there should be a way to capture Zimmermann's Generalization. I now propose an analysis that fulfills these requirements. Section 3 presents distributivity operators; Section 4 relates them to DD items. Section 5 concludes and offers a speculation on how Zimmermann's Generalization can be captured.

3 Distributivity Operators in Algebraic Event Semantics

The following analysis is placed in the context of algebraic event semantics [Krifka, 1989] and of the theory of distributivity developed by Link [1987] and Schwarzschild [1996]. Link postulates a silent operator that shifts a VP to a distributive interpretation, that is, one that holds of any individual whose atomic parts each satisfy the unshifted VP. This so-called D operator is defined as follows. Here, the variable x is resolved to a plural entity, the subject, and y ranges over its atomic parts, that is, the singular individuals of which it consists.

(8) $[\![\mathrm{D}]\!] = \lambda P_{et} \lambda x \forall y [y \leq x \wedge \mathrm{Atom}(y) \rightarrow P(y)]$ [Link, 1987]

The optional presence of the D operator derives the ambiguity between distributive and scopeless readings. For example, (9a) represents a scopeless reading and (9b) a distributive reading. I use the term "scopeless" to refer both to collective and cumulative readings. The distinction between these two readings does not matter for this paper. See Landman [2000] for discussion.

(9) a. The children saw two monkeys.
≈ The children between them saw two monkeys. *scopeless*
b. The children [D [saw two monkeys]].
≈ The children each saw two monkeys. *distributive*

I propose that DD items should be essentially thought of as versions of this D operator (cf. Link [1986] for a similar claim for German *je*, a short form of *jeweils* which seems to lack the occasion reading). Clearly, Link's D operator and *each* are similar, as can be seen from the paraphrase of (9b). I take adverbial *each* and related DD items in Dutch, Norwegian, Italian, Russian, French, and Turkish to be D operators. As for *jeweils* and its relatives in Czech, Bulgarian, 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.

However, Schwarzschild [1996] argues on independent grounds that Link's D operator should be modified to allow for "nonatomic distributive" interpretations in a limited set of circumstances, namely whenever there is a particularly salient way to divide a plural individual. A good example of what Schwarzschild has in mind is provided by Lasersohn [1998]. Shoes typically come in pairs, so a sentence like *The shoes cost $50* can be interpreted as saying that each pair of shoes costs $50, as opposed to each shoe or all the shoes together. To model this kind of example, Schwarzschild modifies D and makes it anaphoric to a salient cover (a partition of a plural individual that allows overlap). C, the "cover variable", is free and anaphoric on the context. Schwarzschild assumes that C is a cover of the entire universe of discourse, but for most purposes one can instead think of C as a cover or a partition of the sum individual in question into salient parts, which may be plural sums. In this case, C partitions the sum of shoes into pairs. Schwarzschild refers to his own version of the D operator as Part.

(10) $[\![\text{Part}_C]\!] = \lambda P_{et} \lambda x \forall y[y \leq x \wedge \text{C}(y) \rightarrow P(y)]$ [Schwarzschild, 1996]

This operator optionally applies to a VP and shifts it to a nonatomic distributive reading. For example, Lasersohn's sentence is modeled as follows:

(11) The shoes [Part [cost $50]].
≈ Each salient plurality of shoes costs $50. *nonatomic distributive*

It is of course possible to think of D as a special case of Part, namely the one that results when the variable C is resolved to the predicate *Atom*. However, I assume that both D and Part are present in the grammar. This assumption will allow us to capture the distinction between *each* and *jeweils*. The former corresponds to D and the latter corresponds to Part. This accounts for the fact that *jeweils* and its relatives across languages have a wider range of readings than *each* and its relatives do.

In count domains, distributivity over atoms is expected to be salient in almost all contexts and to obscure the presence of nonatomic distributive readings [Schwarzschild, 1996]. It is therefore useful to look for nonatomic VP-level distributivity in a noncount domain, such as time. Here we find once again that the readings in question are available given appropriate contextual information or world knowledge. Example (12) is based on observations in Moltmann [1991]. It is odd out of the blue because pills cannot be taken repeatedly, but it is acceptable in a context where the patient's daily intake is discussed. Example (13) is from Deo and Piñango [2011], and is acceptable because it is clear that snowmen are typically built in winter.

(12) The patient took two pills for a month and then went back to one pill.

(13) We built a huge snowman in our front yard for several years.

Since *for*-adverbials are otherwise not able to cause indefinites to covary [Zucchi and White, 2001], and since Part is dependent on a salient level of granularity just like (12) and (13) are, it is plausible to assume that a temporal version of Part is responsible for the distributive interpretation of these sentences. See Champollion [2010] for more discussion of this point. The contribution of this temporal version of Part can be paraphrased as *daily* in (12) and *yearly* in (13).

The original formulations of the operators in (8) and (10) can only "target" (that is, distribute over parts of) the subject. Examples like (12) and (13) motivate a reformulation of the operators that allows them to target different thematic roles, including time. I will represent the relationship between D and the thematic role it targets through coindexation. For evidence that this relationship can be nonlocal, which justifies the use of coindexation, see Champollion [2010]. Coindexation also allows us to capture the fact that DD items can also target different thematic roles [Zimmermann, 2002]. For example, (14) can either involve two stories per boy or two stories per girl, depending on which thematic role is targeted by *each*.

(14) The boys told the girls two stories each.

In the following, I assume a Neo-Davidsonian algebraic semantic system loosely based on Krifka [1989] and Champollion [2010]. Events, verbs and thematic roles are each assumed to be closed under sum formation. Verbs and their projections are all of type vt (event predicates). Here is a sample entry of a verb.

(15) $[\![\text{see}]\!] = \lambda e\ [^{*}\text{see}(e)]$

This entry includes the star operator from Link [1983] as a reminder that the predicate is closed under sum formation. The star operator maps a set P to the predicate that applies to any sum of things each of which is in P. It can be easily generalized to functions such as thematic roles [Champollion, 2010].

Noun phrases are interpreted in situ (I do not consider quantifier raising in this paper). Silent theta role heads, which denote functions of type ve (event to individual), are located between noun phrases and verbal projections. I will often omit them in the LFs for clarity. The precise nature of the compositional process is not essential, but it affects the types of the lexical entries of DD items 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.

(16) a. Type shifter for indefinites: $\lambda\theta_{ve}\lambda P_{et}\lambda V_{vt}\lambda e[V(e) \wedge P(\theta(e))]$
b. Type shifter for definites: $\lambda\theta_{ve}\lambda x\lambda V_{vt}\lambda e[V(e) \wedge \theta(e) = x]$

Each of these type shifters combines a noun phrase with its theta role head to build an event predicate modifier of type $\langle vt, vt\rangle$. For example, after the noun phrases *the children* (definite) and *two monkeys* (indefinite) combine with the theta role heads *agent* and *theme* respectively, their denotations are as follows. Here, $\bigoplus$ child stands for the sum of all children, a plural individual of type e.

(17) $[\![[\text{agent [the children]}]]\!] = \lambda V\lambda e[V(e) \wedge {}^{*}\text{ag}(e) = \bigoplus \text{child}]$

(18) $[\![[\text{theme [two monkeys]}]]\!] = \lambda V\lambda e[V(e) \wedge |{}^{*}\text{th}(e)| = 2 \wedge {}^{*}\text{monkey}({}^{*}\text{th}(e))]$

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 (19). Here and below, I write *2M* as a shorthand for $\lambda e[|{}^{*}\text{th}(e)| = 2 \wedge {}^{*}\text{monkey}({}^{*}\text{th}(e))]$.

(19) $[\![\text{The children saw two monkeys}]\!] = \exists e[{}^*\text{ag}(e) = \bigoplus \text{child} \wedge {}^*\text{see}(e) \wedge 2\text{M}(e)]$

To generate distributive readings, we use Link's D operator. Since VPs are event predicates, VP-level operators must be reformulated as event predicate modifiers. As described above, I assume that the D operator is coindexed with a thematic role θ, its target. My reformulation of Link's D operator is therefore as follows:[4]

(20) $[\![\text{D}_\theta]\!] = \lambda V_{vt} \lambda e[e \in {}^*\lambda e'[V(e') \;\wedge\; \text{Atom}(\theta(e'))]]$

As an example, the distributive reading of (19) is derived like this:

(21) $[\![\text{The children D}_{ag} \text{ [saw two monkeys]}]\!]$
$= \exists e[{}^*\text{ag}(e) = \bigoplus \text{child} \;\wedge\; e \in [[\![D_{ag}]\!](\lambda e'[{}^*\text{see}(e') \;\wedge\; 2\text{M}(e')])]]$
$= \exists e[{}^*\text{ag}(e) = \bigoplus \text{child} \;\wedge\; e \in {}^*\lambda e'[{}^*\text{see}(e') \;\wedge\; 2\text{M}(e') \;\wedge\; \text{Atom}(\text{ag}(e'))]]$

This formula is true just in case there is an event e whose agent is the children, and which consists of seeing-two-monkeys events whose agents are atomic. Remember that events and thematic roles are closed under sum, so e can be a plural event with a plural agent. The formula does not explicitly state that the seeing-two-monkeys events have children as agents. However, this fact is entailed by the assumption that thematic roles are closed under sum formation together with the assumption that the entities in the denotation of singular count nouns like *child* are atoms. Specifically, the existentially quantified event can only have the children as its agent if it consists of events whose individual agents are children.

4 *Each* and *Jeweils* as Distributivity Operators

Adverbial *each* is a VP modifier and can therefore be given the same entry as the D operator in (20). Adnominal and determiner *each* need to be type-shifted, but both are defined in terms of (20). This reflects their synonymousness:[5]

(22) $[\![\text{each}_\theta]\!]_{adverbial} = [\![D_\theta]\!] =$ (20)

(23) $[\![\text{each}_\theta]\!]_{adnominal} = \lambda P_{et} \lambda \theta_{ve} \lambda V_{vt} \lambda e \; [[\![D_\theta]\!](\lambda e'[V(e') \wedge P(\theta(e'))])(e)]$

(24) $[\![\text{each}]\!]_{determiner} = \lambda P_{et} \lambda \theta_{ve} \lambda V_{vt} \lambda e \; [\theta(e) = \bigoplus P \wedge [\![D_\theta]\!](V)(e)]$

Adnominal *each* combines with an indefinite noun phrase and then with a theta head. Determiner *each* combines first with a nominal and then with a theta head. It is not coindexed with anything because it is not a DD item. Since both entries happen to have the same type, I assume that the syntax is responsible for restricting their distribution (syntactically speaking, one is an adverb and

[4] This is not the only way to reformulate the D operator. See Lasersohn [1998] and Dotlačil [2011] for other proposals. This particular definition is taken from Champollion [2010], except that *PureAtom* has been changed to *Atom*. This change is immaterial because we do not distinguish between pure and impure atoms here.

[5] For other semantic analyses of the DD items *each* and *jeweils*, see for example Moltmann [1997], pp. 205ff., and Zimmermann [2002]. For a recent compositional analysis of *each* that uses plural compositional DRT, see Dotlačil [to appear].

the other one is a determiner). In both cases, the result is a phrase of VP modifier type $\langle vt, vt\rangle$, which is also the type of D_θ. Some intermediate steps of the derivations of (1) are shown in (25) and (26).

(25) $[\![[[\text{two monkeys}]\ \text{each}_{ag}]\ \text{theme}]\!]$
$= \lambda V_{vt}\lambda e[[\![D_{ag}]\!](\lambda e'[V(e') \wedge 2\text{M}(e')])(e)]$
$= \lambda V_{vt}\lambda e[e \in {}^*\lambda e'[{}^*\text{see}(e') \wedge 2\text{M}(e') \wedge \text{Atom}(\text{ag}(e'))]]$

(26) $[\![[[\text{Each child}]\ \text{agent}]]\!]$
$= \lambda V_{vt}\lambda e[{}^*\text{ag}(e) = \bigoplus \text{child} \wedge [\![D_{ag}]\!](V)(e)]$
$= \lambda V_{vt}\lambda e[{}^*\text{ag}(e) = \bigoplus \text{child} \wedge e \in {}^*\lambda e'[V(e') \wedge \text{Atom}(\text{ag}(e'))]]$

The result of these derivations is always the same, which reflects their synonymy:

(27) $[\![$The children each$_{ag}$ saw two monkeys$]\!]$
= $[\![$The children saw two monkeys each$_{ag}]\!]$
= $[\![$Each child saw two monkeys$]\!]$
= (21) = $[\![$The children D$_{ag}$ saw two monkeys$]\!]$

We now come to the event-based reformulation of Part. We obtain it by replacing *Atom* in (20) with a free variable C, which is assumed to be anaphoric on the context. This minimal change reflects the close connection between D and Part.

(28) $[\![\text{Part}_{\theta,C}]\!] = \lambda P_{vt}\lambda e[e \in {}^*\lambda e'[P(e') \wedge C(\theta(e'))]]$

Part 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. Note that the definition of (28) entails that C is a cover of $\theta(e)$. The operator (28) is also the lexical entry of adverbial *jeweils*. The same type shift as in (23) brings us from (28) to adnominal *jeweils*:

(29) $[\![\text{jeweils}_{\theta,C}]\!]_{adverbial} = [\![\text{Part}_{\theta,C}]\!] = (28)$

(30) $[\![\text{jeweils}_{\theta,C}]\!]_{adnominal} = \lambda P\lambda\theta\lambda V\lambda e[[\![\text{Part}_{\theta,C}]\!](\lambda e'[V(e') \wedge P(\theta(e'))])(e)]$

As in the case of the Part operator, the C parameter of *jeweils* can be set to *Atom* so long as θ is set to a function which points into a count domain, such as *ag*. In that case, *jeweils* distributes over individuals and is equivalent to *each*. The following example illustrates this with sentence (2a); sentence (2b) is equivalent.

(31) Die Kinder haben jeweils$_{ag,Atom}$ zwei Affen gesehen.
The children have DIST two monkeys seen.
"The children have each seen two monkeys."

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 like τ (runtime). This leads to occasion readings. Suppose for example that it is in the common ground that the children have been to the zoo to see animals last Monday, last Wednesday and last Friday, and that (2a) is uttered with reference to that state of affairs, or sum event. It is interpreted as follows.

(32) ⟦Die Kinder haben jeweils$_{\tau,\text{zoovisit}}$ zwei Affen gesehen.⟧ =
$^*\text{ag}(e_0) = \bigoplus \text{child} \wedge e_0 \in {}^*\lambda e'[^*\text{see}(e') \wedge 2\text{M}(e') \wedge \text{zoovisit}(\tau(e'))]$
"The children 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 (32) 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 *ag* as in (31). What (32) asserts is that e_0 has the children 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 a seeing-two-monkeys event. Runtime is closed under sum just like other thematic roles ($\tau = {}^*\tau$), or in other words, it is a sum homomorphism [Krifka, 1989]. 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.

5 Summary and Discussion

This analysis has captured the semantic similarities between DD items across languages, as well as their variation, by relating them to distributivity operators. DD items can be given the same lexical entry up to type shifting and parameter settings. The parameters provided by the reformulation of the D and Part operators capture the semantic variation: DD items like English *each* are hard-coded for distribution over atoms, which blocks distributivity over a noncount domain like time. DD items like German *jeweils* can distribute over noncount domains, but only if they can pick up salient nonatomic covers from context.

The remaining question is how to capture the correlation expressed in Zimmermann's Generalization (7). That is to say, why does a DD item 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; DD *each* also has a complement, a proform that must acquire its agreement features from its antecedent, the target of *each*; only overt targets have agreement features. Alternatively, a semantic explanation seems plausible: Distributive determiners like English *each* are only compatible with count nominals (*each boy*, **each mud*). Formally, this amounts to an atomicity requirement of the kind the D operator provides. This requirement can be seen as independent evidence of the atomic distributivity hard-coded in the entry (24) via the D operator (20). In other words, the DD item inherits the atomicity requirement of the determiner. Both explanations are compatible with the present framework.

Acknowledgments. Thanks to Anna Szabolcsi, Robert Henderson and to the reviewers for helpful comments. I am also grateful to audiences at the 2011 Stuttgart workshop on quantification and at the 2011 Amsterdam Colloquium.

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